

Green Mode Power Switch with BNO

REV : 01

General Description

The LD7904JGPN is a green mode PWM chip integrated with a 700V MOSFET in a DIP-6 package. It's operating at fixed frequency of 100KHz. With multi-functions built-in this IC, such as high voltage startup, Burn-in/out /OLP/OVP/OTP protection, internal current mode slope compensation, and green-mode power-saving operation under light load or no load condition, this highly integrated device provides high efficiency, low external component counts, and low cost solution for compact power applications.

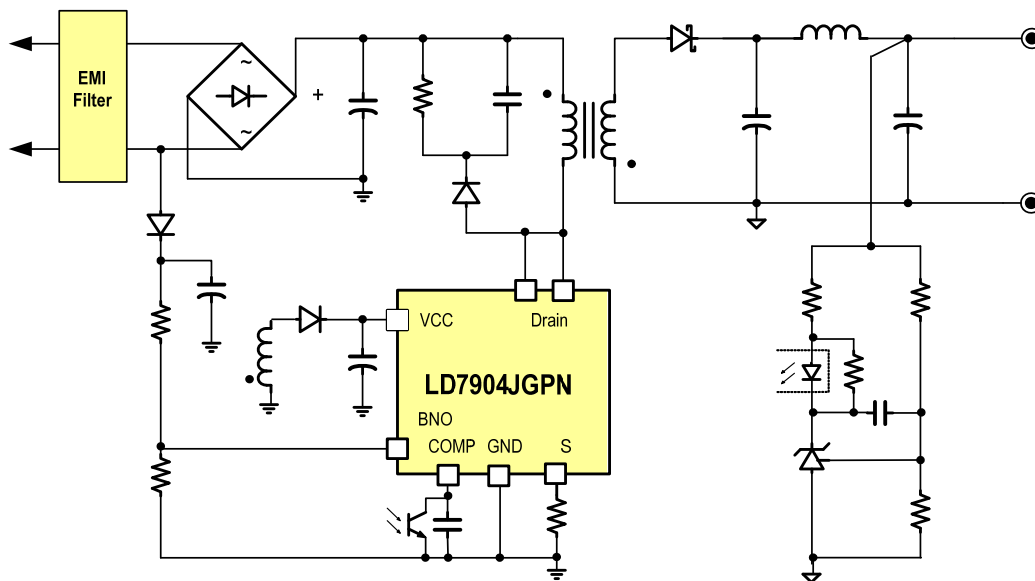
Features

- Built-in 700V Power MOSFET
- Built-in High Voltage startup circuit
- Fixed Switching Frequency at 100KHz
- Frequency Trembling for EMI improve
- Internal High Voltage Startup Circuit
- Under Voltage Lockout (UVLO) on VCC Pin
- Current Mode Control with Slope Compensation
- Green-Mode Control for Power Saving
- OVP / OLP / Internal Thermal Shut Down

Applications

- Switching AC/DC Adaptor
- LCD TV or PC Standby Power
- SMPS for LCD Monitor

Typical Application



Pin Configuration

DIP-6 (TOP VIEW)



YY: Year code (D: 2004, E: 2005)
 WW: Week code
 PP: Production code

Ordering Information

Part number	Package	Top Mark	Shipping
LD7904JGPN	DIP-6 Green Package	LD7904JGPN	3600/ Tube/ Carton

The LD7904JGPN is ROHS compliant.

Protection Mode

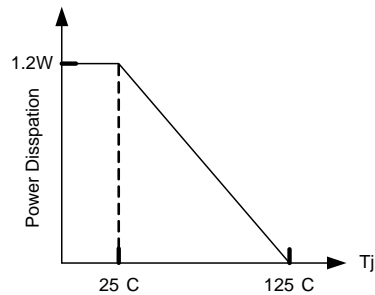
Switching Freq.	VCC OVP	OLP	Internal OTP
100kHz	Auto recovery	Auto recovery	Auto recovery

Pin Descriptions

PIN	NAME	FUNCTION
1	BNO	Brownout Protection Pin. Connect a resistor divider to Input Voltage. If the voltage is less than threshold voltage, the PWM output will be disabled.
2	COMP	Feedback control pin, by connecting a photo-coupler and a capacitor to close the control loop and achieve the stable regulation.
3	GND	Ground of the controller
4	S	Source terminal of internal power MOSFET, connecting a sense resistor to ground.
5,6	Drain	Drain terminal of the internal power MOSFET
8	VCC	Power Supply to Vcc

Recommended Operating Conditions

Product	Drain Current	Rds(on)	230VAC ± 15%		90~264VAC*	
			Adapter	Open Frame	Adapter	Open Frame
LD7904JGPN	4A	2.8Ω	25W	30W	18W	25W



* Typ Vcc=12V & Drain Current =2A at Ta =25°C

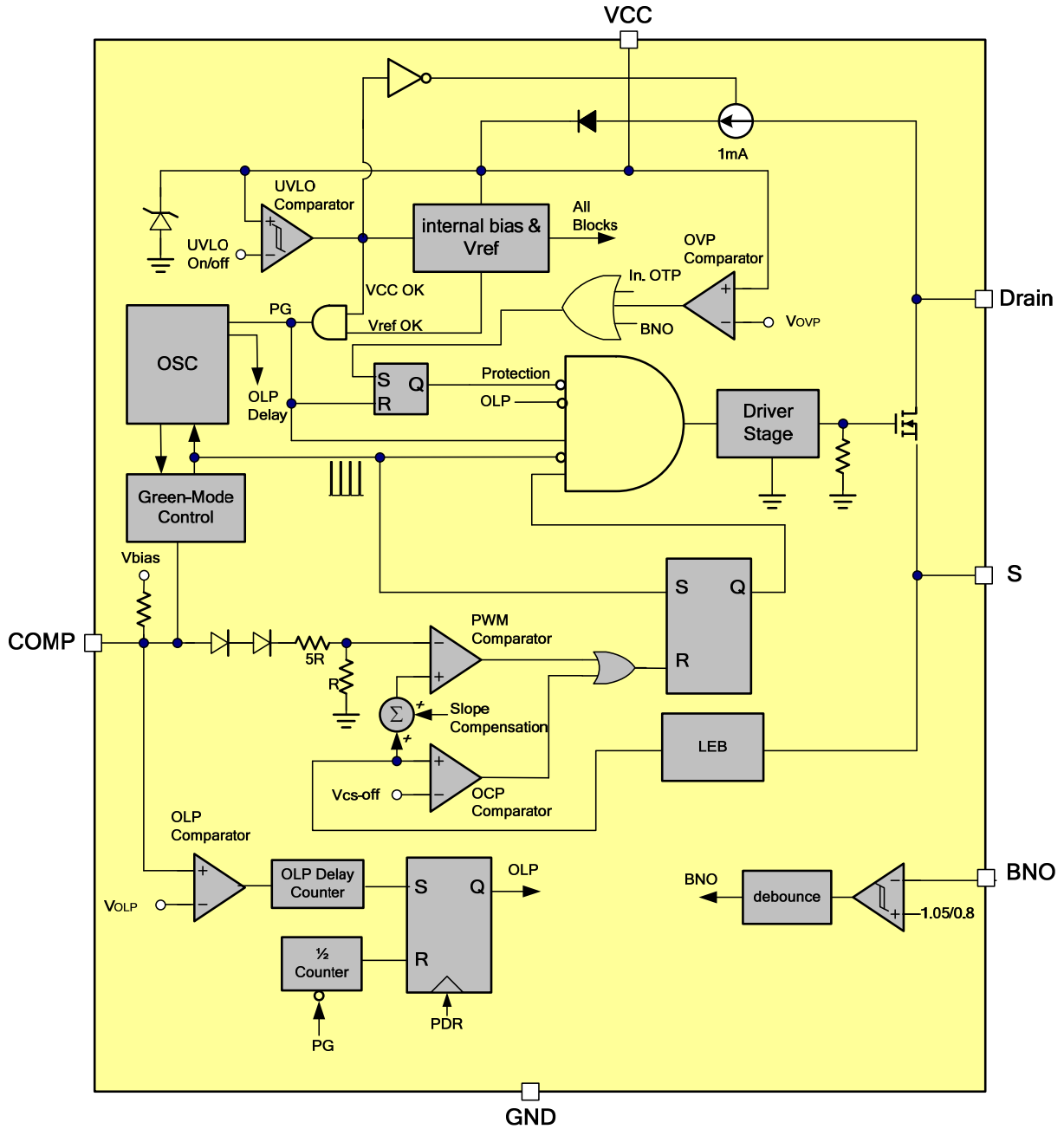
**Calculated maximum Input Power Rating at Ta =25°C

Item	Min.	Max.	Unit
Supply Voltage Vcc	11	25	V
Vcc Capacitor	10	47	μF
COMP Capacitor Value	2.2	100	nF

Note:

1. COMP pin connecting a capacitor is essential to filter out the undesired switching noise for stable operation.
2. The small signal components as closed to IC pin as possible.

Block Diagram



Absolute Maximum Ratings

Supply Voltage VCC.....	-0.3V~30V
COMP.....	-0.3V ~7V
S pin DC Voltage.....	-0.3V ~7V
S pin negative pulse voltage (Duration Time < 100nS)	-1.5V
Drain.....	-0.3V~700V
Peak Pulse drain current.....	4A
Total Maximum Power Dissipation of (25°C).....	1.25W
Package thermal resistance (DIP-6)	
θ_{JA}	80°C/W
θ_{JC}	30°C/W
Operating Junction Temperature Range.....	-40°C to 125°C
Operating Ambient Temperature Range	-40°C to 85°C
Storage Temperature Range.....	-65°C to 150°C
Lead temperature (Soldering, 10sec).....	260°C
ESD Voltage Protection, Human Body Model (Exclusive Drain Pin).....	2.5KV
ESD Voltage Protection, Machine Model (Exclusive Drain Pin).....	250 V

Caution:

Stresses beyond the ratings specified in “Absolute Maximum Ratings” may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

Recommended Operating Conditions

Item	Min.	Max.	Unit
Supply Voltage Vcc	11	25	V
Vcc Capacitor	10	47	μF
COMP Capacitor Value	2.2	100	nF

Note:

1. It's necessary to connect a capacitor with COMP pin to filter out the undesired switching noise for more stable operation.
2. Using smaller signal components close to IC pins is preferable.

Electrical Characteristics

(Ta=25°C, V_{CC}=15.0V, unless otherwise stated,) **Electrical Characteristics for Control Section**

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
High Voltage Supply (Drain Pin)					
High Voltage Current Source	V _{CC} <UVLO(on), HV=500V	0.5	1.0	1.5	mA
Off State Leakage Current	V _{CC} >UVLO(off), HV=500V	-	8	35	μA
Supply Voltage (Vcc Pin)					
Startup Current		200	300	400	μA
Operating Current	V _{COMP} =0V	-	1.1	-	mA
	V _{COMP} =3V	-	3.1	-	mA
	OLP Tripped	-	0.6	-	mA
	OVP Tripped	-	0.6	-	mA
UVLO (off)		8.0	9.0	10.0	V
UVLO (on)		15.0	16.0	17.0	V
OVP on Vcc Pin		25	26	27	V
Voltage Feedback (Comp Pin)					
Short Circuit Current	V _{COMP} =0V	0.2	0.26	0.32	mA
Open Loop Voltage	COMP pin open	5.5	6	-	V
Fixed Frequency Mode		-	2.5	-	V
Green Mode Threshold V _{COMP}		-	2.1	-	V
Zero Duty Trip Level(off)		-	1.6	-	V
Hysteresis		-	100	-	mV
Current Sense Comparator(Cs Pin)					
Maximum Input Voltage V _{cs_off}		0.425	0.45	0.475	V
Leading Edge Blanking Time		-	380	-	ns
Slope compensation	0 to max. duty	-	150	-	mV
Input impedance		1	-	10	MΩ
Delay to Output		-	100	-	ns
Oscillator & Control					
Frequency		94	100	106	kHz
Green Mode Frequency		22	25	28	kHz
Frequency Trembling	fs = 100kHz	-	±6.2	-	kHz

Electrical Characteristics

(Ta=25°C, V_{CC}=15.0V, T_j=25°C, unless otherwise stated,)

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Frequency Temp. Stability	-25~85°C	-	5	-	%
Voltage Stability	V _{CC} =11~25V)	-	-	1	%
Maximum Duty		-	75	-	%
OLP (Over Load Protection)					
OLP Trip Level		4.8	5.0	5.2	V
OLP Delay Time		-	84		ms
Brownout Protection (BNO Pin)					
Brownout Turn-On Trip Level		1.00	1.05	1.10	V
Brownout Turn-Off Trip Level		0.75	0.80	0.85	V
BNO Pin De-bounce Time			250		us
Soft Start					
Soft Start Duration		-	4	-	ms
On Chip OTP					
OTP Level		-	140	-	°C
Hysteresis		-	30	-	°C

Electrical Characteristics for MOSFET

PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
Drain to Source Breakdown Voltage					
Breakdown Voltage BV _{DSS}	V _{CC} =0V, COMP=0V, I _D =250μA	700			V
Drain on Resistance					
Drain to S pin On-Resistance	I _D =2A; V _{CC} =15V; T _j =25°C			2.8	Ω

Typical Performance Characteristics

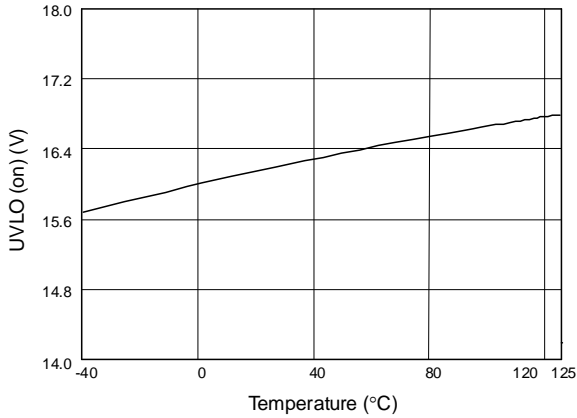


Fig. 1 UVLO (on) vs. Temperature

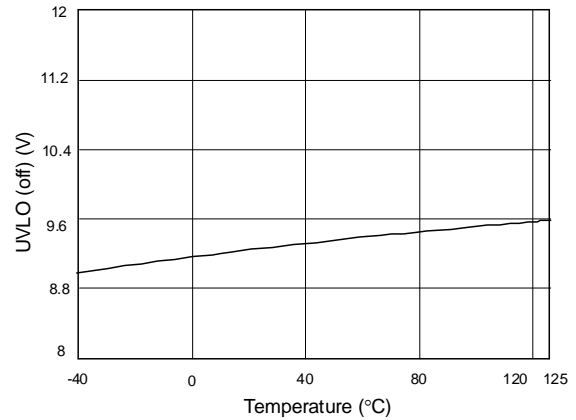


Fig. 2 UVLO (off) vs. Temperature

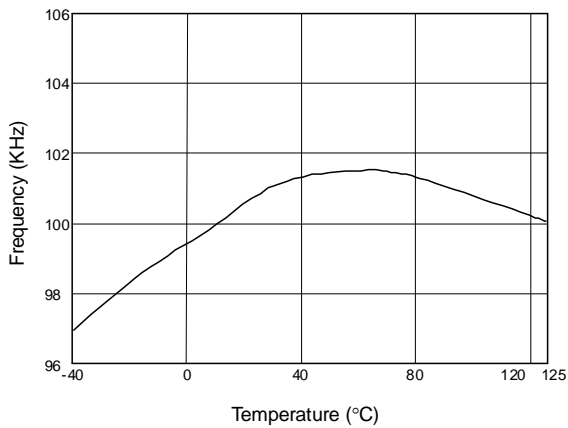


Fig. 3 Frequency vs. Temperature

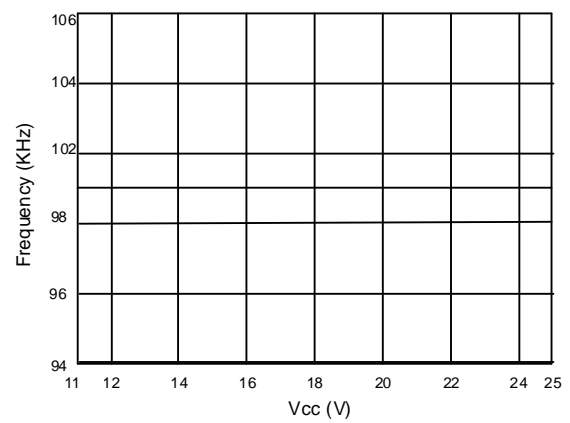


Fig. 4 Frequency vs. Vcc

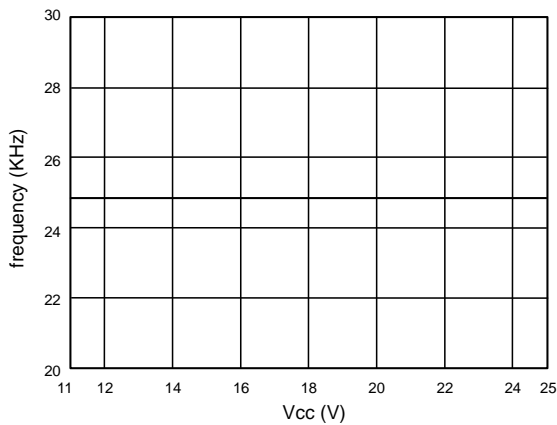


Fig. 5 Green mode frequency vs. Vcc

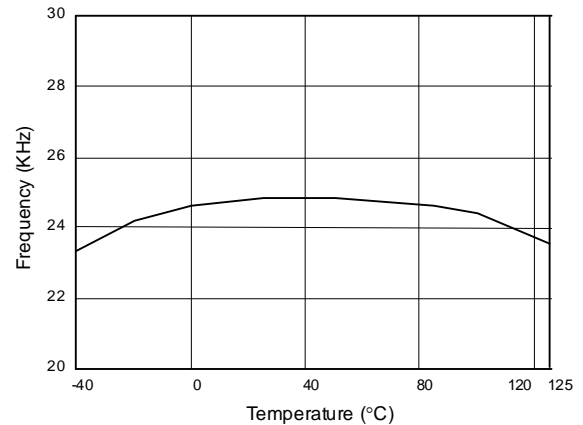


Fig. 6 Green Mode Frequency vs. Temperature

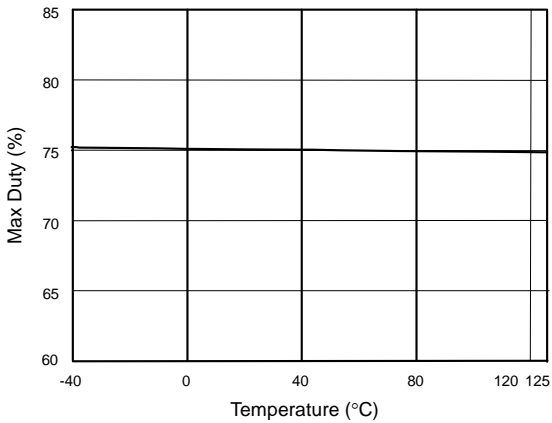


Fig. 7 Max Duty vs. Temperature

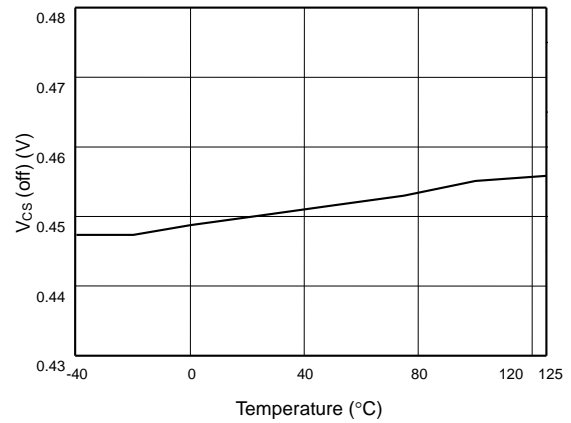


Fig. 8 Vcs (off) vs. Temperature

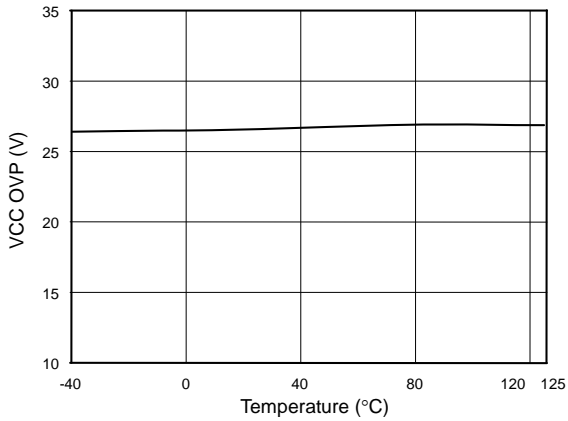


Fig. 9 VCC OVP vs. Temperature

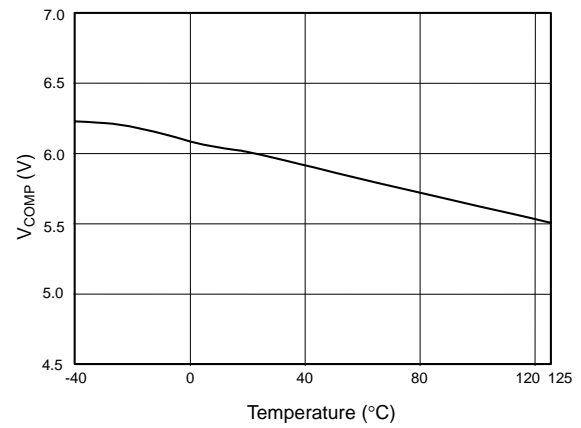


Fig. 10 VCOMP open loop voltage vs. Temperature

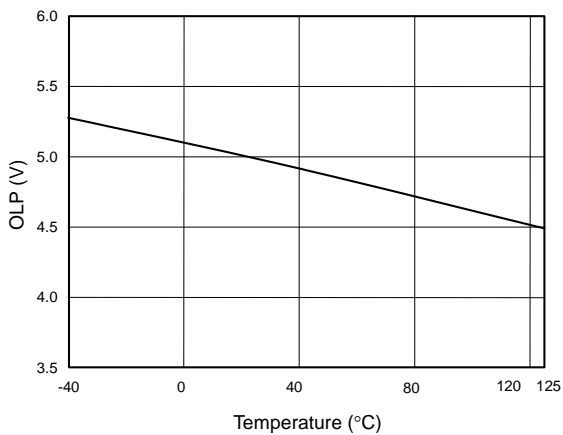


Fig. 11 OLP-Trip Level vs. Temperature

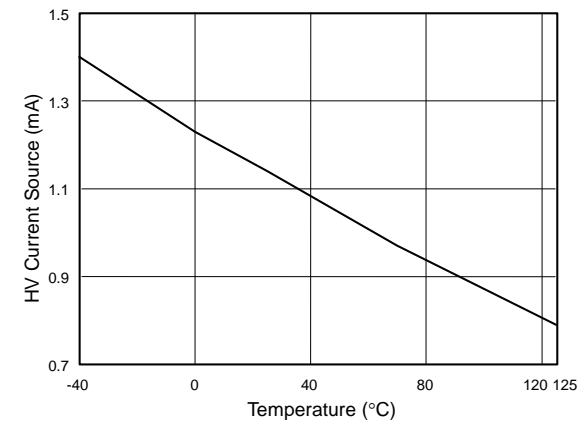


Fig. 12 HV Current Source vs. Temperature (HV=500V, Vcc=0V)

Application Information

Operation Overview

The LD7904J is a green-mode chip and is intended for the modern switching power suppliers and adaptors which demand higher efficiency and low loss. With integrated multi-functions in this chip, the LD7904 could minimize the external components counts and reduce the product size. The major features are described as below.

High Voltage Startup Circuit

Traditional PWM controller requires external startup resistor to provide the startup current. However high resistance will take more start up time while low resistance cause more power loss. To optimize the circuit performance and energy saving, the LD7904J features high voltage startup to enhance the performance.

As shown in Fig. 13, During startup, a high-voltage(HV) constant current source (~1mA) sinks current from the Drain pin to provide the PWM IC start current to and Vcc capacitor C1 charge current. In this period the PWM IC only sink 300uA thus most of the HV current is utilized to charge the Vcc capacitor. After the Vcc higher than UVLO(on) threshold, this HV current source will turn off and LD7904J is start to work then Vcc supply current is provide from the auxiliary winding of the transformer. Therefore, the power losses on the startup circuit can be eliminated and the power saving can be easily achieved. By using such configuration, the turn-on delay time will be almost same no matter low-line or high-line conditions. Whenever the Vcc voltage is higher than UVLO(on).

Under Voltage Lockout (UVLO)

An UVLO comparator is implemented in LD7904J to detect the voltage on the VCC pin. It would assure the supply voltage enough to turn on the LD7904J PWM controller and further to drive the internal power MOSFET. As shown in Fig. 14, a hysteresis is built in to prevent the shutdown from the voltage dip during startup. The turn-on and turn-off threshold level are set at 16.0V and 9.0V, respectively.

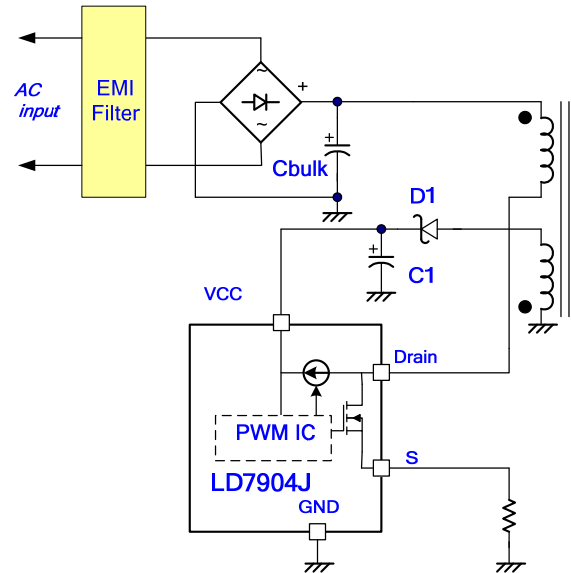


Fig. 13

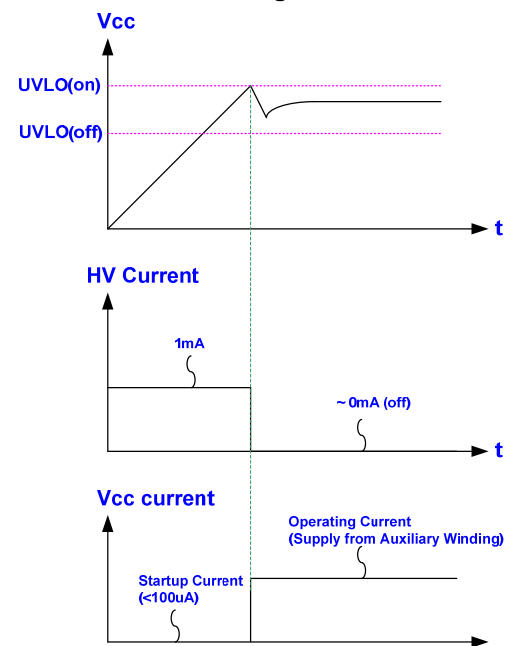


Fig. 14

Current Sensing and Leading-edge Blanking

The typical current mode of PWM controller feedbacks both current signal and voltage signal to close the control loop and achieve regulation. The LD7904J detects the internal MOSFET current from the S pin and pulse-by-pulse limit current. The maximum voltage

threshold of the current sensing pin is V_{cs_off} (~0.45V). The MOSFET peak current can be obtained from the below equation.

$$I_{PEAK(MAX)} = \frac{V_{cs_off}}{R_S}$$

Due to the integrated leading edge blanking circuit and internal spike filter, it doesn't need external LC filter parts.

Internal Slope Compensation

Stability is crucial for current mode control when it operates at CCM and more than 50% of duty-cycle. To stabilize the control loop, the slope compensation is required in the traditional UC384X design by injecting the ramp signal from the RT/CT pin through a coupling capacitor. In the LD7904J, the internal slope compensation circuit has been implemented to simplify the external circuit design.

On/Off Control

The gate driver of LD7904J can be disabled immediately by pulling the COMP pin voltage level lower than the Zero Duty Trip Level. The disable-mode can be released when the COMP pin voltage level is higher than the Zero Duty Trip Level.

Oscillator and Switching Frequency

The switching frequency of LD7904J is fixed at 100KHz to provide the optimized operations by considering the EMI performance, thermal treatment, component sizes, and transformer design. The Trembling frequency is internally pre-set for ± 6.2 KHz when incorporating with 100KHz switching frequency.

Green-Mode Operation

By using the green-mode control, the switching frequency can be reduced under the light load condition. This feature helps to improve the efficiency in light load conditions. The green-mode control is Leadtrend Technology's own IP.

Maximum Duty-Cycle

The maximum duty-cycle of LD7904J is limited to 75% to avoid the transformer saturation.

Voltage Feedback Loop

The voltage feedback signal is provided from the TL431 on the secondary side through the photo-coupler to the COMP pin of LD7904J. The input stage of LD7904J, like the UC384X, is incorporated with a 2-diode voltage offset circuit and a voltage divider with a 1/6 ratio. Therefore,

$$V_{+(PWM_{COMPARATOR})} = \frac{1}{6} \times (V_{COMP} - 2V_F)$$

A pull-high resistor is embedded internally and thus an external one is not required.

OVP (Over Voltage Protection) on Vcc

LD7904J implements an OVP function on Vcc. When the Vcc voltage is higher than the OVP threshold voltage, the output gate drive circuit will be shutdown and stop the switching of the power MOSFET.

If the fault condition is removed, the LD 7904 will automatically restart at the next UVLO(on).

If the fault condition is not removed, at the next UVLO(on) the Vcc will trip the OVP level again and re-shutdown the output. Then the Vcc is working as a hiccup mode.

The Figure 16 shows its operation.

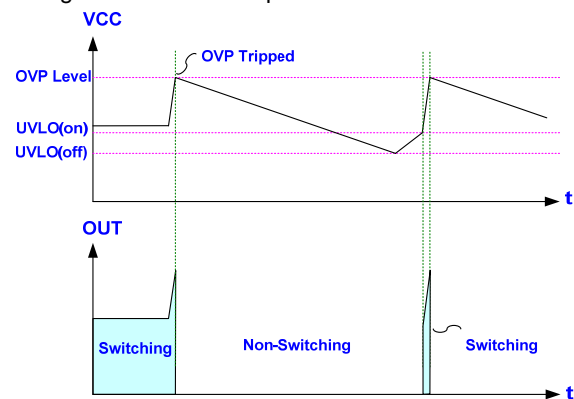


Fig. 16

Over Load Protection (OLP)

To protect the circuit from being damaged under over load condition or short circuit condition, an OLP function is implemented in the LD7904J. The Figure 17 shows the waveforms of the OLP operation. While in OLP condition,

the feedback loop will force the Comp pin (V_{COMP}) voltage increase to provide more power to output. When the V_{COMP} trips up to the OLP threshold 5V and stays longer than the OLP delay time, the LD7904J will turn off the gate output to stop the switching of power circuit. The OLP delay time is to prevent the false trigger from the power-on and turn-off transient. Typically the OLP delay time will be around 83mS.

By such protection mechanism, the average input power while OLP can be reduced to very low level so that the component temperature and stress can be controlled within the safe operating area.

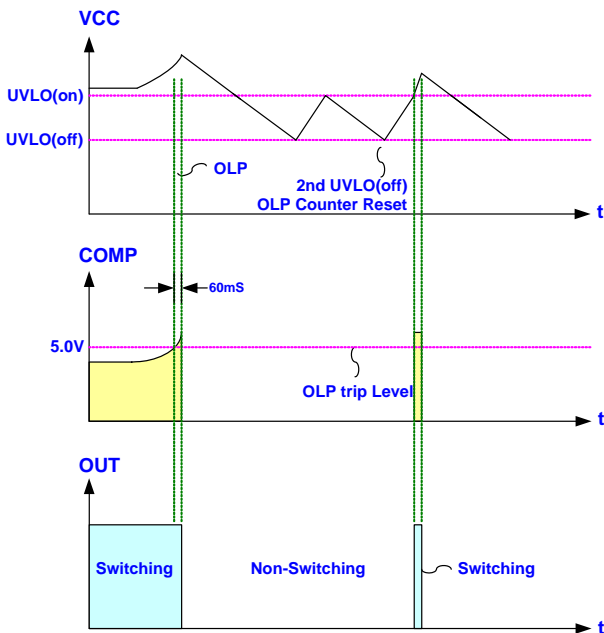


Fig. 17

Brownout Protection

The LD7904JGPN programmable to set the brownout protection point though BNO pin. The voltage across the BNO pin is proportional to the bulk capacitor voltage, referred as the line voltage. A brownout comparator is implemented to detect the abnormal line condition. As soon as the condition is detected, it will shut down the controller to prevent the damage. Figure 18 shows the

operation. When V_{BNO} falls below 0.80V, the gate output will be kept off even V_{CC} has already achieved UVLO(ON). It therefore makes V_{CC} hiccup between UVLO(ON) and UVLO(OFF). Unless the line voltage is large enough to pull V_{BNO} larger than 1.05V, the gate output will not start switching even when the next UVLO(ON) is tripped. A hysteresis is implemented to prevent the false trigger during turn-on and turn-off. Figure 18 shows the circuit.

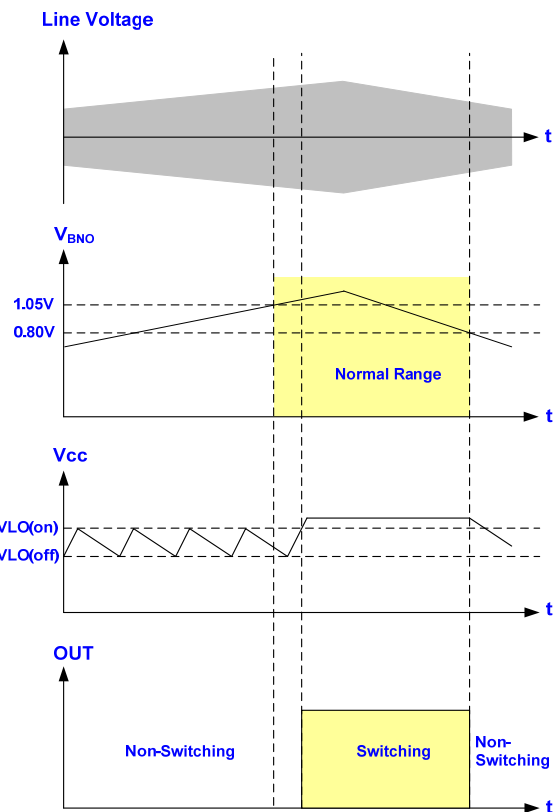


Fig. 18

Open/Short fault Protection

Some critical protections were integrated in the LD7904J to prevent the power supply damaged while open/short fault condition. The LD7904J will shut down to protect the power circuit under following open or short conditions:

1. COMP pin short to ground
2. S pin floating

Internal Thermal Shut Down

In order to protect IC from thermal damage, when junction temperature is above 140°C the LD7904J will shut down. While its temperature cools down gradually to 110°C(Typ.) the LD7904J will restart again.

Power Dissipation and Thermal Management

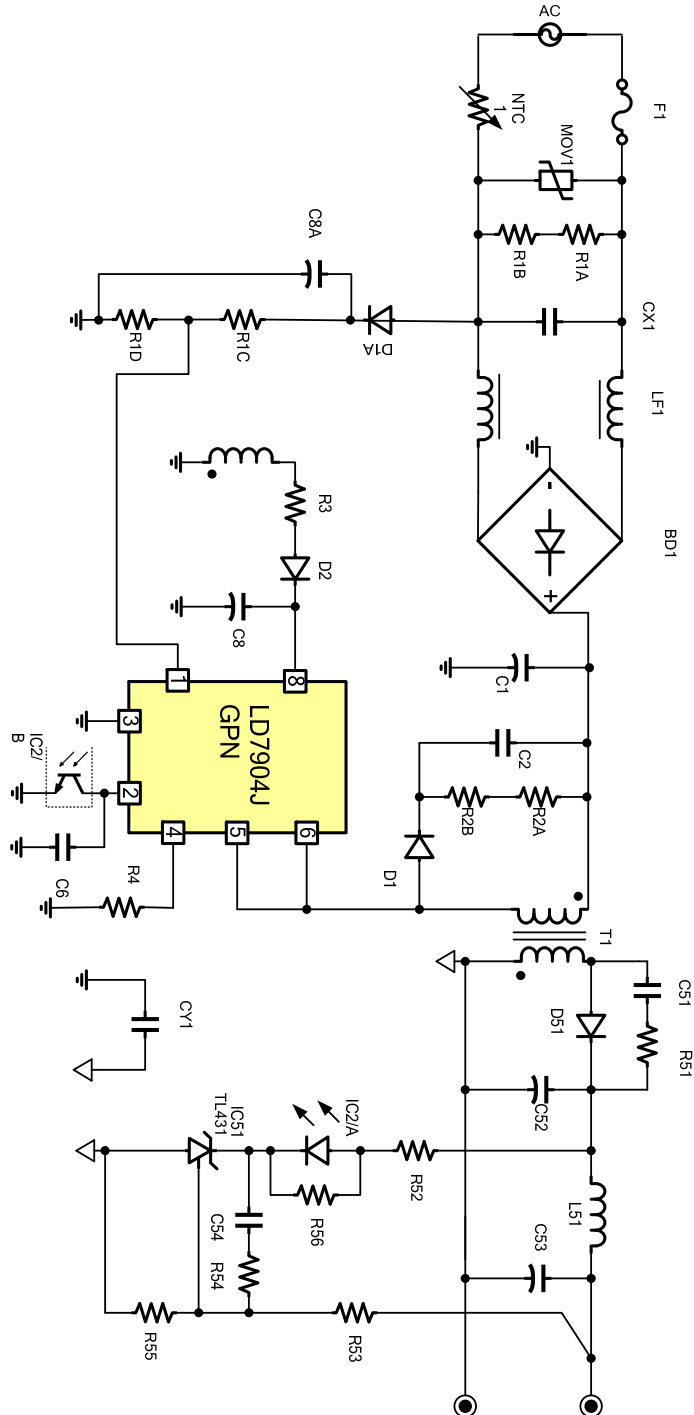
The power supply designer should carefully consider the operating case temperature and operating junction temperature for the LD7904J. The maximum operating junction temperature is 125°C. The switcher should NOT operate in any condition over this limitation.

Junction Temp.(T_J)

= Case Temp.(T_C) + Power loss * thermal resistance(θ_{JC})

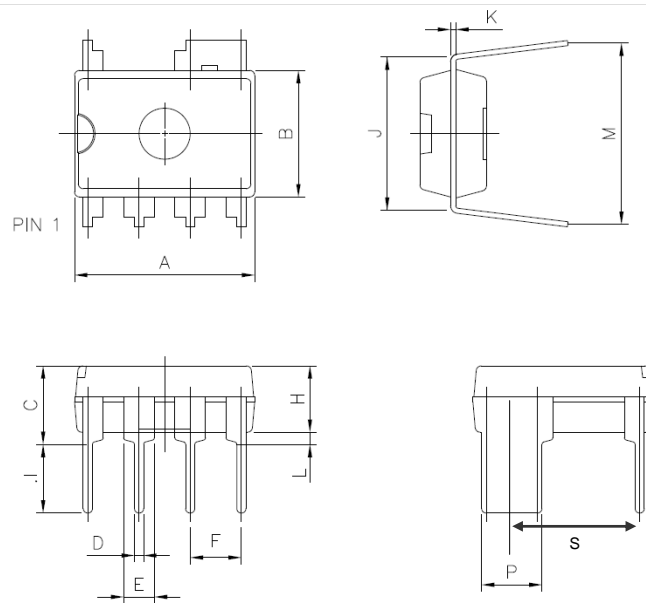
Reference Application Circuit- 12V/2A

Pin $0.1W$ @ $P_o=0W</math> & AC264V_{in}$



Package Information

DIP-6



Symbol	Dimension in Millimeters		Dimensions in Inches	
	Min	Max	Min	Max
A	9.017	10.160	0.355	0.400
B	6.100	6.600	0.240	0.260
C	3.300	4.320	0.130	0.170
D	0.356	0.584	0.014	0.023
E	1.143	1.778	0.045	0.070
F	2.480	2.600	0.098	0.102
H	3.170	3.600	0.125	0.142
I	2.921	3.810	0.115	0.150
J	7.366	7.874	0.290	0.310
K	0.246	0.305	0.010	0.012
L	0.381	0.540	0.015	0.021
M	8.509	9.525	0.335	0.375
P	2.920	3.100	0.115	0.121
S	6.273	6.427	0.247	0.253

Important Notice

Leadtrend Technology Inc. reserves the right to make changes or corrections to its products at any time without notice. Customers should verify the datasheets are current and complete before placing order.

Revision History

Rev.	Date	Change Notice
00	2011/6/17	Original Specification
01	2012/4/25	DIP-6 package dimensions updated