XR5017S

1.2A, 26V Synchronous

DESCRIPTION

The XR5017S is a current mode monolithic buck switching regulator. Operating with an input range of 4.5V~26V, the XR5017S delivers 1.2A of continuous output current with two integrated N-Channel MOSFETs. The internal synchronous power switches provide high efficiency without the use of an external Schottky diode. At light loads, regulators operate in low frequency to maintain high efficiency and low output ripple. Current mode control provides tight load transient response and cycle-by-cycle current limit.

The XR5017S guarantees robustness with over current protection and hiccup, thermal protection, start-up current run-away protection, and input under voltage lockout.

The XR5017S is available in 6-pin SOT23-6 package, which provides a compact solution with minimal external components.

FEATURES

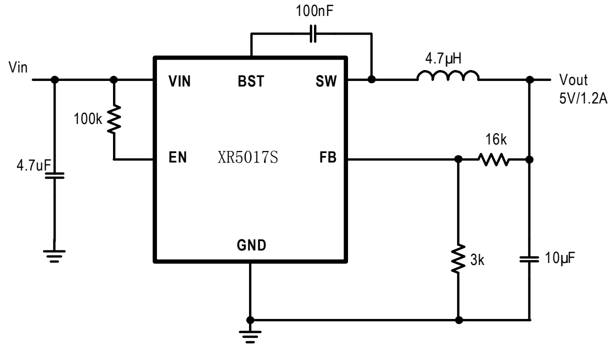
- 4.5 V to 26 V operating input range 1.2A output current
- Up to 94% efficiency
- High efficiency (>78%) at light load
- Internal Soft-Start
- Fixed 1.2MHz Switching frequency
- Available in SOT23-6 package
- Input under voltage lockout
- Start-up current run-away protection
- Over current protection and Hiccup
- Thermal protection

APPLICATIONS

- Distributed Power Systems
- Automotive Systems
- High Voltage Power Conversion
- Industrial Power Systems
- Battery Powered Systems

TYPICAL APPLICATION

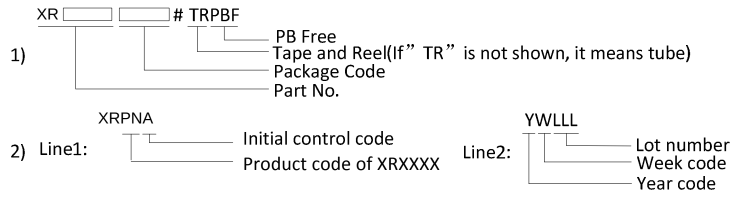
5V/1.2A Step Down Regulators



ORDER INFORMATION

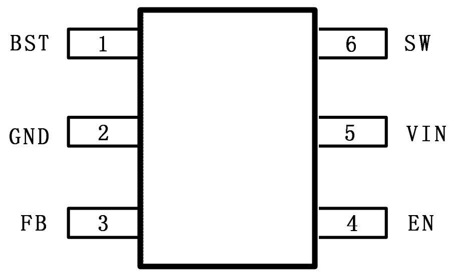
DEVICE[1)]	PACKAGE	TOP MARKING[2)]
XR5017SSOTB#TRPBF	SOT23-6	XRBVX YWLLL

Notes: : :



PIN CONFIGURATION

TOP VIEW



SOT23

ABSOLUTE MAXIMUM RATING111)))

VIN, EN, SW Pin .... -0.3V to 26V
BST Pin .... SW-0.3V to SW+5V
All other Pins . ... -0.3V to 6V
Junction Temperature[2) 3)] 150ºC
Lead Temperature 260ºC
Storage Temperature .... -65ºC to +150ºC

RECOMMENDED OPERATING CONDITIONS

Input Voltage VIN . ...4.5V to 26V
Output Voltage Vout. ....0.8V to 21V
Operating Junction Temperature . . ..-40ºC to 125ºC

THERMAL PERFORMANCE[4)]

$\theta_{JA\,JAJA}$ θ_{Jc}

SOT23-6 . ... 220...130ºC/W

Note：：：

1) Exceeding these ratings may damage the device.
2) The XR5017S guarantees robust performance from -40°C to 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
3) The XR5017S includes thermal protection that is intended to protect the device in overload conditions. Thermal protection is active when junction temperature exceeds the maximum operating junction temperature. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.
4) Measured on JESD51-7, 4-layer PCB.

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, T_A = 25ºC, unless otherwise stated.

Item	Symbol	Condition	Min.	Typ.	Max.	Units
V_{IN} Under voltage Lockout Threshold	V_{IN_MIN}	V_{IN} falling	4.0	4.2	4.4	V
V_{IN} Under voltage Lockout Hysteresis	$V_{IN\_MIN\_HYST}$	V_{IN} rising		300		mV
Shutdown Supply Current	I_{SD}	V_{EN}=0V		0.1	1	μA
Supply Current	I_Q	V_{EN}=5V, V_{FB}=1.2V		40	60	μA
Feedback Voltage	V_{FB}	4.5V<V_{VIN}<26V	776	800	824	mV
Top Switch Resistance[5)]	$R_{DS(ON)T}$			300		mΩ
Bottom Switch Resistance[5)]	$R_{DS(ON)B}$			150		mΩ
Top Switch Leakage Current	I_{LEAK_TOP}	V_{IN}=26V, V_{EN}=0V, V_{SW}=0V			1	uA
Bottom Switch Leakage Current	I_{LEAK_BOT}	V_{IN}= V_{SW} = 26V, V_{EN}=0V			1	uA
Top Switch Current Limit[5)]	I_{LIM_TOP}	Minimum Duty Cycle		2		A
Switch Frequency	f_{SW}			1.2		MHz
Minimum On Time[5)]	T_{ON_MIN}			80		ns
Minimum Off Time[5)]	T_{OFF_MIN}	V_{FB}=0.6V		120		ns
EN Shutdown Threshold	V_{EN_TH}	V_{EN} falling, FB=0V	1.2	1.3	1.4	V
EN Shutdown Hysteresis	V_{EN_HYST}	V_{EN} rising, FB=0V		100		mV
Thermal Shutdown[5)]	T_{TSD}			140		°C
Thermal Shutdown hysteresis[5)]	T_{TSD_HYST}			15		°C

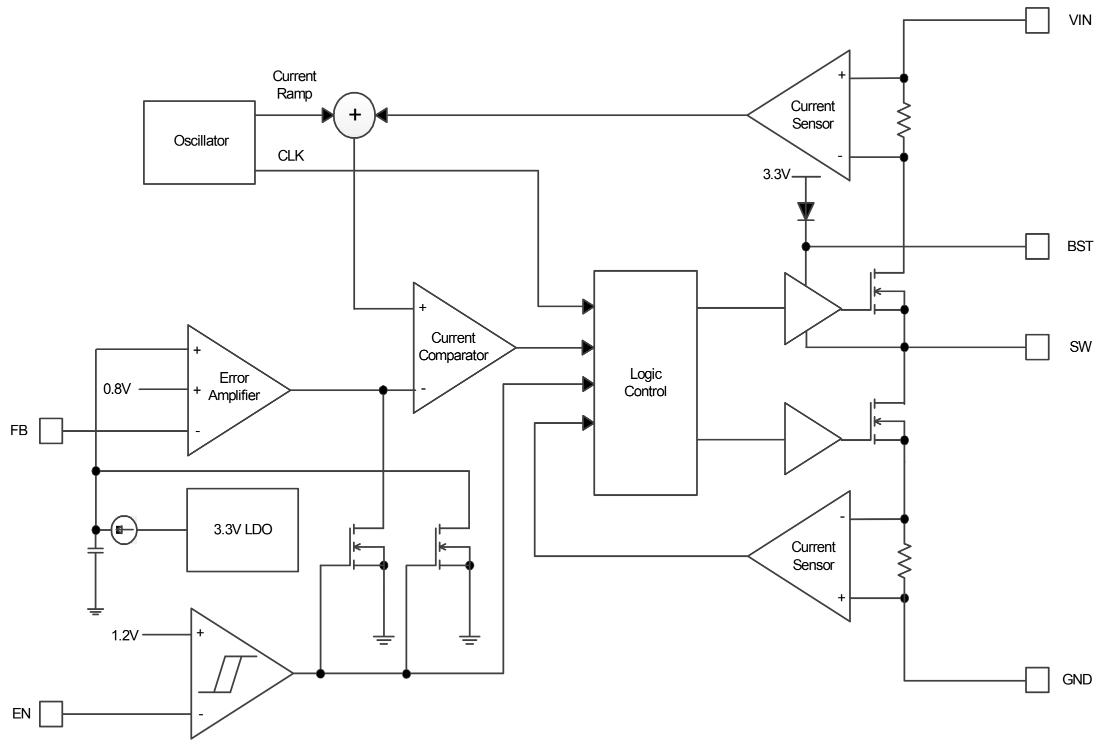
Note:

5) Guaranteed by design.

PIN DESCRIPTION

SOT23-6 Pin	Name	Description
1	BST	Bootstrap pin for top switch. A 0.1uF or larger capacitor should be connected between this pin and the SW pin to supply current to the top switch and top switch driver.
2	GND	Ground.
3	FB	Output feedback pin. FB senses the output voltage and is regulated by the control loop to 800mV. Connect a resistive divider at FB.
4	EN	Drive EN pin high to turn on the regulator and low to turn off the regulator.
7	VIN	Input voltage pin. VIN supplies power to the IC. Connect a 4.5V to 26V supply to VIN and bypass VIN to GND with a suitably large capacitor to eliminate noise on the input to the IC.
8	SW	SW is the switching node that supplies power to the output. Connect the output LC filter from SW to the output load.

BLOCK DIAGRAM



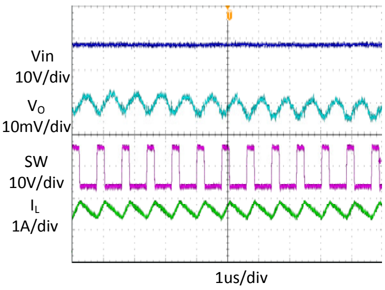
TYPICAL PERFORMANCE CHARACTERISTICS

Vin = 12V, Vout = 3.3V, L = 4.7μH, Cout = 10μF, TA = +25°C, unless otherwise noted

Steady State Test

VIN=12V, Vout=3.3V

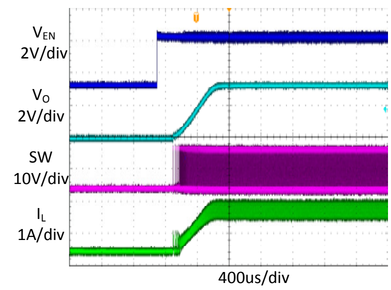
Iout=1.2A



Startup through Enable

VIN=12V, Vout=3.3V

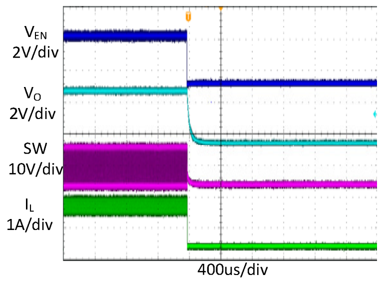
Iout=1.2A(Resistive load)



Shutdown through Enable

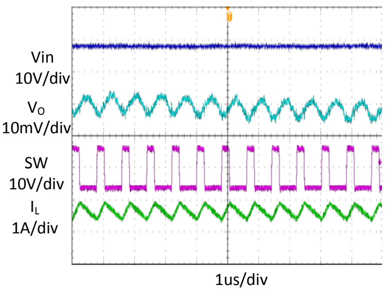
VIN=12V, Vout=3.3V

Iout=1.2A(Resistive load)



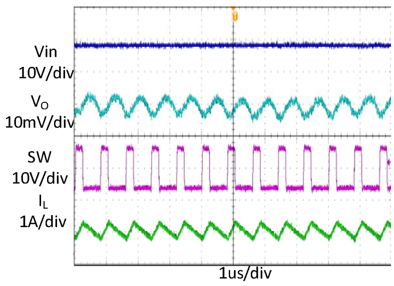
Heavy Load Operation

1.2A LOAD



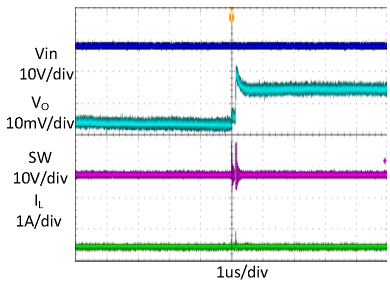
Medium Load Operation

0.6A LOAD



Light Load Operation

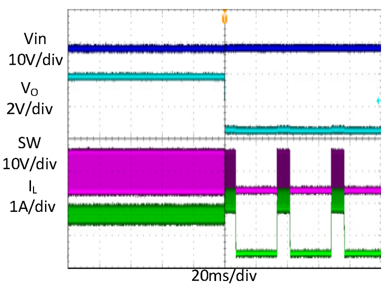
0 A LOAD



Short Circuit Protection

VIN=12V, Vout=3.3V

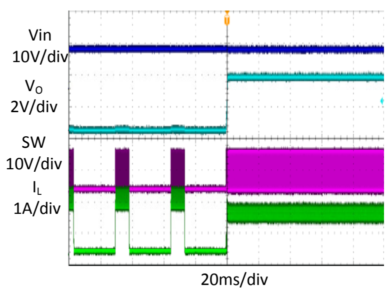
Iout=1.2A- Short



Short Circuit Protection

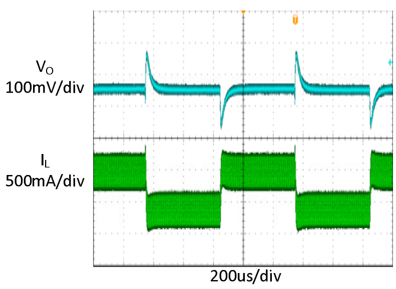
VIN=12V, Vout=3.3V

Iout= Short –1.2A



Load Transient

0.6A LOAD → 1.2A LOAD →0.6A LOAD

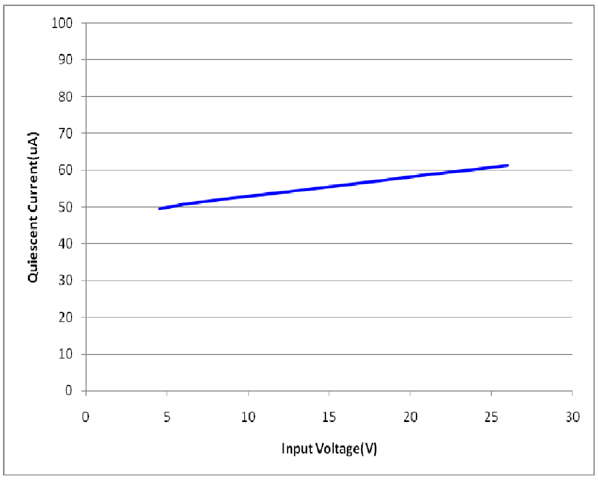


TYPICAL PERFORMANCE CHARACTERISTICS *(continued)*

Vin = 12V, Vout = 3.3V, L = 4.7μH, Cout = 10μF, TA = +25°C, unless otherwise noted

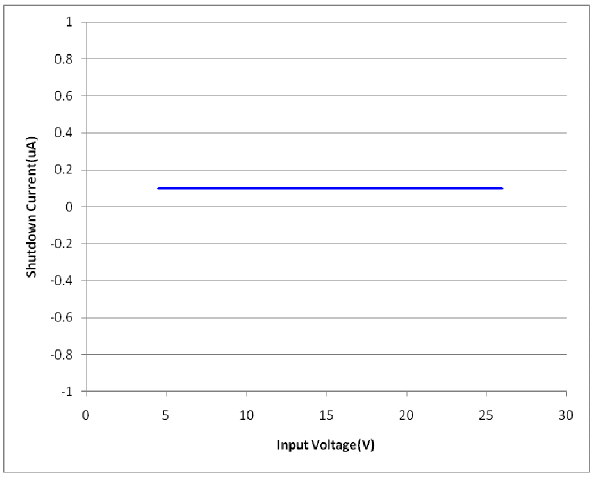
Quiescent Current Vs. Input Voltage

VIN=4.5V ~ 26V, VEN=5V, VFB=1V

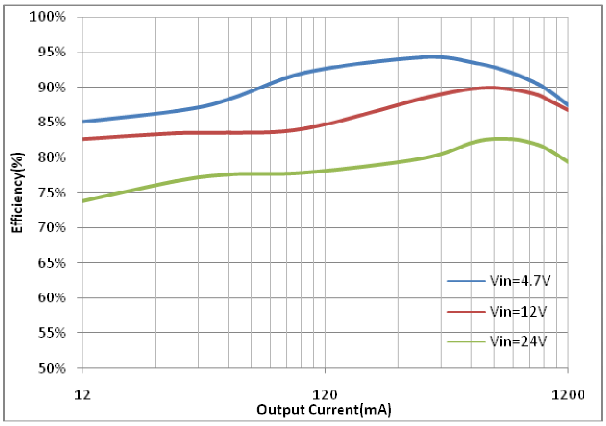


Shutdown Current Vs. Input Voltage

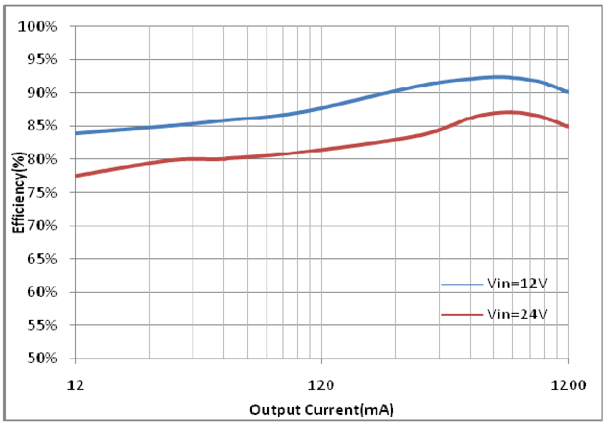
VIN=4.5V ~ 26V, VEN=0V



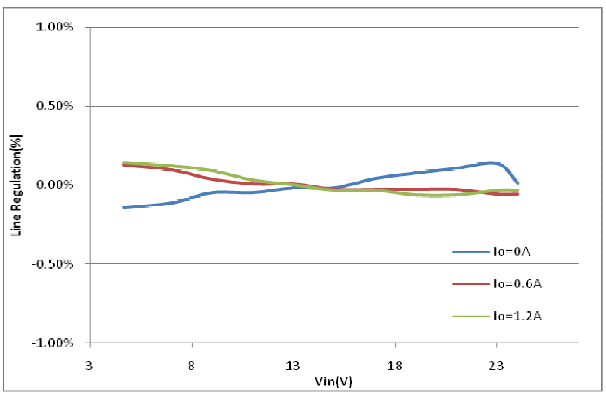
Efficiency @ Vout=3.3V



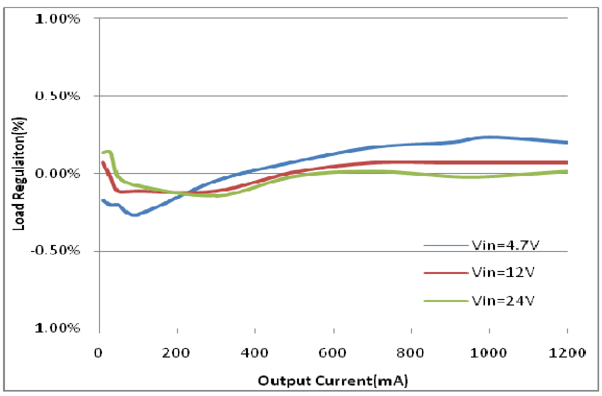
Efficiency @ Vout=5V



Line regulation



Load regulation @ Vout=3.3V



FUNCTIONAL DESCRIPTION

The XR5017S is a synchronous, current-mode, step-down regulator. It regulates input voltage from 4.5V to 26V down to an output voltage as low as 0.8V, and is capable of supplying up to 1.2A of load current.

Current-Mode Control

The XR5017S utilizes current-mode control to regulate the output voltage. The output voltage is measured at the FB pin through a resistive voltage divider and the error is amplified by the internal transconductance error amplifier.
Output of the internal error amplifier is compared with the switch current measured internally to control the output current limit.

PFM Mode

The XR5017S operates in PFM mode at light load. In PFM mode, switch frequency is continuously controlled in proportion to the load current, i.e. switch frequency decreases when load current drops to boost power efficiency at light load by reducing switch-loss, while switch frequency increases when load current rises, minimizing both load current and output voltage ripples.

Shut-Down Mode

The XR5017S operates in shut-down mode when voltage at EN pin is driven below 0.3V. In shut-down mode, the entire regulator is off and the supply current consumed by the XR5017S drops below 0.1uA.

Power Switch

N-Channel MOSFET switches are integrated on the XR5017S to down convert the input voltage to the regulated output voltage. Since the top MOSFET needs a gate voltage greater than the input voltage, a boost capacitor connected between BST and SW pins is required to drive the gate of the top switch. The boost capacitor is charged by the internal 3.3V rail when SW is low.

Vin Under-Voltage Protection

A resistive divider can be connected between Vin and ground, with the central tap connected to EN, so that when Vin drops to the pre-set value, EN drops below 1.2V to trigger input under voltage lockout protection.

Output Current Run-Away Protection

At start-up, due to the high voltage at input and low voltage at output, current inertia of the output inductance can be easily built up, resulting in a large start-up output current. A valley current limit is designed in the XR5017S so that only when output current drops below the valley current limit can the bottom power switch be turned off. By such control mechanism, the output current at start-up is well controlled.

Over Current Protection and Hiccup

XR5017S has a cycle-by-cycle current limit. When the inductor current triggers current limit, XR5017S enters hiccup mode and periodically restart the chip. XR5017S will exit hiccup mode while not triggering current limit.

Thermal Protection

When the temperature of the XR5017S rises above 140°C, it is forced into thermal shut-down. Only when core temperature drops below 125°C can the regulator becomes active again.

PCB Layout Note

1. Place the input decoupling capacitor as close to XR5017S (VIN pin and PGND) as possible to eliminate noise at the input pin.
2. Put the feedback trace as far away from the inductor and noisy power traces as possible.
3. To improve thermal conduction, put an array of vias right under the exposed pad. Use small vias (15mil barrel diameter) so that the holes can be filled during the plating process. Very large holes can cause ‘solder-wicking’ problems during the reflow soldering process. Use a vias pitch (distance between the centers of two adjacent vias) of 40mil.

APPLICATION INFORMATION

Output Voltage Set

The output voltage is determined by the resistor divider connected at the FB pin, and the voltage ratio is:

$$V_{FB} = V_{OUT} \cdot \frac{R_2}{R_2 + R_3}$$

where V_{FB} is the feedback voltage and V_{OUT} is the output voltage.

Choose R_3 around 10kΩ, and then R_2 can be calculated by:

$$R_3 = R_2 \cdot \left(\frac{V_{OUT}}{0.8V} - 1 \right)$$

The following table lists the recommended values.

VOUT(V)	R2(kΩ)	R3(kΩ)
2.5	7.5	16
3.3	5.1	16
5	3.0	16

Input Capacitor

The input capacitor is used to supply the AC input current to the step-down converter and maintaining the DC input voltage. The ripple current through the input capacitor can be calculated by:

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

where I_{LOAD} is the load current, V_{OUT} is the output voltage, V_{IN} is the input voltage.

Thus the input capacitor can be calculated by the following equation when the input ripple voltage is determined.

$$C_1 = \frac{I_{LOAD}}{f_S \cdot \Delta V_{IN}} \cdot \frac{V_{OUT}}{V_{IN}} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

where C_1 is the input capacitance value, f_S is the switching frequency, $\triangle V_{IN}$ is the input ripple voltage.

The input capacitor can be electrolytic, tantalum or ceramic. To minimizing the potential noise, a small X5R or X7R ceramic capacitor, i.e. 0.1uF, should be placed as close to the IC as possible when using electrolytic capacitors.

A 22uF ceramic capacitor is recommended in typical application.

Output Capacitor

The output capacitor is required to maintain the DC output voltage, and the capacitance value determines the output ripple voltage. The output voltage ripple can be calculated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \cdot L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \cdot \left(R_{ESR} + \frac{1}{8 f_S \cdot C_2}\right)$$

where C_2 is the output capacitance value and R_{ESR} is the equivalent series resistance value of the output capacitor.

The output capacitor can be low ESR electrolytic, tantalum or ceramic, which lower ESR capacitors get lower output ripple voltage.

The output capacitors also affect the system stability and transient response, and a 22uF ceramic capacitor is recommended in typical application.

Inductor

The inductor is used to supply constant current to the output load, and the value determines the ripple current which affect the efficiency and the output voltage ripple. The ripple current is typically allowed to be 30% of the maximum switch current limit, thus the inductance value can be calculated by:

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

where V_{IN} is the input voltage, V_{OUT} is the output voltage, f_S is the switching frequency, and $\triangle I_L$ is the peak-to-peak inductor ripple current.

External Bootstrap Capacitor

A bootstrap capacitor is required to supply voltage to the top switch driver. A 0.1uF low ESR ceramic capacitor is recommended to connected to the BST pin and SW pin.

PCB Layout Note

For minimum noise problem and best operating performance, the PCB is preferred to following the guidelines as reference.

1. Place the input decoupling capacitor as close to XR5033 (VIN pin and PGND) as possible to eliminate noise at the input pin. The loop area formed by input capacitor and GND must be minimized.
2. Put the feedback trace as far away from the inductor and noisy power traces as possible.
3. The ground plane on the PCB should be as large as possible for better heat dissipation

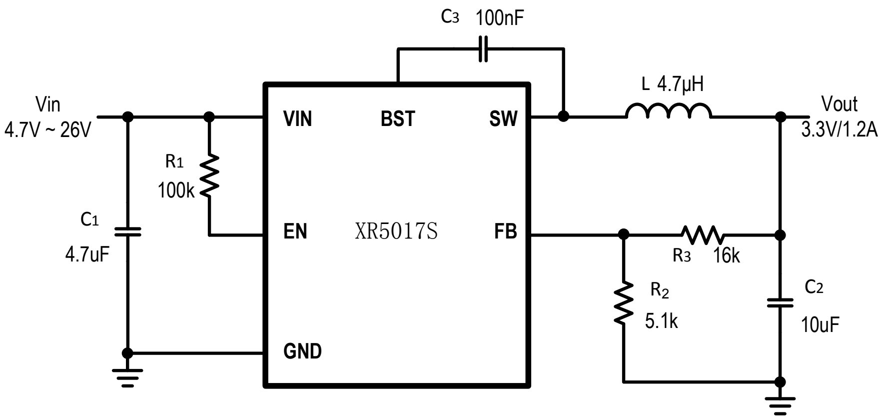
REFERENCE DESIGN

Reference 1：

V_{IN} : 4.7V ~ 26V

V_{OUT}: 3.3V

I_{OUT} : 0~1.2A

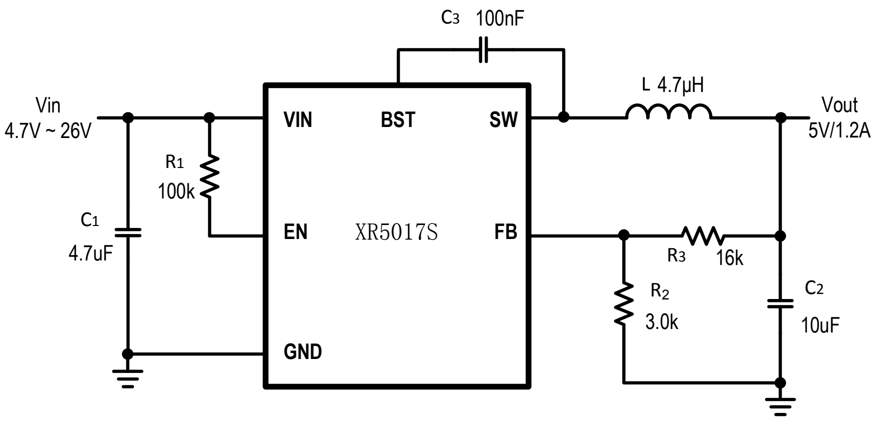


Reference 2：

V_{IN} : 6V ~ 26V

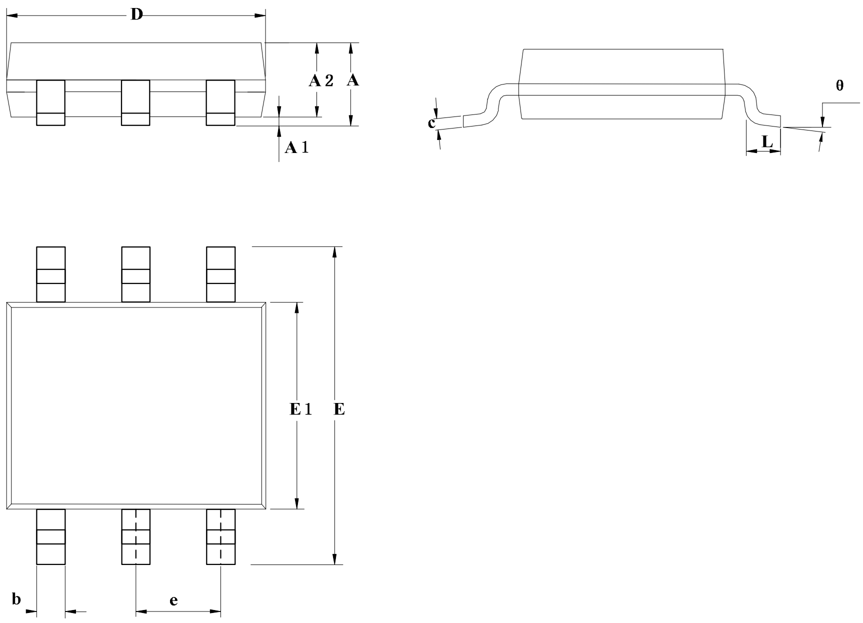
V_{OUT}: 5V

I_{OUT} : 0~1.2A



PACKAGE OUTLINE

SOT23-6 UNIT: mm



SYMBOL	MILLIMETER		
	MIN	NOM	MAX
A	1.05	1.15	1.25
A1	0	0.05	0.15
A2	0.95	1.05	1.20
b	0.20	0.40	0.60
c	0.05	—	0.21
D	2.72	2.92	3.12
E	2.60	2.80	3.00
E1	1.40	1.60	1.80
e	0.95（BSC)		
L	0.30	0.45	0.60
θ	0°	—	8°