Switching·Power·Controller IC

1. Feature

Built-in 800 V high voltage power switch
Built-in AC line over power compensation
Built-in fast start high voltage current source
Built-in energy efficiency processing standby power is less than 0.10 W
Built-in overvoltage, under-voltage and short circuit protection
Built-in overload and over temperature protection
Accurate temperature compensation, precise cycle-by-cycle current control
Low starting current and low operating current
Small interference by adaptive frequency swing design
High conversion efficiency to meet ENERGY STAR requirements
Rated output power up to 6 W at full voltage
Highly isolated SOP6 package with few external components is available

2. Applications

Power Adapter
Battery Charger
Portable Device Charging Power Supply
Household Appliance Controller Power Supply

3. Description

The LN5R04DA is a high performance, current mode PWM controller. Built-in high voltage power switch provides a continuous output power up to 5 W over a wide voltage range of 85~265 V. The control chip produced by the cost-effective bipolar manufacturing process, combined with the integrated packaging of the high-voltage power tube, saves the overall cost of product to the maximum. The power controller operates in a typical flyback circuit topology to form a compact AC/DC power converter. The high-voltage starting current source inside the IC can start the system only by the weak current trigger of the starting resistor, which greatly reduces the power of the starting resistor. When the output power is small, the IC will automatically reduce the operating frequency, thus achieving very low standby power. The patented drive circuit keeps the switch tube in critical saturation state, which improves the system's working efficiency, making it easy for the system to meet the ENERGY STAR certification requirements for standby power and efficiency. When the VCC pin Voltage reaches 10 V, the overvoltage protection will be started inside the chip. Limiting the output voltage rise can prevent the output voltage from being too high due to damage of the optocoupler or feedback circuit. The IC also provides a perfect overload and short circuit protection function, which can quickly protect the abnormal conditions such as output overload and output short circuit, and improves reliability of the power supply. The IC also integrates an over temperature protection function to reduce the operating frequency or turn off the output when the chip is overheated.

Built-in line voltage compensation allows the system to maintain a consistent maximum input power limits over the full voltage range.

A standard SOP6 green package that meets RoHs requirements is available.

4. Functional Block Diagram

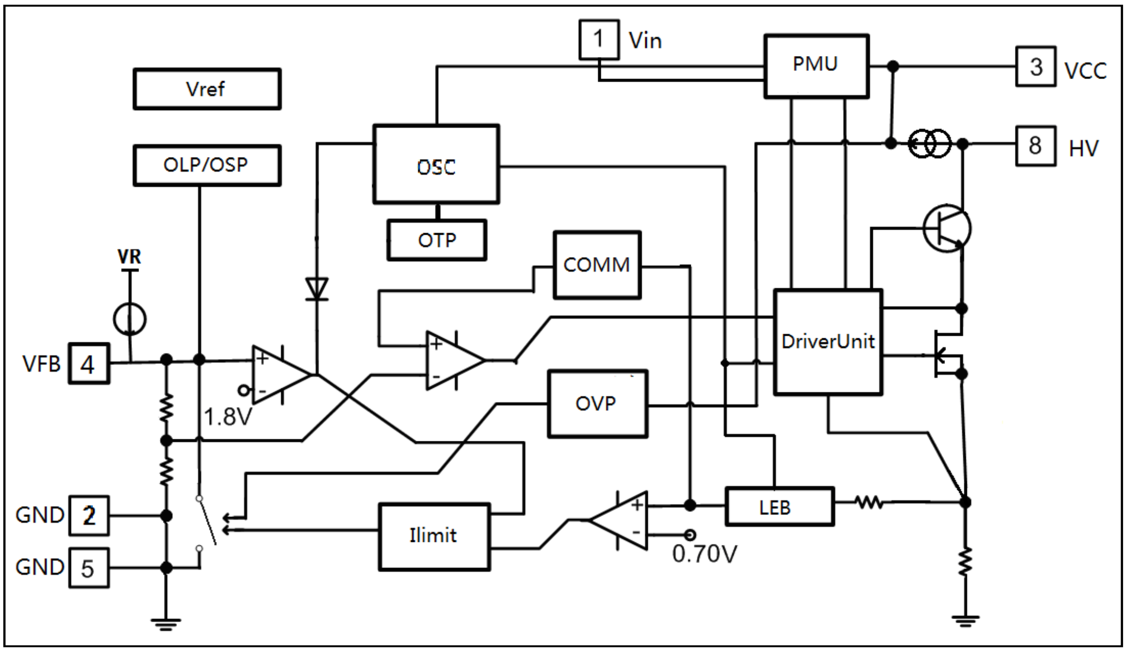

Fig1. Internal functional block diagram

5. Pin Definitions

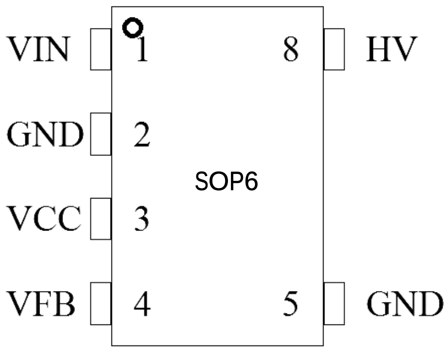

Fig2. Pin Definitions

6. Pin Function Description

PIN	Symbol	Function
1	VIN	High-voltage current source trigger input, external resistor to high-voltage DC terminal
2	NC	Unused, can be connected to VCC or connected to GND
3	VCC	Power supply pin
4	VFB	Feedback signal input pin
5	GND	Ground pin
6,7	NC	These two pins do not exist (PIN 6 metal part is connected to PIN 5, PIN 7 metal part is connected to PIN 8)
8	HV	High voltage switch output pin, connected to the transformer primary winding

7. Typical Simplified Schematic

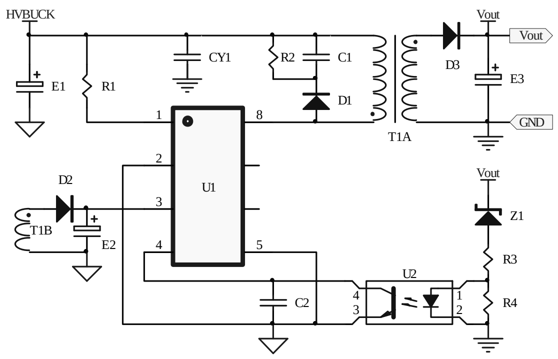

Fig3. Typical Simplified Schematic

8. Absolute Maximum Ratings

Parameter		Rating	Units
VCC pin Voltage		18	V
Other Pin Voltage		$VCC^{+0.3}$	V
HV Pin Voltage		-0.3 to +750	V
Peak Switch Current		1000*	mA
PD		1200	mW
Min/Max Operating Junction Temperature T_J		-20 to +150	℃
Min/Max Operating Ambient Temperature Ta		-20 to +105	℃
Min/Max Storage Temperature Tstg		-55 to +150	℃
Recommended Soldering Conditions		+260 ℃,10 S	
ESD	HBM	2500	V
	MM	250	V

Note*:Test with a 10 us pulse width period of 1 s signal.

9. Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Units
VCC	VCC Voltage	5	-	9	V
V_{IN}	Other Pin Voltage (Except HV)	-0.3	-	VCC	V
V_{PEAK_REV}	Peak Reverse Voltage (HV PIN)	-	-	600	V
TA	Operating Ambient Temperature	-20	-	85	℃

10. Electrical Characteristics(Ta = 25℃, VCC=7.5V, if not otherwise noted)

Power Switch Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
B_{HV}	HV Breakdown voltage	V_{CC}=0 V, I_{HV}=1 mA	750	800		V
V_{HVON}	Turn-on Saturation Voltage	I_{HV}=250 mA			3.0	V
Tr_{HV}	HV Rise Time	CL=1 nF	-	-	75	nS
Tf_{HV}	HV Fall Time	CL=1 nF	-	-	75	nS
$T_{offdelay}$	HV Turn-off Delay	Lp=3.0 mH	-	500	-	nS
I_{CHG}	High Voltage Starting Current Source	R_{VIN}=2.2 MΩ		0.5	-	mA

OSC Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
F_{OSC}	Switching Frequency		-	65	-	kHz
ΔF_{OSC}_V	F_{OSC} VS VCC	VCC=5-9 V	-	-	1	%
ΔF_{OSC}_T	F_{OSC} VS Ta	Ta=0 ℃ to 85 ℃		-	1	%
F_{OSC_Back}	Frequency Turn Back Range		-	2	-	%

PWM Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
D_{MIN}	Min. Turn-on Duty	VFB=0 V	-	1.5	-	%
D_{MAX}	Max. Turn-on Duty	VFB>4.5 V	55	60	65	%

Current Limit Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
I_{LIMIT}	Limit Current		0.28	0.32	0.36	A
G_{VCC}	Current Rejection Ratio			60	70	dB
T_{ILD}	Transmission Delay			150	250	nS
T_{LEB}	Leading Edge Blanking Time		-	500	-	nS

VFB Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
I_{FB}	Pull-up Current		-	0.45	-	A
R_{FB}	Pull-down Resistor		-	30	-	kΩ
G_{VCC}	Power Rejection Ratio	VCC=5-9 V	-	60	70	dB

VCC Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
I_{QS}	Startup Current		-	15	50	uA
I_Q	Operating Current	VCC=7.5 V, SW=OFF	-	2.8	-	mA
V_{ST}	Starting Voltage		-	9.5	-	V
V_{STOP}	Under-voltage		-	4.4	-	V
V_{RST}	Restart Voltage		-	2.0	-	V
V_{SZ}	VCC Over-voltage		9.5	10	10.5	V

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12. Application and Implementation

The LN5R04DA is a highly integrated PWM controller IC that is built-in high voltage power switch provides a continuous output power up to 5 W over a wide voltage range of 85~265 V. The patented drive circuit keeps the switch tube in critical saturation state, which improves the system's working efficiency, making it easy for the system to meet the ENERGY STAR certification requirements for standby power and efficiency.

12.1 Start-up Section

During system startup, the chip only needs to input a very small trigger current from the VIN pin to turn on the internal high-voltage current source circuit to achieve fast system charging start. Therefore, only a very small VIN resistor is needed to meet the circuit startup requirements, which greatly reduces the power of the resistor itself and further reduces the standby power of the whole machine.

A resistance of 2.2-6.8 MΩ can be used as a VIN resistor in general applications.

Since the VIN resistor is subjected to the input DC high voltage for a long time, the application should ensure that the voltage withstand capability of the resistor meets the requirements. It is recommended to use two resistors in series, for example, two types of 1206 resistors are connected in series.

12.2 VCC Over-voltage and Under-voltage Protection

The IC has under-voltage protection with hysteresis. The IC begins to start when the startup current charges the VCC voltage to 9.5 V. The initial startup current is provided by the internal high voltage current source. The energy required to supply the VCC voltage by the auxiliary winding during power supply flyback begins after the IC is started. When the IC is working normally, keep the VCC voltage between 5-9 V (including the case of full load output). If the VCC voltage drops to 4.4 V, the oscillator will be turned off until the VCC voltage drops to 2.0 V and the circuit begins to restart.

The internal VCC of the IC has an upper voltage comparator control. If the VCC tries to be greater than 10 V, the comparator will operate and the FB will be pulled down, locking VCC to 10 V, and reaching the overvoltage limit function. This function can easily realize the simple front-end voltage feedback function, and also avoid a large increase in the output voltage when the output is opened, and ensuring the load is safe. Because of this characteristic, the design of VCC should be kept in an appropriate range to avoid excessive rise of VCC at high output load and the drop of output voltage caused by IC overvoltage limiting action.

During the switch-on period, a certain current is required to maintain the switch on. Therefore, it should be ensured that the VCC capacitor has sufficient energy during the on-time. The VCC voltage should not drop to the under-voltage protection point. Generally, the VCC capacitor should be no less than 22 uF, and it is not appropriate to connect resistor in series with the VCC rectifier diode.

12.3 FB Feedback and Control

In normal operation, the voltage of FB pin will determine the value of the maximum switching current. The higher the voltage, the higher the switching current (only limited by the peak current) will be. The FB pin is internally connected to the 450 uA current source, and the pull-down resistor is about 30 kΩ (approximate equivalent value). The external resistor can be connected to the ground to reduce the feedback depth. Select the external resistor should not to affect the maximum peak current is appropriate. It is recommended to use a resistor with resistance of 7.5 k-10 k. The external resistor can improve the response speed of system to overload and input voltage jump, which is beneficial to short circuit protection. In addition, when the FB voltage is lower than 1.8 V, the oscillation period will increase and the switching frequency will decrease. The more the voltage is lower than 1.8 V, the lower the switching frequency will be. The external FB capacitor will have an effect on the feedback bandwidth, which in turn affect certain external parameters, such as transient characteristic.

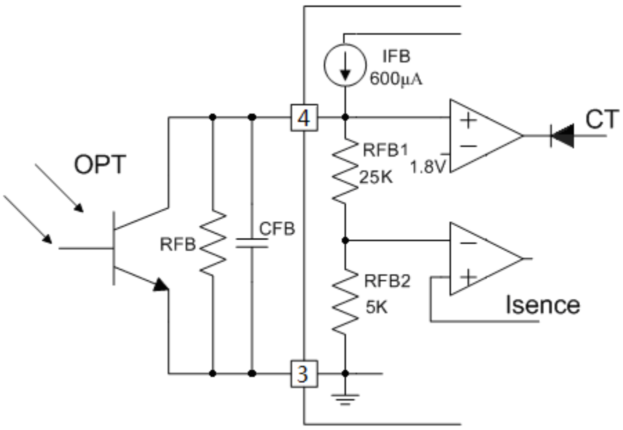


Fig4. Feedback and control part of the circuit diagram

12.4 Maximum Switching Current Limit

The IC has a cycle-by-cycle current limit function. The switching current is detected every switching cycle. When the current set by FB or the upper limit current is reached, it enters the off period. The current detection has the function of immediate leading edge blanking, masking the switching peak and avoiding the false detection of the switching current. Reasonable temperature compensation eliminates the effects of temperature. Compared to conventional MOSFET (Ron varies greatly when temperature changes), the switching chip can switch the current very accurately over a wide range, which will allow the designer to design a solution without having to leave too much margin to meet the larger operating temperature range and improve the safety of the circuit.

The maximum switching current is set by the chip and no external adjustment is required.

12.5 Over Temperature Protection

Accurate over-temperature protection is integrated inside the IC. When the internal temperature of the chip reaches 140 °C, the thermal protection circuit operates and internally pulls down the FB voltage. Decrease the peak value of the switching current while reducing the switching frequency and decrease with increasing temperature until the oscillator is turned off.

12.6 Heat Dissipation Requirements

Although the circuit has high conversion efficiency, the chip still consumes a certain amount of power inside. For a typical power switch, the necessary heat dissipation measures should be used to avoid excessive temperature and thermal protection or performance degradation. The main heat inside the IC is the heat generated by the switching loss of the switch tube.

Therefore, the proper heat dissipation position is passed through the Pin 8 pin of the IC. An easy-to-use method is to lay a certain area of PCB copper on the Pin 8. If necessary, tinning the copper foil will greatly increase the heat dissipation capability. For a typical application of 85-265 V input, 5 W output, a copper foil area of 80 mm^2 or more is necessary.

13. Layout Guidelines

13.1 Principles of high-frequency layout

When switching power supply layout should follow the principle of high-frequency layout, where possible, the current loop should be kept to a minimum. It should be advanced and then out of the dual-capacitor and appropriate to maintain a single point of connection capacitance. Three typical current loops are shown in the following figure:

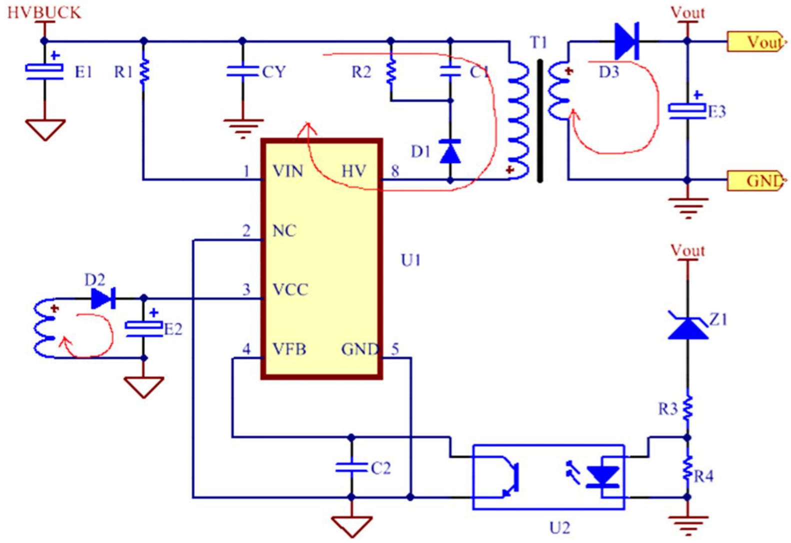


Fig5. Typical current loop diagram

13.2 Typical layout reference

An example of a typical PCB layout is shown below.

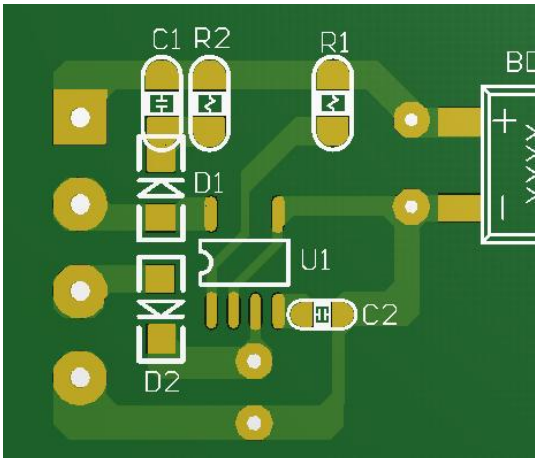


Fig6. Typical layout reference (bottom view)

14. Typical Application Circuit Schematic（input：90~265 Vac）

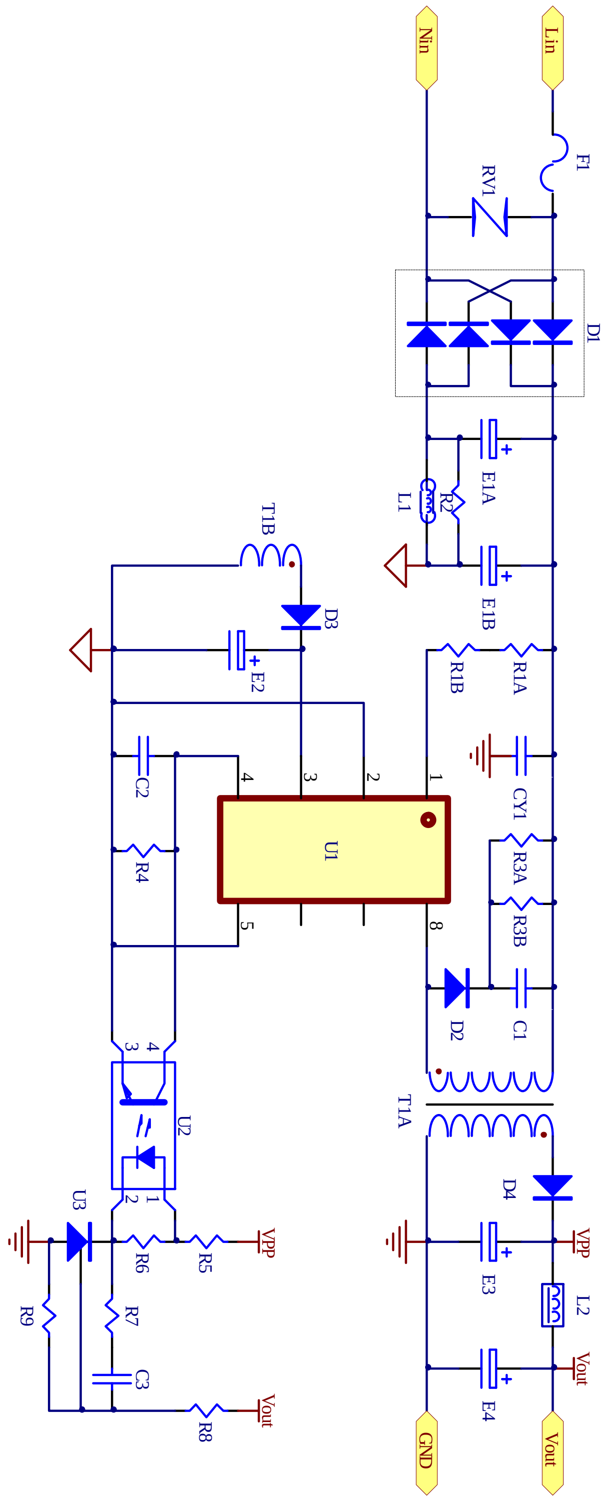
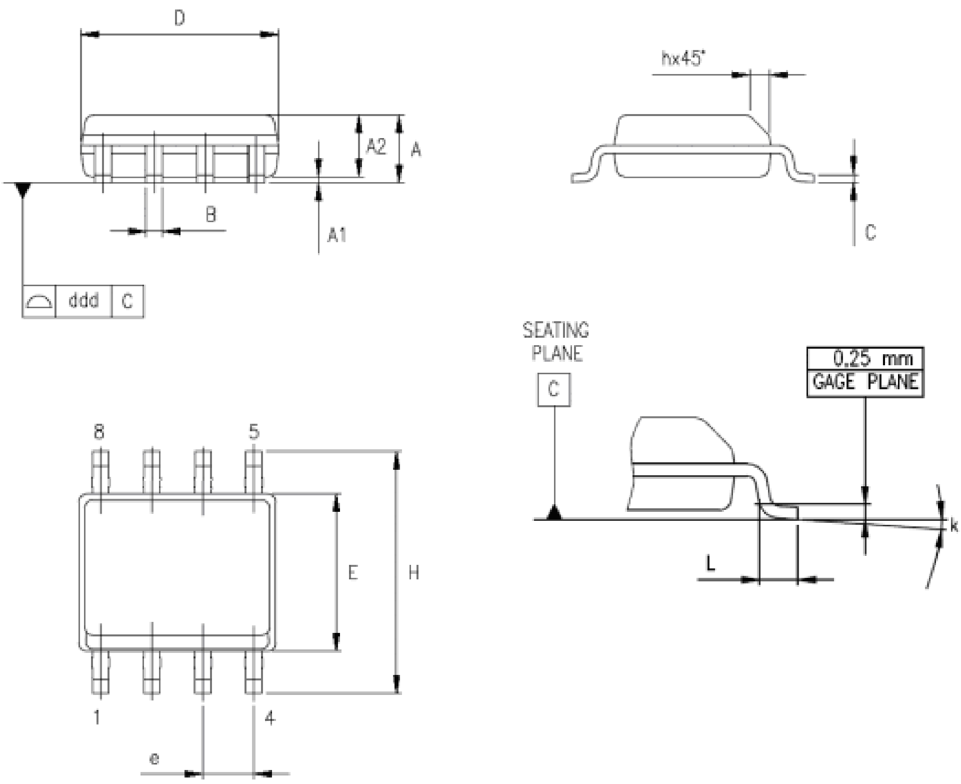


Fig7. Typical Application Circuit Schematic

15. Mechanical and Packaging

SOP6



Dimensions			
Ref.	Databook (mm.		
	Nom.	Min.	Max.
A	1.35		1.75
A1	0.10		0.25
A2	1.10		1.65
B	0.33		0.51
C	0.19		0.25
D	4.80		5.00
E	3.80		4.00
e		1.27	
H	5.80		6.20
h	0.25		0.50
L	0.40		1.27
k	8° (max.)		
ddd			0.1

Fig8. Mechanical Dimensional Drawings (mm)

16. Orderable Information

Part No.	RoHs	package	Quantity per Tube
LN5R04DA	Pb Free	SOP6	100 PCS/TUBE

17. Important Notice

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