High efficiency, 3A synchronous rectification Step-Down converter

General Description

The SL7136/36P/36D2 is a high-efficiency synchronous Buck converter that can operate over a wide input voltage range of 2.5V to 5.5V and can deliver up to 3A of output current. It integrates the main switch and synchronous switch inside, and has extremely low on-resistance to reduce conduction loss. The switching frequency is 1.0 MHz, which can reduce the size of the external inductor and output capacitor and reduce the output voltage ripple.

The SL7136/36P/36D2 is available in SOT23-5 / SOT23-6 / DFN2×2-8 package.

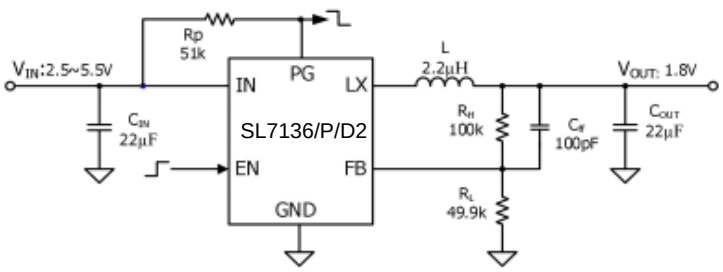
Features

- 2.5V~5.5V input voltage range
- 35uA ultra-low quiescent current
- Internal soft-start reduces chip stress
- Input Overvoltage Protection (OVP)
- Short circuit protection Hiccup mode
- Internal integrated low $R_{DS(ON)}$ switch
- 1.0 MHz switching frequency minimizes external components
- Optimized PFM mode to improve light-load efficiency
- 100% duty cycle supports input and output low dropout operation
- RoHS Compliant and Halogen Free
- SL7136:SOT23-5 / SL7136P:SOT23-6 / SL7136D2:DFN2×2-8 package

Applications

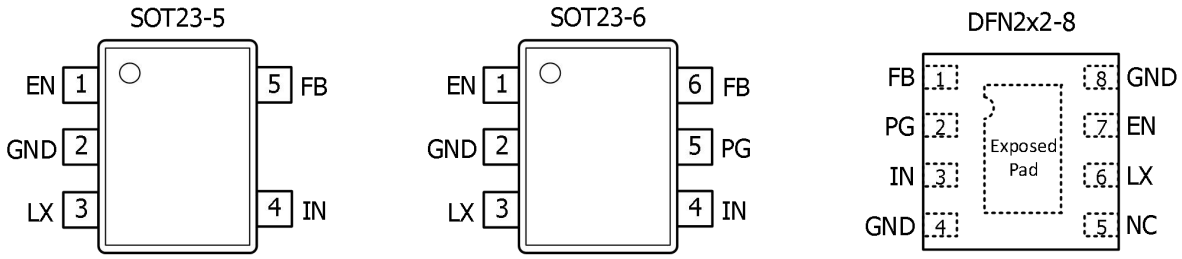
- Set-top box
- Mobile phones, handheld game consoles, media players
- Electric toys, meters, etc.

Typical Application Circuit



Power Good feature is only available in SL7136P/36D2。

Pin Configurations



Pin Description

PIN			Symbol	Description
SOT23-5	SOT23-6	DFN2×2-8		
1	1	7	EN	Enable signal input pin, the chip works when input high level, do not leave the pin floating.
2	2	4,8	GND	Ground pin.
3	3	6	LX	Inductor pin. This pin should be connected to the switching node of the inductor.
4	4	3	IN	Power input pin. Use a ceramic decoupling capacitor of at least22uF to connect this pin to ground.
/	5	2	PG	Power Good Indicator Pin, Low If Output voltage < 90% of the regulation voltage, High Otherwise.
5	6	1	FB	Feedback pin. Connect this pin to the center point of the output divider resistor to set the output voltage.

Ordering Information

Type Number	Frequency	Power Good	Ordering Number	Package	Package Quantity
SL7136	1.0 MHz	N	SL7136YT5	SOT23-5	3000PCS
SL7136P	1.0 MHz	Y	SL7136PYT6	SOT23-6	3000PCS
SL7136D2	1.0 MHz	Y	SL7136D2YF8	DFN2x2-8	3000PCS

Absolute Maximum Ratings (T_A=25℃)

Note: Do not exceed these limits to prevent damage to the device. Exposure to absolute maximum rating conditions for long periods may affect device reliability.

Symbol	Parameter		Min.	Max.	Unit
V_{IN}	IN Pin Voltage Range to GND		-0.3	6.5	V
V_{LX}	LX Pin Voltage Range to GND		-0.3	6.5	V
V_{EN}, V_{FB}, V_{PG}	EN, FB, PG Voltage		-0.3	6.5	V
T_{STG}	Storage Junction Temperature		-55	150	℃
T_A	Operating Temperature Range		-40	85	℃
θ_{JA}	Thermal Resistance, Junction to Ambient	SOT23-5/6	-	130	℃/W
		DFN2x2-8	-	55	℃/W
θ_{JC}	Thermal Resistance, Junction to Case	SOT23-5/6	-	60	℃/W
		DFN2x2-8	-	15	℃/W
ESD	Electrostatic Discharge Capability Human Body Model, ANSI/ESDA/JEDEC JS-001-2017		-	2	kV
	Electrostatic Discharge Capability Charged Device Model, ANSI/ESDA/JEDEC JS-002-2018		-	1	kV

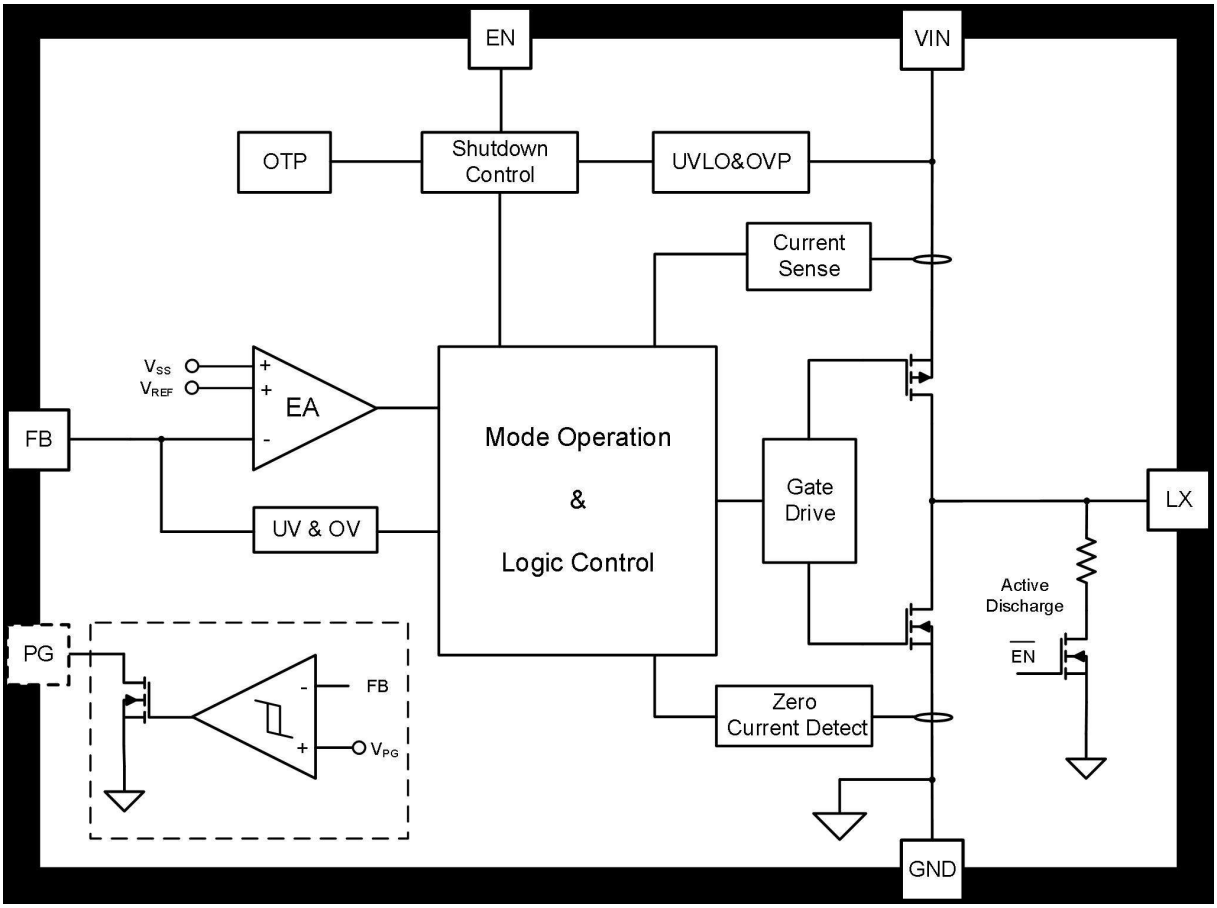
Electrical Characteristics（T_A=25℃）

(V_{IN} = 5V, V_{OUT} = 1.8V, L = 2.2uH, C_{OUT} = 22uF, unless otherwise specified)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_{IN}	Input Voltage Range	-	2.5		5.5	V
V_{UVLO}	Input UVLO threshold	V_{IN} rising		2.3	2.45	V
V_{HYS}	UVLO hysteresis			0.18		V
OVP	VIN OVP Threshold	V_{IN} rising		6.2		V
I_Q	Quiescent Current	I_{OUT}=0, V_{FB}=V_{REF}*105%		35	65	μA
I_{SHDN}	Shutdown Current	V_{EN}=0V		0.1	10	μA
V_{REF}	Feedback Reference Voltage		0.588	0.600	0.612	V
$R_{DS(ON),P}$	PFET RON			87		mΩ
$R_{DS(ON),N}$	NFET RON			50		mΩ
I_{LIM}	PFET Current Limit	V_{OUT}=2.5V	4			A
R_{Dis}	LX Discharge Resistance	V_{EN}=0V		50		Ω
V_{ENH}	EN rising threshold	-	1.5			V
V_{ENL}	EN falling threshold	-			0.4	V
I_{EN_LK}	EN Leakage Current			0.01	1.0	uA
V_{PG_TH}	Power Good Threshold	PG low，FB falling SL7136P/36D2		90		%
		PG high，FB rising SL7136P/36D2		90		%
I_{PG_SINK}	Power Good Sink Current	SL7136P/36D2			2	mA
F_{OSC}	Oscillator Frequency	I_{OUT}=1.5A		1.0		MHz
		V_{OUT}=0V		400		kHz

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
t_{ON_MIN}	Min ON Time			60		ns
D_{MAX}	Max Duty Cycle		100			%
T_{SS}	Soft Start Time			500		us
T_{SD}	Thermal Shutdown Temperature			165		℃
T_{HYS}	Thermal Shutdown Hysteresis			25		℃

Block Diagram

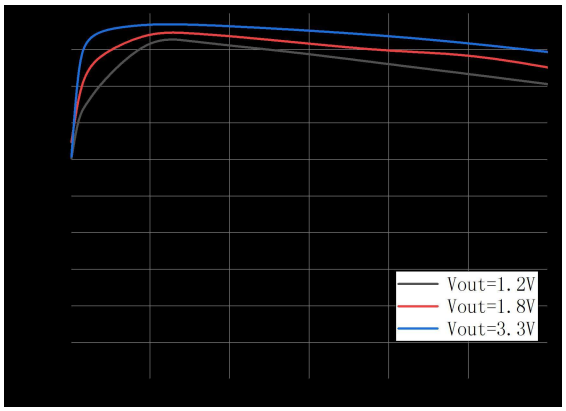


Power Good feature is only available in SL7136P/36D2。

Typical Performance Characteristics

Efficiency vs. Output Current

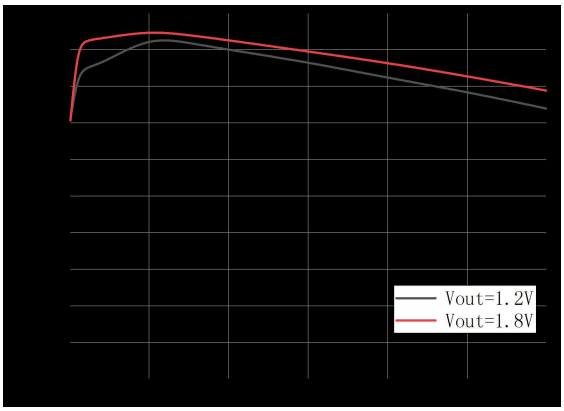
(V_{IN}=5V, C_{IN}=C_{OUT}=22uF, L=2.2uH)



Output Current(A)

Efficiency vs. Output Current

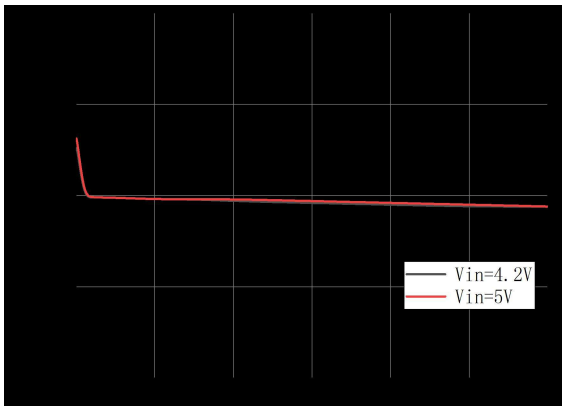
(V_{IN}=3.3V, C_{IN}=C_{OUT}=22uF, L=2.2uH)



Output Current(A)

Output Voltage vs. Output Current

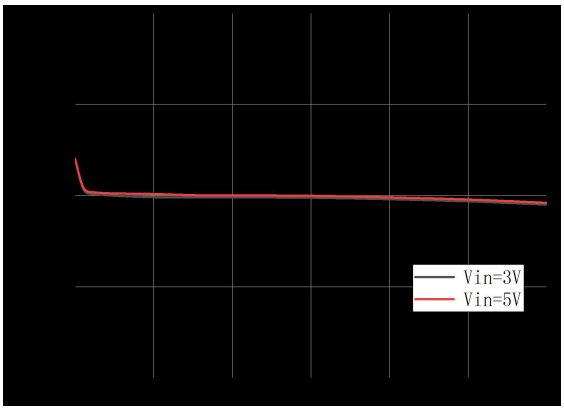
(VOUT=3.3V, C_{IN}=C_{OUT}=22uF, L=2.2uH)



Output Current(A)

Output Voltage vs. Output Current

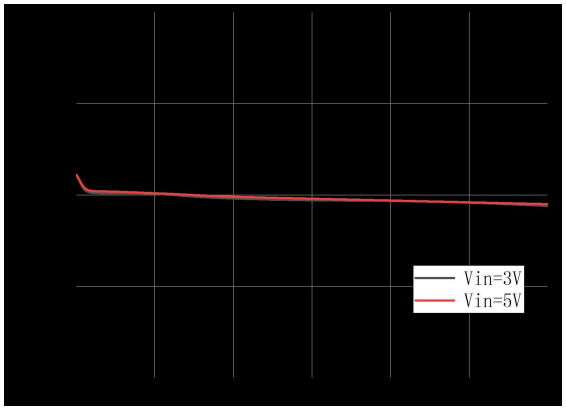
(VOUT=1.8V, C_{IN}=C_{OUT}=22uF, L=2.2uH)



Output Current(A)

Output Voltage vs. Output Current

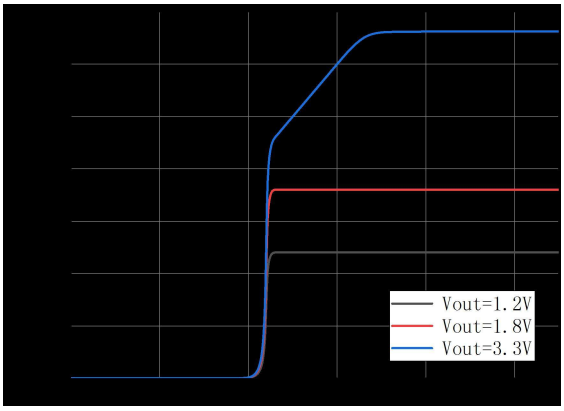
(VOUT=1.2V, C_{IN}=C_{OUT}=22uF, L=2.2uH)



Output Current(A)

Input Voltage vs. Output Voltage

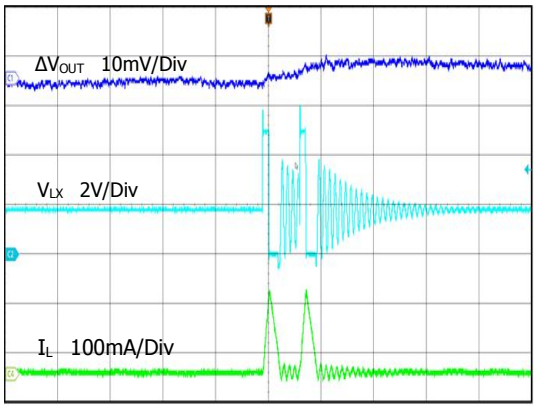
(C_{IN}=C_{OUT}=22uF, L=2.2uH,I_{OUT}=0A)



Input Voltage(V)

Output Ripple

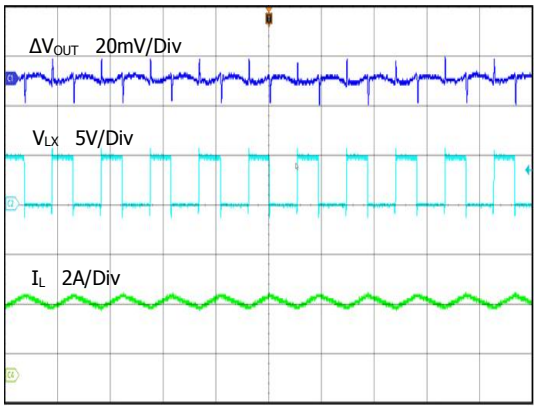
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A)



Time(1us/Div)

Output Ripple

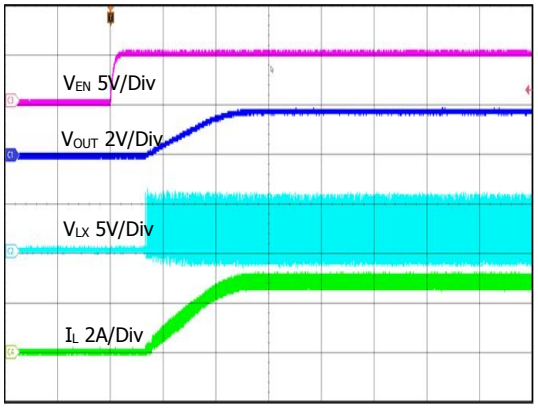
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A)



Time(1us/Div)

Startup from Enable

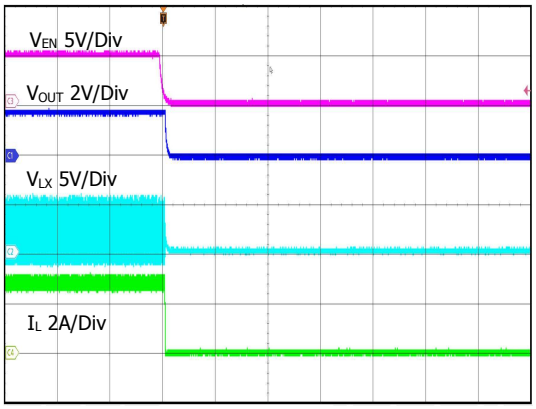
(V_{IN}=5V, V_{OUT}=1.8V, R_L=0.6Ω)



Time(400us/Div)

Shutdown from Enable

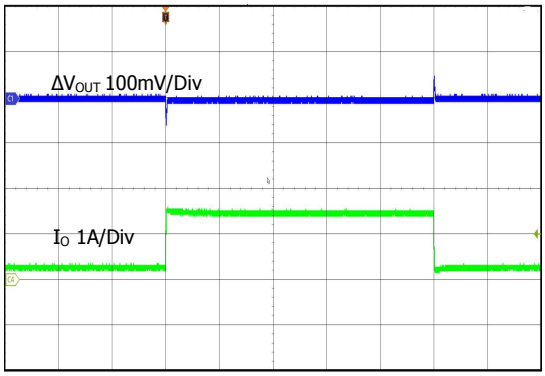
(V_{IN}=5V, V_{OUT}=1.8V, R_L=0.6Ω)



Time(400us/Div)

Load Transient

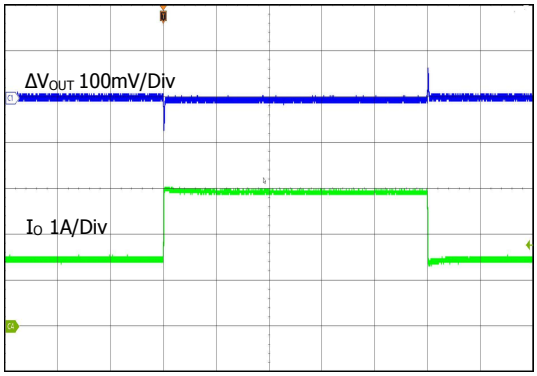
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0.3A to 1.5A,C_{ff}=100pF)



Time(1ms/Div)

Load Transient

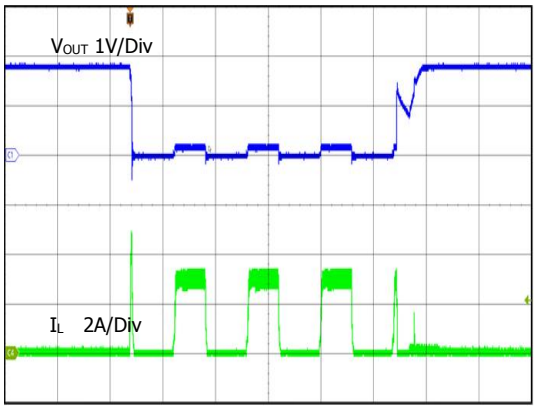
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=1.5A to 3A,C_{ff}=100pF)



Time(1ms/Div)

Short Circuit Protection

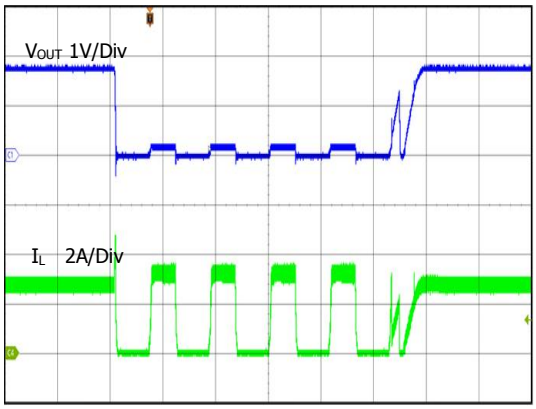
(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=0A to short to 0A)



Time(2ms/Div)

Short Circuit Protection

(V_{IN}=5V, V_{OUT}=1.8V, I_{OUT}=3A to short to 3A)



Time(2ms/Div)

Functional Description

1. Input Protection

The chip has an under-voltage lockout function, which ensures that the chip will not start until the battery voltage reach the specified voltage, and a hysteresis function is set for UVLO to ensure that noise on the power supply does not cause system failure. When the input voltage is less than 2.5V, the chip stops working and is in a protection state. The under-voltage lockout circuit of the chip has a simple structure, low power consumption, and only a very small static power consumption, which does not affect the efficiency of the power supply, hardly increases the burden on the chip cooling system and affects the stability of the system, and enables the system to be able to work properly.

2. Soft Start

During the power-up of the chip, the output voltage rises from zero to the maximum value. Due to the effect of negative feedback, the duty cycle of the PWM control signal of the power tube changes from the maximum value and gradually decreases until the circuit is stable. Due to the existence of output filter capacitors in the circuit, it is easy to generate inrush current when charging the capacitors. At this time, a large current will flow through the power tube, which is easy to burn the circuit system. Therefore, there is a voltage soft start in the chip, and the output voltage gradually increases from 0V to the rated output voltage during power-on, reducing the inrush current received by the load.

3. Power Good (only for SL7136P/36D2)

PG pin is an open-drain output and requires a pullup resistor. PG is actively held low in soft-start and shutdown. It is released when the output voltage rises above 90% of nominal regulation point.

4. FB Adjustment

FB is feed-back, the output voltage is divided by the resistor and then connected to this pin. The feedback voltage will be connected to the internal comparator of the chip and compared with the internal reference voltage(0.6V). The result of the comparison will control the change of the duty cycle, so as to achieve the purpose of stabilizing the voltage.

5. PWM/PFM Working Mode

The PWM/PFM hybrid control method is to stabilize the output voltage by changing the width and pulse frequency of the square wave. At full load, PWM is used, which has relatively high efficiency and a wide range of duty cycles. The PFM work mode is used at light load, which has higher efficiency than PWM.

Application Information

1. Setting the Output Voltage

The output voltage is set by an external resistor divider according to Equation:

$$V_{OUT} = V_{FB} \times \left(1 + \frac{R_H}{R_L}\right) = 0.6V \times \left(1 + \frac{R_H}{R_L}\right)$$

There is no strict requirement for the feedback resistor. An R_H value greater than 10kΩ is reasonable for most applications. R_L must not be higher than 100 kΩ to achieve high efficiency at light load while providing acceptable noise sensitivity.

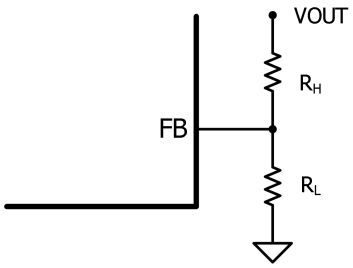


Figure 1 Feedback Network

2. Selecting the Inductor

Most applications work best with a 1 - 2.2μH inductor. Select an inductor with a DC resistance less than 50mΩ to optimize efficiency. a high-frequency, switch-mode power supply with a magnetic device produces a strong electronic magnetic inference in the system. Any shield inductor, are ideal for applications as they can decrease the influence effectively.

For most designs, estimate the inductance value with Equation:

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

Where ΔI_L is the inductor ripple current.

Choose an inductor current that is approximately 30% of the maximum load current. The maximum inductor peak current can be calculated with Equation:

$$I_{PEAK} = I_{LOAD} + \frac{\Delta I_L}{2}$$

3. Selecting the Input Capacitor

A typical X5R or better grade ceramic capacitor with 6.3V rating and no less than 22μF capacitance is recommended. To minimize the potential noise problem, we place this ceramic capacitor really close to the IN and GND pins. Care should be taken to minimize the loop area formed by C_{IN}, and IN/GND pins.

When using ceramic capacitors, ensure that they have enough capacitance to provide a sufficient charge to prevent an excessive voltage ripple at the input. The input voltage ripple caused by the capacitance can be estimated with Equation:

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

4. Selecting the Output Capacitor

The output capacitor is selected to handle the output ripple noise requirements. Both steady state ripple and transient requirements must be taken into consideration when selecting this capacitor. Estimate the output voltage ripple with Equation:

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

Where L is the inductor value, and R_{ESR} is the equivalent series resistance (ESR) value of the output capacitor.

For the best performance, it is recommended to use X5R or better grade ceramic capacitor with 6.3V rating and no less than 22μF capacitance.

5. PCB Layout Guidelines

Efficient layout of the switching power supplies is critical for stable operation. For best results, follow the guidelines below.

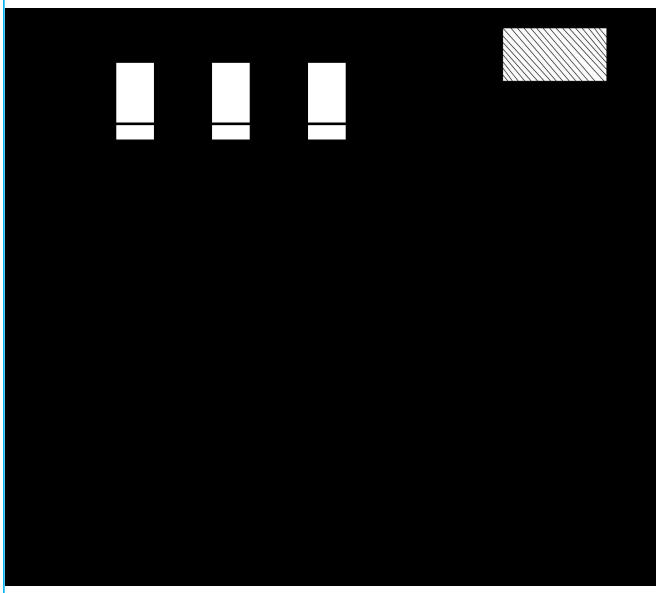
1. Place the high-current paths (GND, IN, and LX) very close to the device with short, direct, and wide traces.
2. Place the input capacitor as close to IN and GND as possible.
3. Place the external feedback resistors next to FB.
4. Keep the switching node LX short and away from the feedback network.
5. Keep the VOUT sense line as short as possible or away from the power inductor, especially the surrounding inductor.

Package Information

SOT23-5

Symbol	Dimensions In Millimeters		
	Min	NOM	Max
A	1.050	1.150	1.250
A1	0.000	0.060	0.150
A2	1.000	1.100	1.200
A3	0.550	0.650	0.750
D	2.820	2.920	3.020
E1	1.510	1.610	1.710
E	2.600	2.800	3.000
b	0.300	0.400	0.500
e	0.950BSC		
θ	0°	4°	8°
L	0.270	0.420	0.570
c	0.100	0.152	0.200

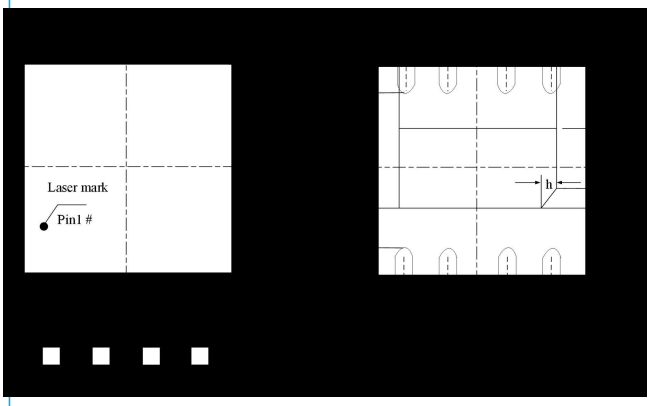
SOT23-6



Symbol	Dimensions In Millimeters		
	Min	NOM	Max
A	-	-	1.25
A1	0.04	-	0.10
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
D	2.82	2.92	3.02
E	2.60	2.80	3.00
E1	1.50	1.60	1.70
b	0.33	-	0.41
b1	0.32	0.35	0.38
e	0.95BSC		
e1	1.90BSC		
θ	0°	-	8°
L	0.30	-	0.60
c	0.15	-	0.19
c1	0.14	0.15	0.16

Package Information

DFN8-L 2*2



Symbol	Dimensions In Millimeters		
	Min	Nom	Max
A	0.80	0.85	0.90
	0.70	0.75	0.80
A1	0.00	0.02	0.05
b	0.20	0.250	0.30
c	0.203REF		
D	1.95	2.00	2.05
D2	1.55	1.60	1.65
Nd	1.50BSC		
e	0.50BSC		
E	1.95	2.00	2.05
E2	0.75	0.80	0.85
L	0.25	0.30	0.35
K	0.25	0.30	0.35
h	0.20REF		