

High performance PWM Power Switch IC

1. Feature

- Meet DoE VI and CoC V5 energy efficiency requirements
- Built-in 680V BVdss MOSFET power switch
- No load standby power consumption as low as 50 mW
- Built-in oscillator with maximum 65 kHz frequency limit
- Built-in soft start control circuit reduces switch impact
- Built-in second-generation C.T.™ technology optimizes EMI performance
- Extended mode light load control for optimized efficiency and light load power
- Full range of no audio noise working methods
- Integrated synchronous current ramp compensation
- VDD overvoltage clamp and undervoltage lockout (UVLO)
- Gate drive output voltage smart clamp function
- Built-in input line voltage compensation
- Cycle-by-Cycle Current Limiting with Leading Edge Blanking (OCP)
- Output overcurrent, overload, short circuit protection (OLP)
- Wide voltage output power up to 100W
- Available in a highly isolation PDK8 package and meets the green halogen-free requirements

2. Applications

- Power Adapter
- Battery Charger
- Quick Charger
- Open-frame Power

3. Description

The LN9T27xD is a high performance, highly integrated current mode PWM controller that makes it easy to build low standby power, low cost, high performance solutions to meet CoC V5 and DoE VI energy efficiency in applications. The PWM switching frequency is internally set by the chip and has full temperature compensation. The maximum value is set at 65 kHz. Under no-load or light load conditions, the IC can operate in intelligent interrupt mode to reduce switching losses, so it can be achieved good conversion efficiency while having lower standby power consumption. The low VDD startup current and operating current allow the LN9T27xD to have very high reliability and longevity. A resistor with larger resistance can be used to complete the circuit startup, which also reduces the loss of the startup resistor, further reduces the system standby power. The built-in current ramp compensation greatly optimizes the reliability of the circuit over large PWM duty cycles and avoids subharmonic oscillations that may occur. The built-in leading edge blanking circuit avoids the inductance turn-on current spike interference with current sampling and the effect on the snubber diode reverse recovery current, and the external no longer requires an additional blanking circuit. The LN9T27xD also offers a very comprehensive protection

circuit with auto-recovery, including cycle-by-cycle current limit (OCP), output overload protection (OLP) with high and low voltage compensation, VDD overvoltage protection and undervoltage lockout (UVLO).

Based on the new smartEnergy™ technology from Lii Semi, the system standby power and light load efficiency are greatly improved. The conversion efficiency can meet the CoC and DoE VI energy efficiency requirements in general application, and the no-load power can be as low as 50 mW or less.

By incorporating the unique second-generation C.T.™ patented technology from Lii Semi into the output pulse with specially designed output soft clamp totem pole technology, the EMI characteristics of the system have been greatly improved and can easily meet the electromagnetic compatibility standards of various countries.

Highly isolated standard PDK8 green packages are available.

4. Functional Block Diagram

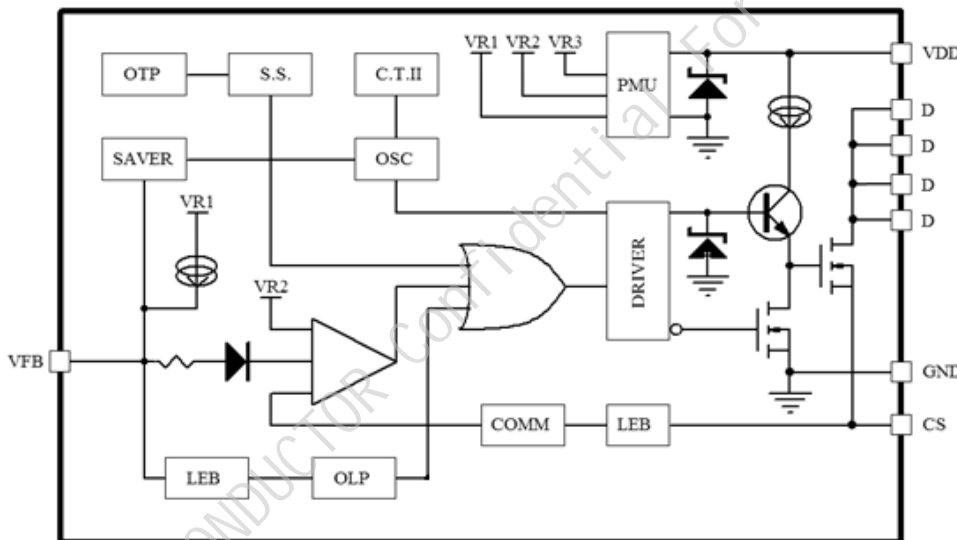


Fig1. Internal functional block diagram

5. Pin Definitions

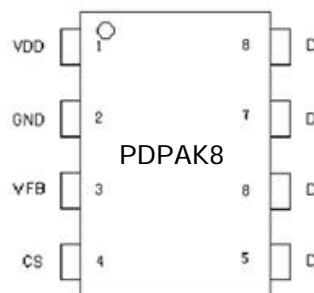


Fig2. Pin Definitions

6. Pin Function Description

PIN	Symbol	Function
1	VDD	Power supply pin, connect the starting resistor and auxiliary power supply circuit
2	GND	Ground pin
3	VFB	Feedback signal input pin, connected to output feedback signal (optocoupler)
4	CS	Switch current sense signal input pin, connected to the current limit resistor
5,6,7,8	D	The high-voltage MOSFET switch's drain pin, which connects the transformer primary winding

7. Typical Simplified Schematic

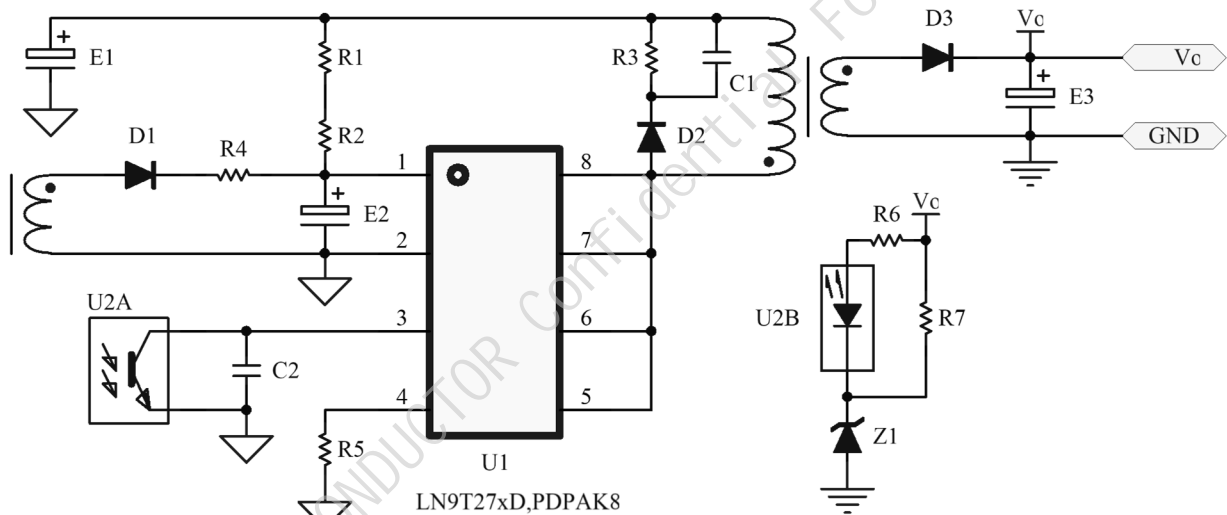


Fig3. Typical Simplified Schematic

8. Absolute Maximum Ratings *

Parameter		Rating	Units
D Pin Voltage		680**	V
D Pin Input Current	LN9T27GD	15***	A
	LN9T27KD	17***	A
	LN9T27PD	19***	A
VDD Pin Voltage		30**	V
Other Pin Voltage		-0.3 to +7	V
PD		1800	mW
Min/Max Operating Junction Temperature T _J		-40 to +150	°C
Min/Max Operating Ambient Temperature T _a		-20 to +125	°C
Min/Max Storage Temperature T _{stg}		-55 to +150	°C
Recommended Soldering Conditions		260°C , 10S	
ESD	HBM	2500	V
	MM	250	V

Note*: Stresses beyond those listed under “absolute maximum ratings” may cause permanent damage to the device. These are stress ratings only, 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. **: With 10 mA limit. ***: Only allow 1 ms pulse and period is 1 s.

9. Recommended Operating Conditions

Symbol	Parameter	Min	Typ	Max	Units	
VDD	VDD Supply Voltage	10		25	V	
V _{ds}	Drain Peak Voltage	-	-	650	V	
I _{ds}	Drain Peak Current	LN9T27GD	-	-	3	A
		LN9T27KD	-	-	4.5	A
		LN9T27PD	-	-	6	A
T _A	Operating Ambient Temperature	-20	-	105	°C	

10. Electrical Characteristics(Ta = 25°C, VDD=15V, if not otherwise noted)

MOSFET Section (Drain Pin)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Units
BV _{DSS}	Drain-Source Voltage	VDD=0 V, I _D =1 mA		680	-	-	V
I _{HV}	D-S Leakage Current	V _D =680 V		-	-	10	uA
R _{DSON}	MOSFET R _{DSON}	I _D =1.5 A, T _J =25 °C	LN9T27GD	-	0.55	-	Ω
		I _D =2.0 A, T _J =25 °C	LN9T27KD	-	0.37	-	Ω
		I _D =2.5 A, T _J =25 °C	LN9T27PD	-	0.25	-	Ω
T _R	Switch Rise Time	CL=1 mH		-	35	-	nS
T _F	Switch Fall Time	CL=1 mH		-	35	-	nS
I _D	Drain Current Pulsed	LN9T27GD	T _J =25 °C	-	15	-	A
			T _J =125 °C	-	3	-	A
		LN9T27KD	T _J =25 °C	-	17	-	A
			T _J =125 °C	-	4.5	-	A
		LN9T27PD	T _J =25 °C	-	19	-	A
			T _J =125 °C	-	6	-	A

VDD Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
I _{OS}	VDD Startup Current	VDD=15 V	-	1	10	uA
I _O	Operating Current	VDD=16 V, VFB=OPEN	-	1.2	-	mA
V _{STOP}	UVLO Threshold Voltage	FB=0	6.5	7	8	V
V _{START}			-	17	-	V
V _{OVP}	VDD OVP Threshold		-	28	-	V
VDD_CL	VDD Clamp Voltage	I _{VDD} =10 mA	-	30	-	V

OSC Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
F _{OSC}	Switching Frequency		60	65	70	kHz
ΔF _{OSC_T}	F _{OSC} VS Ta	VDD=16 V, Ta=-20 °C to 100 °C	-	5	-	%
ΔF _{OSC_V}	F _{OSC} VS VCC	VDD=12-25 V	-	5	-	%
F _{OSC_MIN}	Min. Burst Mode frequency	VDD=16 V	-	22	-	kHz

VFB Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{FB}	VFB Open Loop Voltage	V_{FB} is open		4.6		V
I_{FB_S}	FB Short Circuit Current	FB=0		0.20		mA
V_{TH_MIN}	Zero Duty Cycle Threshold Voltage	VDD=16 V		0.75		V
V_{TH_MAX}	Power Limit Threshold Voltage	VDD=16 V		3.7		V
T_{OLPI}	Power Limit Delay Time	VDD=16 V		85		mS
D_{MAX}	Max. Duty Cycle	VDD=16 V, FB=3.3 V, CS=0		80		%

CS Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
T_{LEB}	L.E.B Time		-	250	-	nS
Z_{CS}	CS Input Resistance		-	40	-	K Ω
T_{OCP}	OCP Delay Time	VDD=16 V, $V_{CS} > V_{TH_OC}$, FB=3.3 V	-	75	-	nS
V_{TH_OCP}	Max. CS Threshold	FB=3.3V	-	0.75	-	V
T_{SS}	Internal Soft Start Delay		-	12	-	mS
V_{TH_OSP}	OSP Threshold Voltage		-	1.45	-	V

CycleturningTMII (C.T.II) Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
ΔF_{OSC}	C.T. Range		-	± 4	-	%
T_{CT}	C.T. Time		-	4	-	mS

OTP Section

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
OTP	OTP		-	145	-	$^{\circ}$ C
OTP _{HYT}	OTP hysteresis		-	30	-	$^{\circ}$ C

Thermal Data

Symbol	Parameter	Rating	Unit
θ_{JA}^1	Thermal Resistance Junction-Ambient	40	°C/W
θ_{JC}^2	Thermal Resistance Junction-Case	2	°C/W

Notes: 1. All leads are soldered on a 250 mm² copper foil with 2 oz thick to measuring. 2. Measured on the surface of the package near pin 5/6/7/8.

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12. Application and Implementation

The LN9T27xD is a highly integrated PWM control IC that is optimized for 100 W off-line applications. Its high-efficiency Burst mode control greatly reduces standby loss, improves conversion efficiency at light loads, and easily meets international energy efficiency standards such as CoC V5 and DoE VI.

12.1 Start-up current and start-up control

The LN9T27xD can operate at very low start-up current conditions, with accurate UVLO control enabling fast and reliable power-up in a short period of time. Allowing a large start-up resistor value can significantly reduce the start-up power consumption, such as 3 M Ω , although a 1/8W power-class resistor can meet the required power requirements, but must still carefully consider its ability to withstand voltage, The use of resistors in series is recommended, for example, using two 1206-type chip resistors in series.

The start-up resistor can be connected between AC input terminal or the positive of input DC high voltage and the VDD storage capacitor.

12.2 Operating current and VDD capacitance

The normal operating current of LN9T27xD is as low as 1.2 mA. The loss of the IC itself is small during operation. An electrolytic capacitor with capacity of not less than 4.7 μ F can meet the sufficient energy required for IC power supply and driving, but consider the larger input capacitance of MOSFET and the wider operating temperature range, a lower internal resistance (ESR) type of the capacitor should be chosen to provide fast and large current when the MOSFET is turned on, speeding up MOSFET turn-on.

12.3 Cycleturning™ II (C.T. II)

The LN9T27xD integrates the optimized second-generation Cycleturning™ proprietary technology from the clock cycle is modulated at the set time in the work process, resulting in a larger switching pulse spectrum to reduce the narrowband energy density, so that the average interference intensity in any single bandwidth is greatly reduced. Therefore, the cost of the system on EMI is also greatly reduced.

12.4 Extended BM operating characteristics

Under no-load or light-load conditions, the ratio of the total loss of MOSFET switching losses will increase significantly, and the switching loss is proportional to the switching frequency. Lowering the switching frequency can significantly reduce the switching losses of the MOSFET. LN9T27xD by detecting the FB voltage and time size, the system no-load or light load will automatically adjust the switching frequency to a lower value, the more FB voltage is lower than the set control voltage, the more the frequency decreases, but the circuit automatically limits the minimum value of the frequency drop above 22 kHz to avoid audible noise.

When the system frequency drops to near 22 kHz, if the FB voltage is still lower than the set threshold voltage, the output will be disabled to ensure that the output voltage will not be too high.

12.5 Current detection and leading edge blanking

The LN9T27xD provides cycle-by-cycle current limiting, and the switching current is sampled into the IC through the current limiting resistor. The built-in leading-edge blanking eliminates current spikes into the IC, avoid the current limit function malfunction, the MOSFET will not be turned off by mistake, so the traditional external blanking circuits will no longer be needed.

The duty cycle of the PWM is determined by the combination of the sampling current and the FB voltage. The typical threshold voltage of the overcurrent comparator when FB is floating is 0.75 V.

12.6 Synchronous slope compensation

The IC integrates a voltage slope that is synchronized with the clock to the compensation circuit of the current sampling signal, which greatly improves the infinite loop stability of the circuit at large duty cycles and CCM, prevents possible subharmonic oscillation problems, and enhances output voltage stability.

12.7 Output power switch

The LN9T27xD integrates a MOSFET power switch BV_{dss} voltage up to 680 V. The power switch has extremely low R_{dsON} internal resistance and extremely high switching speed. It can maintain extremely low switching loss at switching frequency up to 65 kHz. Excellent electrical performance ensures the performance characteristics of the chip and has a very high reliability.

12.8 Protective function

Excellent power systems require sophisticated fault protection to achieve high reliability. The LN9T27xD is designed with a wide range of protection features to meet user requirements including cycle-by-cycle current limiting (OCP), output overload protection (OLP), VDD overvoltage lockout, and under-voltage lockout (UVLO) and Over temperature protect (OTP).

With built-in input voltage compensation technology, the output power is limited to a relatively constant value, which makes the selection of the output rectifier device very easy, and the output diode specifications can be selected more economically to meet a relatively constant output over-current at wide input voltage conditions results in lower system cost.

When the output is overloaded, the FB voltage rises and reaches the set TD_PL value, the circuit will turn off the MOSFET output, and the system will restart when the VDD voltage drops to the UVLO set point. If the fault does not cancel, the circuit will enter the hiccup protection mode.

After normal operation, VDD is powered by the auxiliary winding of the transformer. If the voltage exceeds the limit voltage, it will be clamped. When the voltage is lower than the UVLO setting voltage, the circuit output will be turned off and the system will be restarted.

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:

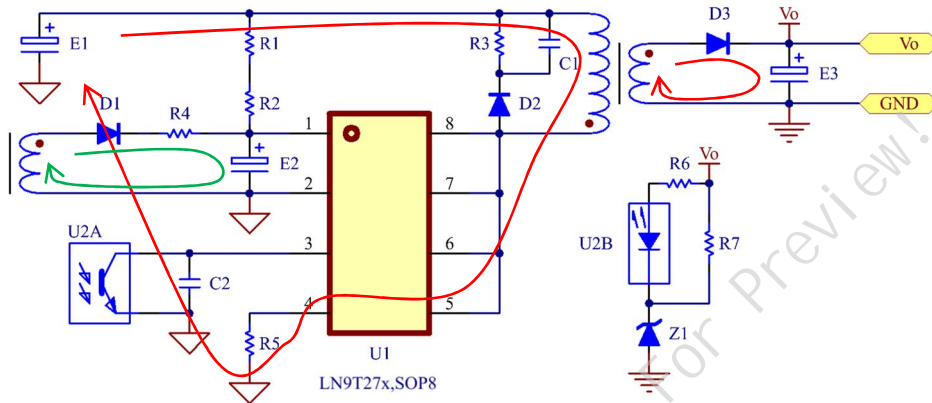


Fig4. Typical current loop diagram

13.2 Typical layout reference

An example of a typical PCB layout is shown below.

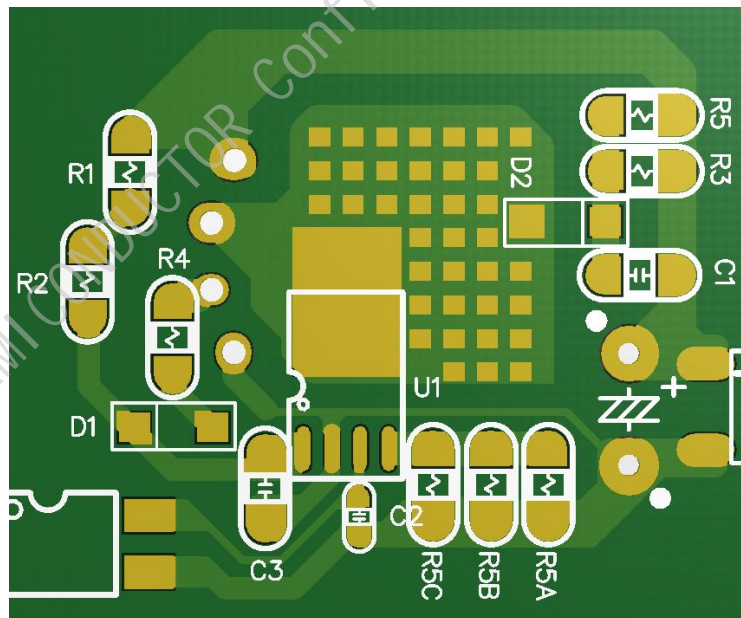


Fig5. Typical layout reference (bottom view)

14. Typical Application Circuit Schematic (input : 90~265 Vac, 45~100W PD Charger)

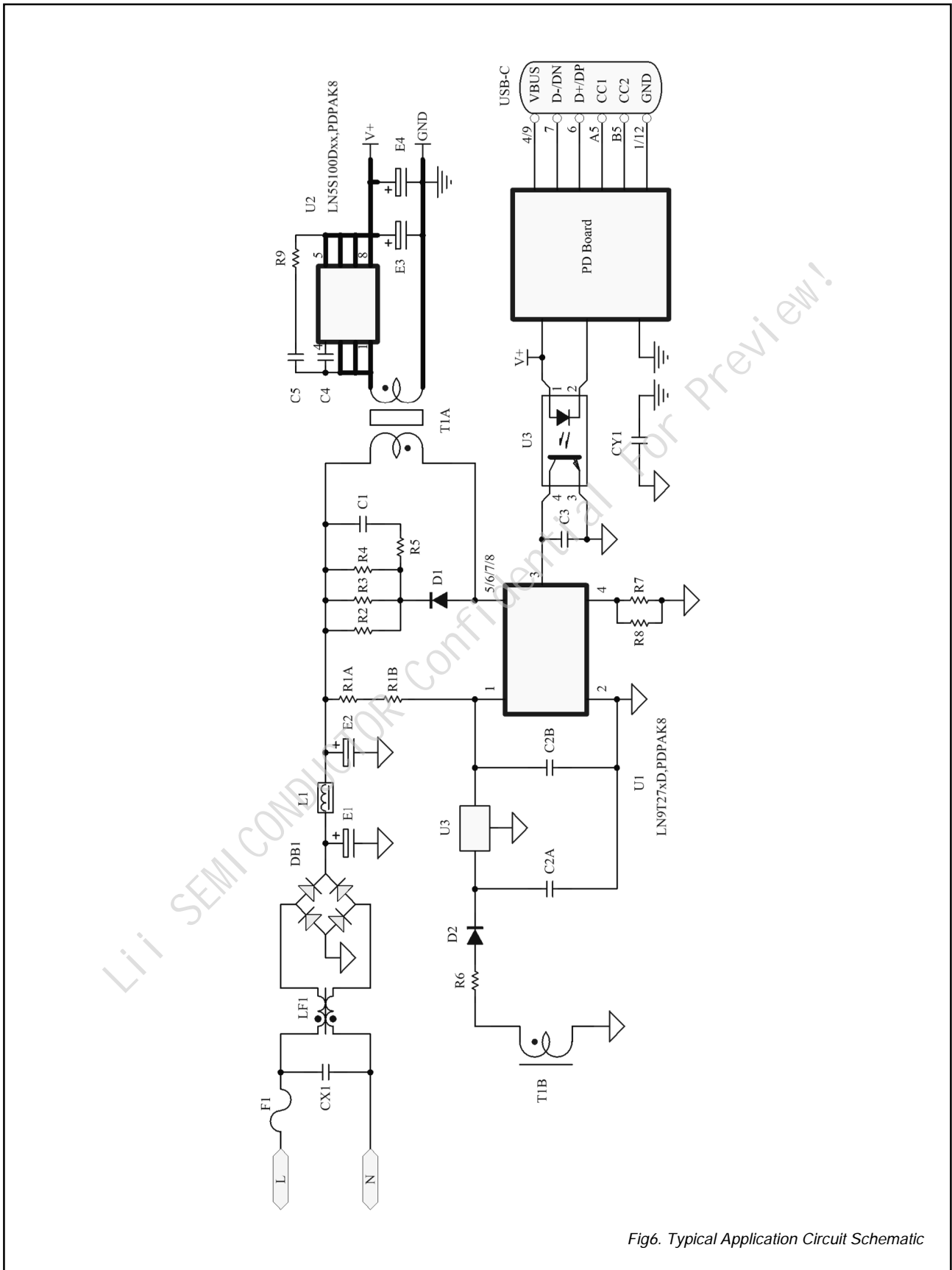
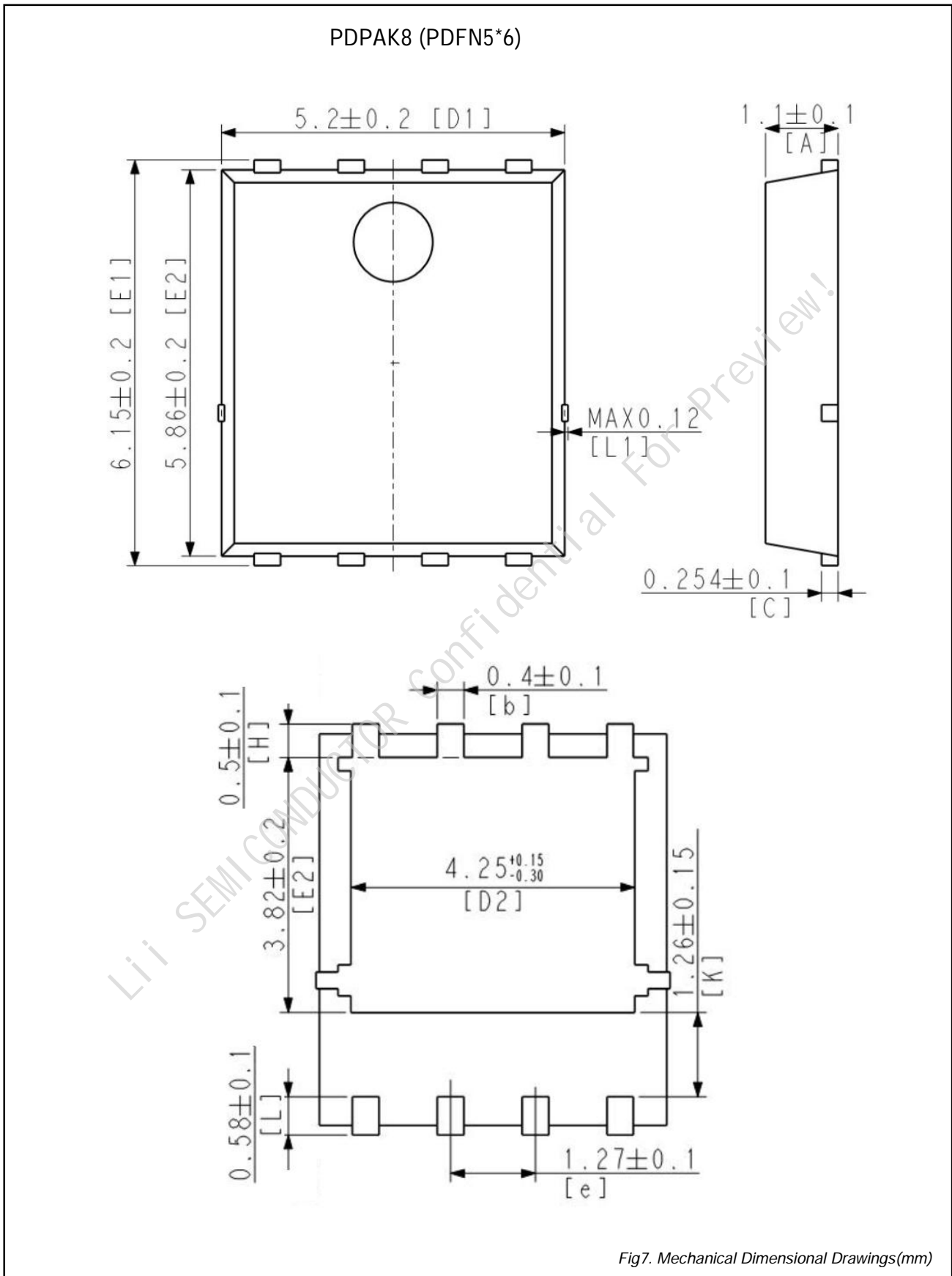


Fig6. Typical Application Circuit Schematic

15. Mechanical and Packaging




16. Orderable Information

Part Number	RdsON	BVDSS	Package	Packing Quantity
LN9T27GD	0.55Ω	680V	PDPAK8	5000PCS/REEL
LN9T27KD	0.37Ω	680V	PDPAK8	5000PCS/REEL
LN9T27PD	0.25Ω	680V	PDPAK8	5000PCS/REEL

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