4.75V to 18V Input, 2A Synchronous Step Down DC/DC Converter

UM5482S8 *SOP8*

General Description

The UM5482S8 is a synchronous buck regulator. The device integrates two 100mΩ MOSFETs, and provides 2A of continuous load current over a wide input voltage of 4.75V to 18V. 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, available in an 8-pin SOP package, provides a very compact solution with minimal external components.

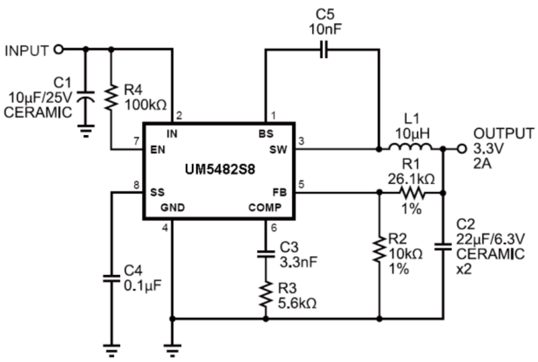
Applications

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

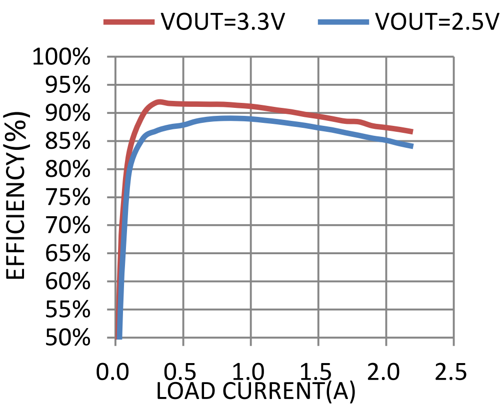
Features

- 2A Output Current
- Wide 4.75V to 18V Operating Input Range
- Integrated 100mΩ Power MOSFET Switches
- Output Adjustable from 0.923V to 15V
- Up to 92% Efficiency
- Programmable Soft-Start
- Stable with Low ESR Ceramic Output Capacitors
- Fixed 340kHz Frequency
- Cycle-by-Cycle Over Current Protection
- Input Under Voltage Lockout
- SOP8 Package

Typical Application Circuit

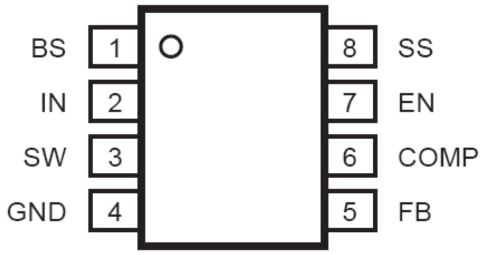


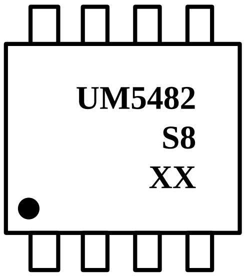
Efficiency vs Load Current



Pin Configurations

Top View





XX: Week Code
UM5482S8
SOP8

Ordering Information

Part Number	Packaging Type	Marking Code	Shipping Qty
UM5482S8	SOP8	UM5482S8	3000pcs/13Inch Tape & Reel

Pin Description

Pin Number	Symbol	Function
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 18V power source. Bypass IN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
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.
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.
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.

Absolute Maximum Ratings(Note 1)

Over operating free-air temperature range (unless otherwise noted)

Parameter	Symbol	Value	Unit
Input Voltage	V_{IN}	-0.3 to 20	V
EN Voltage	V_{EN}	-0.3 to 20	V
Switch Node Voltage	Vsw	21	V
Boost Voltage	V_{BS}	V_{SW}-0.3V to V_{SW}+6.0V	V
All Other Pins		-0.3V to +6.0V	V
Continuous Power Dissipation (T_A=25 ℃)		1.38	W
Operating Junction Temperature	T_J	-40 to +125	℃
Storage Temperature Range	T_{STG}	-40 to +150	℃
Maximum Lead Temperature for Soldering 10 Seconds	T_L	+260	℃

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-rated conditions for extended periods may affect device reliability.

Recommended Operating Conditions

Symbol	Parameter	Value	Unit
T_A	Operating Temperature Range	-40 to +85	℃
T_J	Junction Temperature Range	-40 to +125	℃

Thermal Information

Symbol	Parameter		Value	Unit
$R_{\theta JA}$	Junction-to-ambient thermal resistance	SOP8	90	℃/W
$R_{\theta JC}$	Junction-to-case (top) thermal resistance	SOP8	45	℃/W

Electrical Characteristics

T_A=25 ℃, V_{IN}=12V (unless otherwise noted)

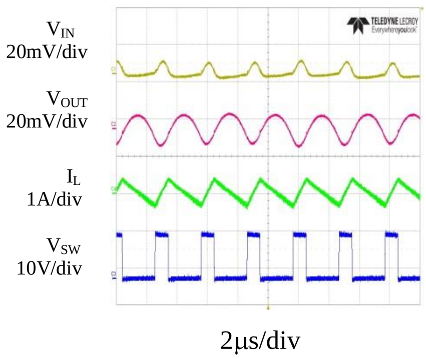
Parameter	Test Conditions	Min	Typ	Max	Unit
Shutdown Supply Current	V_{EN}=0V		1	3	µA
Supply Current	V_{EN}=2.0V, V_{FB}=1.0V		0.6	1.5	mA
Feedback Voltage, V_{FB}	4.5V≤V_{IN}≤18V	0.900	0.923	0.946	V
Feedback Overvotage Threshold			1.1		V
Error Amplifier Voltage Gain (1)	A_{EA}		400		V/V
Error Amplifier Transconductance, G_{EA}	△Ic=±10µA		1200		µA/V
High-Side Switch On Resistance (1)			100		mΩ
Low-Side Switch On Resistance (1)			100		mΩ
High-Side Switch Leakage Current	V_{EN}=0V, V_{SW}=0V			10	µA
Upper Switch Current Limit	Minimum Duty Cycle	2.8	3.5		A
Lower Switch Current Limit	From Drain to Source		1.1		A
COMP to Current Sense Transconductance, G_{CS}			3.5		A/V
Oscillation Frequency, F_{OCS1}		300	340	370	kHz
Short Circuit Oscillation Frequency, F_{OCS2}			34		kHz
Maximum Duty Cycle, D_{MAX}	V_{FB}=0.9V		90		%
Minimum On Time (1)			110		ns
EN Shutdown Threshold Voltage	V_{EN} Rising	1.1	1.6	1.8	V
EN Shutdown Threshold Voltage Hysteresis			210		mV
EN Lockout Threshold Voltage		2.2	2.5	2.7	V
EN Lockout Hysteresis			210		mV
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}=1V		6		µA
Soft-Start Period	C_{SS}=0.1µF		15		ms
Thermal Shutdown (1)			160		℃

Note1: Guaranteed by design, not tested.

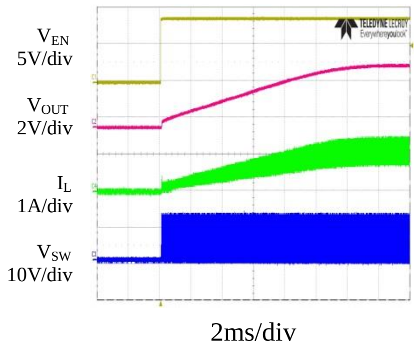
Typical Performance Characteristics

V_{IN} = 12V, V_{OUT} = 3.3V, L = 10µH, C1 = 10µF, C2 = 22µF, T_A = +25 ℃, unless otherwise noted.

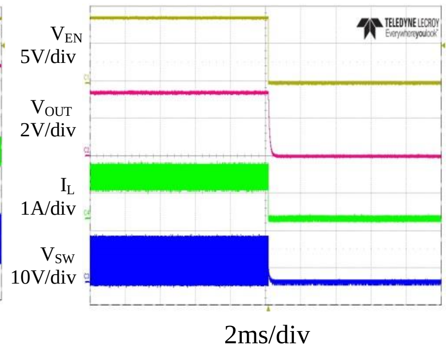
Steady State test
V_{IN}=12V,V_{OUT}=3.3V
I_{OUT}=0A, I_{IN}=7.7mA



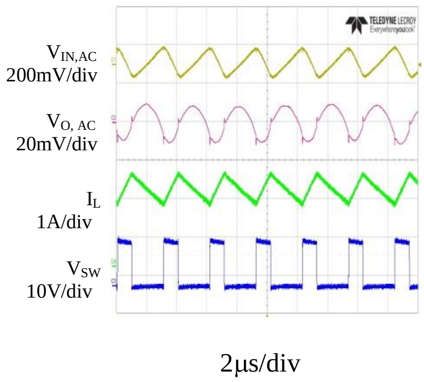
Startup through Enable
V_{IN}=12V,V_{OUT}=3.3V,
I_{OUT}=1A (Resistance Load)



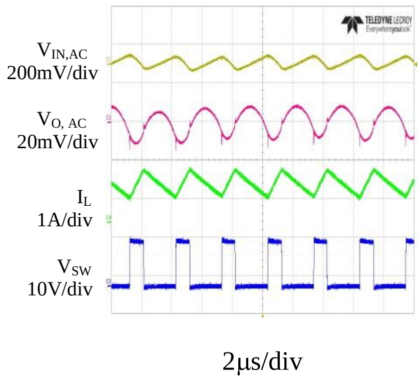
Shutdown through Enable
V_{IN}=12V,V_{OUT}=3.3V,
I_{OUT}=1A (Resistance Load)



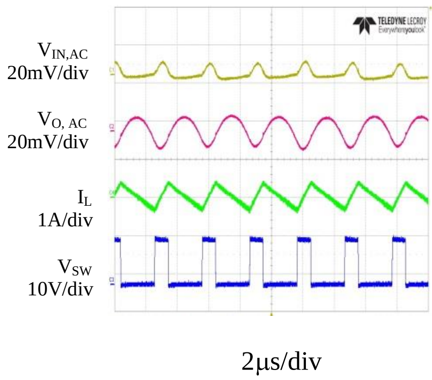
Heavy Load Operation
2A Load



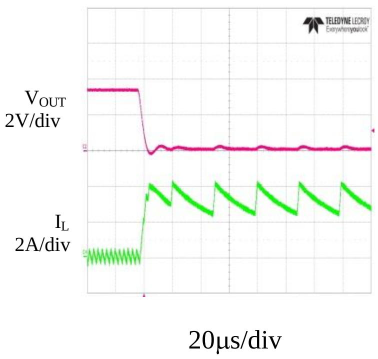
Medium Load Operation
1A Load



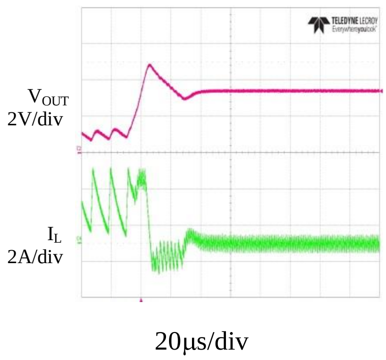
Light Load Operation
No Load



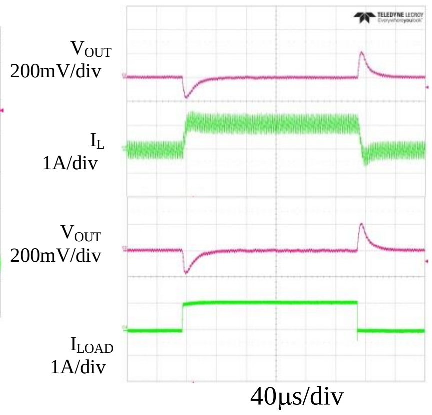
Short Circuit Protection



Short Circuit Recovery



Load Transient



OPERATION FUNCTIONAL DESCRIPTION

The UM5482S8 is a synchronous rectified, current-mode, step-down regulator. It regulates input voltages from 4.75V to 18V down to an output voltage as low as 0.923V, and supplies up to 2A of load current.

The UM5482S8 uses current-mode control to regulate the output voltage. The output voltage is measured at FB through a resistive voltage divider and amplified through the internal transconductance error amplifier.The voltage at the COMP pin is compared to the switch current measured internally to control the output voltage.

The converter uses internal N-Channel MOSFET switches to step-down the input voltage to the regulated output voltage. Since the high side MOSFET requires a gate voltage greater than the input voltage, a boost capacitor connected between SW and BS is needed to drive the high side gate. The boost capacitor is charged from the internal 5V rail when SW is low.

When the UM5482S8 FB pin exceeds 20% of the nominal regulation voltage of 0.923V, the over voltage comparator is tripped and the COMP pin and the SS pin are discharged to GND, forcing the high-side switch off.

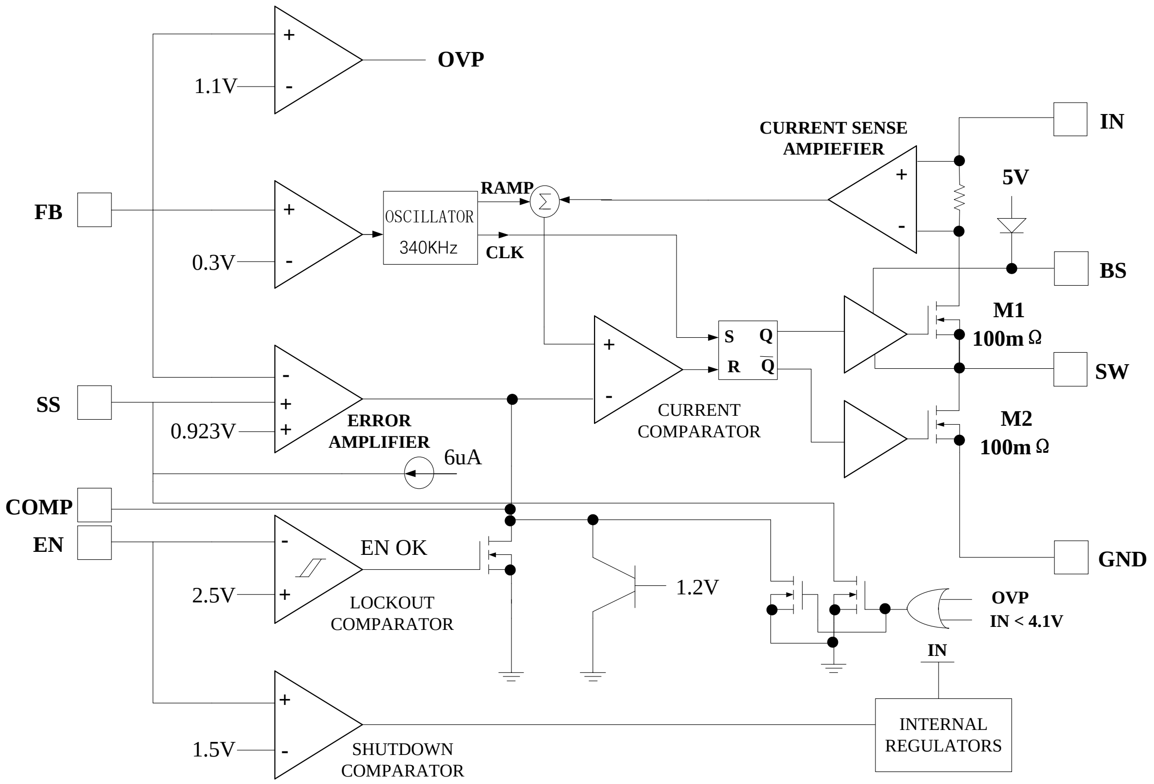


Figure 1.Functional Block Diagram

APPLICATIONS INFORMATION

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:

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

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:

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

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:

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

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.

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:

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

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:

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

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:

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

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:

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

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:

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

The characteristics of the output capacitor also affect the stability of the regulation system. The UM5482S8 can be optimized for a wide range of capacitance and ESR values.

Compensation Components

UM5482S8 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 AVEA 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 2), 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:

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

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, fZ1, below one-forth of the crossover frequency provides sufficient phase margin.

Determine the C3 value by the following equation:

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

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, and it will be a must if the applicable condition is:

- V_{OUT} is 5V or 3.3V, and duty cycle is high:
- $D = \frac{V_{OUT}}{V_{IN}} > 65\%$

In these cases, an external BS diode is recommended from the output of the voltage regulator to BS pin, as shown in Figure 2

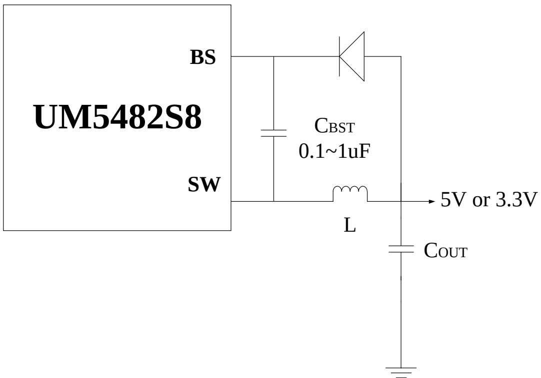


Figure 2.Add Optional External Bootstrap Diode to Enhance Efficiency

Typical Application Circuit

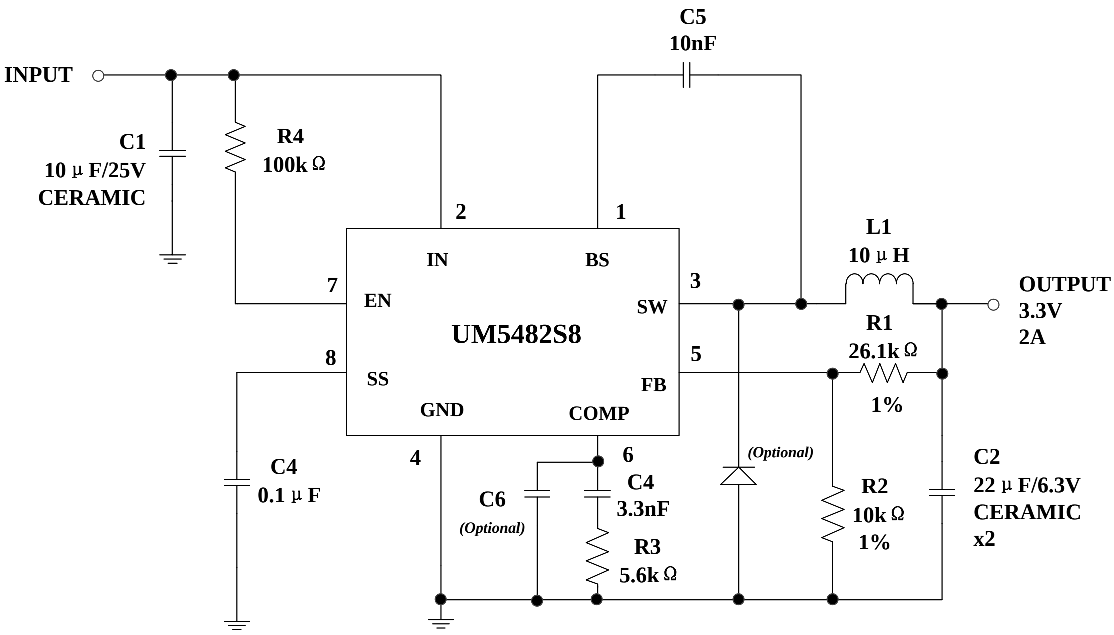
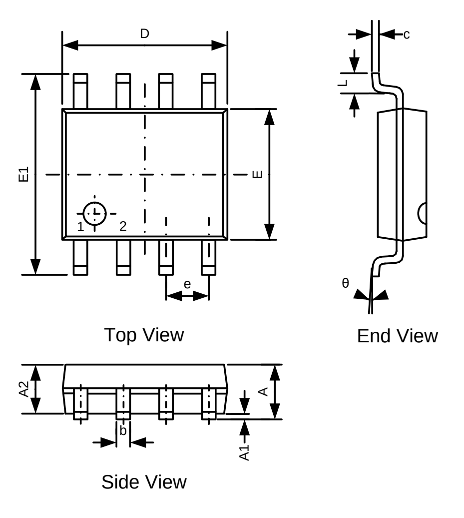


Figure 3.UM5482S8 with 3.3V Output, 22µF/6.3V Ceramic Output Capacitor

Package Information

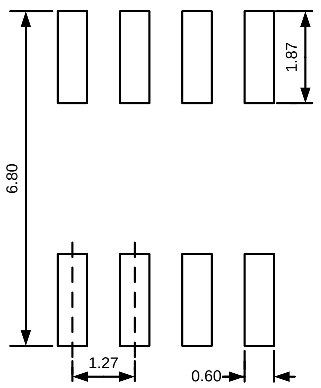
UM5482S8: SOP8

Outline Drawing



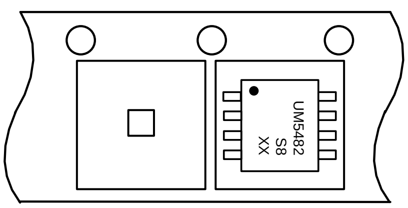
DIMENSIONS						
Symbol	MILLIMETERS			INCHES		
	Min	Typ	Max	Min	Typ	Max
A	1.35	1.55	1.75	0.053	0.061	0.069
A1	0.10	-	0.25	0.004	-	0.010
A2	1.25	-	1.65	0.049	-	0.065
b	0.30	-	0.51	0.012	-	0.020
c	0.15	-	0.25	0.006	-	0.010
D	4.70	4.90	5.10	0.185	0.193	0.200
E	3.80	3.90	4.00	0.150	0.154	0.157
E1	5.80	6.00	6.20	0.228	0.236	0.244
e	1.27BSC			0.050 BSC		
L	0.40	-	1.27	0.016	-	0.050
θ	0 °	-	8 °	0 °	-	8 °

Land Pattern

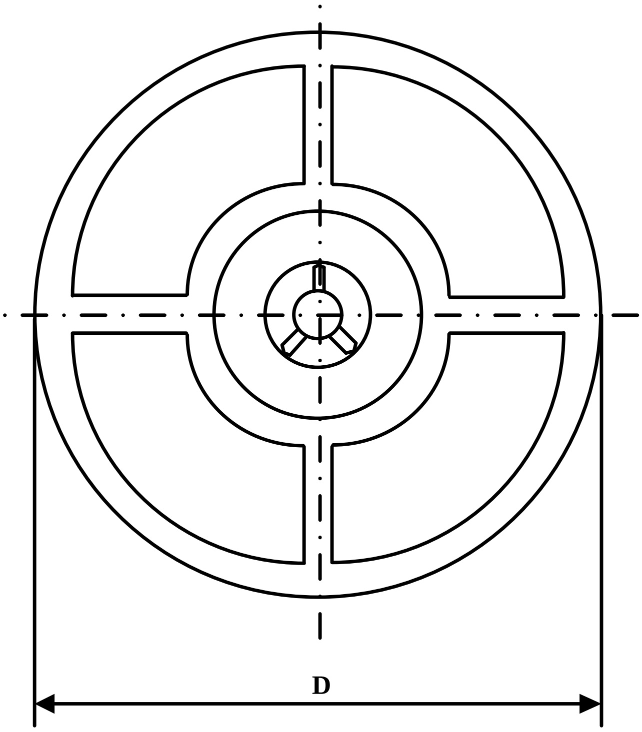


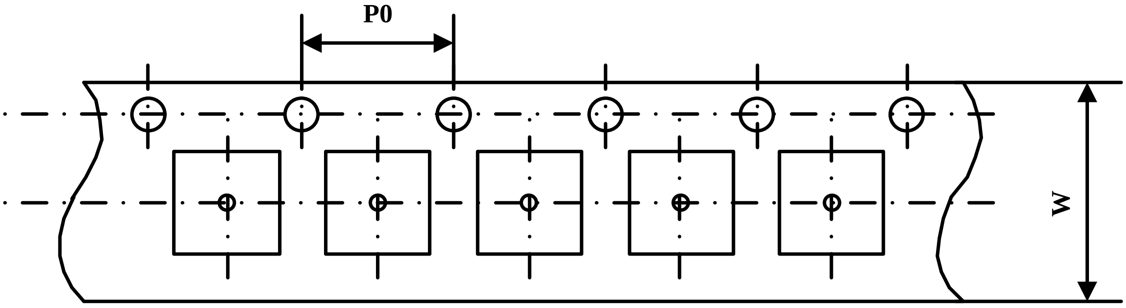
NOTES:
1. Compound dimension: 4.90×3.90;
2. Unit: mm;
3. General tolerance ±0.05mm unless otherwise specified;
4. The layout is just for reference.

Tape and Reel Orientation



Packing Information





Part Number	Package Type	Carrier Width(W)	Pitch(P0)	Reel Size(D)
UM5482S8	SOP8	12 mm	4 mm	330 mm

GREEN COMPLIANCE

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