

## Green Mode Power Switch

REV : 00

### General Description

The LD7904JGP7 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, 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.

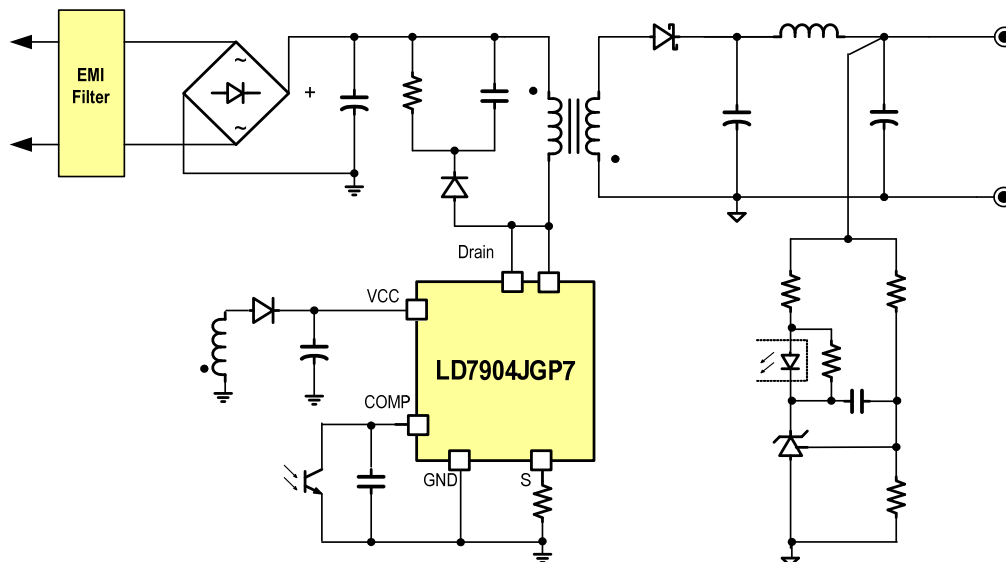
### Features

- 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           |
|-------------|---------|---------------|------------|--------------------|
| LD7904JGP7  | DIP-6   | Green Package | LD7904JGP7 | 3600/ Tube/ Carton |

The LD7904JGP7 is ROHS compliant.

## Protection Mode

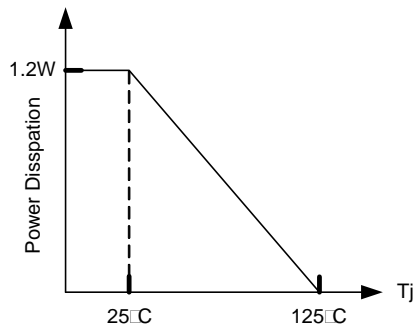
| Switching Freq. | VCC OVP       | OLP           | Internal OTP  |
|-----------------|---------------|---------------|---------------|
| 100kHz          | Auto recovery | Auto recovery | Auto recovery |

## Pin Descriptions

| PIN | NAME  | FUNCTION   |
|-----|-------|--|
| 1   | NC    | NC   |
| 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  |
| 7   | NC    | NC   |
| 8   | VCC   | Power supply to Vcc  |

## Recommended Operating Conditions

| Product    | Drain Current | Rds(on) | 230VAC ± 15% |            | 90~264VAC* |            |
|------------|---------------|---------|--------------|------------|------------|------------|
|            |               |         | Adapter      | Open Frame | Adapter    | Open Frame |
| LD7904JGP7 | 4A            | 2.8Ω    | 25W          | 30W        | 18W        | 25W        |



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

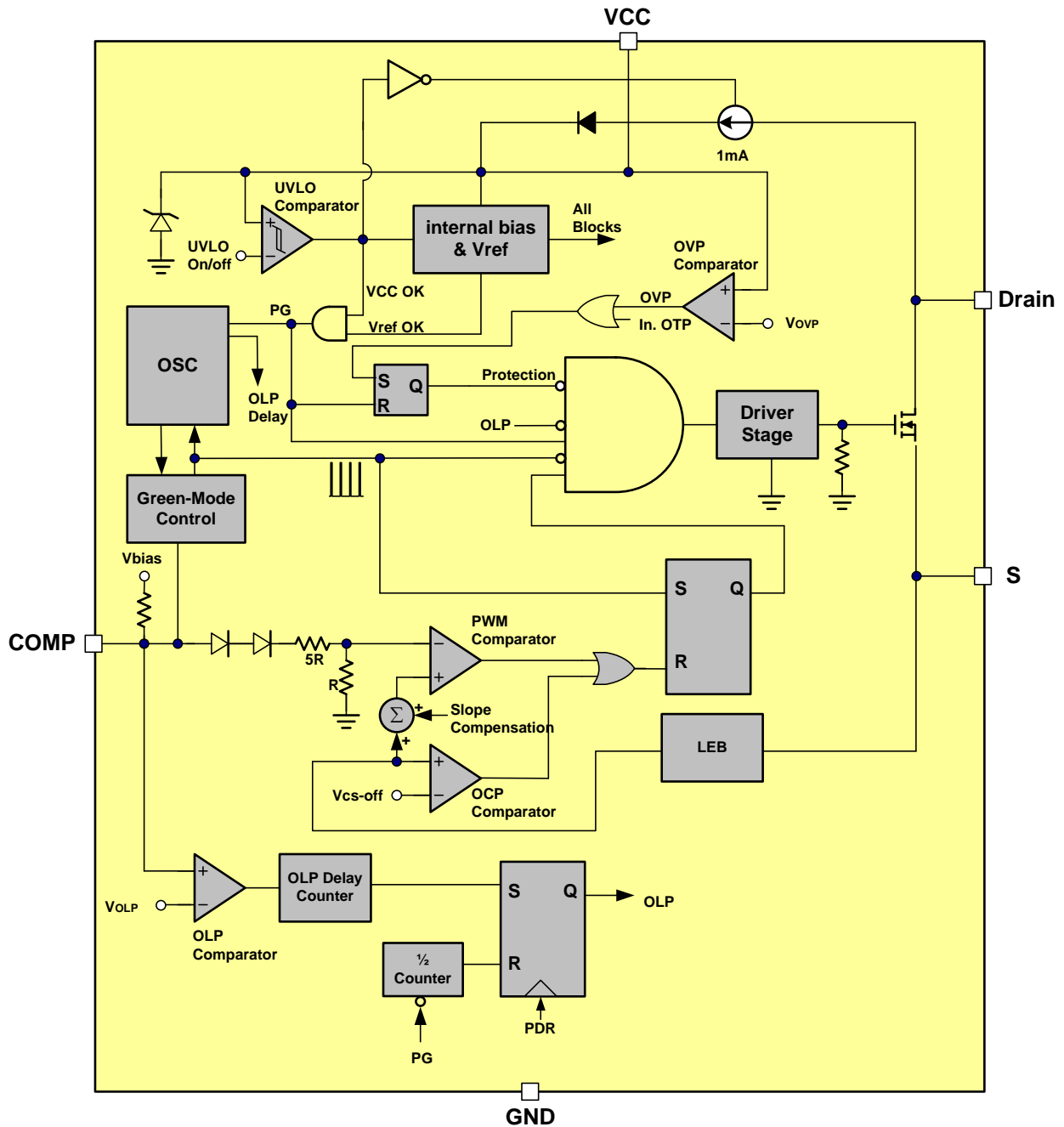
\*\*Calculated maximum Input Power Rating at Ta =25°C

| 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)                                  |                |
| $\theta_{JA}$ .....   | 80°C/W         |
| $\theta_{JC}$ .....   | 30°C/W         |
| Operating Junction Temperature Range.....                           | -40°C to 125°C |
| Operating Ambient Temperature Range.....                            | -20°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.

## Electrical Characteristics

(Ta=25°C, V<sub>CC</sub>=15.0V, unless otherwise stated.) **Electrical Characteristics for Control Section**

| PARAMETER                                  | CONDITIONS                          | MIN   | TYP  | MAX   | UNITS |
|--|-------------------------------------|-------|------|-------|-------|
| <b>High Voltage Supply (Drain Pin)</b>     |                                     |       |      |       |       |
| High Voltage Current Source                | V <sub>CC</sub> <UVLO(on), HV=500V  | 0.5   | 1.0  | 1.5   | mA    |
| Off State Leakage Current                  | V <sub>CC</sub> >UVLO(off), HV=500V | -     | 8    | 35    | μA    |
| <b>Supply Voltage (V<sub>CC</sub> Pin)</b> |                                     |       |      |       |       |
| Startup Current                            |                                     | 200   | 300  | 400   | μA    |
| Operating Current                          | V <sub>COMP</sub> =0V               | -     | 1.1  | -     | mA    |
|  | V <sub>COMP</sub> =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 V <sub>CC</sub> Pin                 |                                     | 25    |      | 27    | V     |
| <b>Voltage Feedback (Comp Pin)</b>         |                                     |       |      |       |       |
| Short Circuit Current                      | V <sub>COMP</sub> =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 <sub>COMP</sub>     |                                     | -     | 2.1  | -     | V     |
| Zero Duty Trip Level(off)                  |                                     | -     | 1.6  | -     | V     |
| Hysteresis                                 |                                     | -     | 100  | -     | mV    |
| <b>Current Sense Comparator(Cs Pin)</b>    |                                     |       |      |       |       |
| Maximum Input Voltage V <sub>cs_off</sub>  |                                     | 0.425 | 0.45 | 0.475 | V     |
| Leading Edge Blanking Time                 |                                     | -     | 380  | -     | ns    |
| Slope compensation                         | 0 to max. duty                      | -     | 150  | -     | mV    |
| Input impedance                            |                                     | 1     | -    | -     | MΩ    |
| Delay to Output                            |                                     | -     | 100  | -     | ns    |
| <b>Oscillator &amp; Control</b>            |                                     |       |      |       |       |
| Frequency                                  |                                     | 94    | 100  | 106   | kHz   |
| Green Mode Frequency                       |                                     | 22    | 25   | 28    | kHz   |
| Frequency Trembling                        | f <sub>s</sub> = 100kHz             | -     | ±6.2 | -     | kHz   |

## Electrical Characteristics

(Ta=25°C, V<sub>CC</sub>=15.0V, Tj=25°C, unless otherwise stated.)

| PARAMETER                         | CONDITIONS               | MIN | TYP | MAX | UNITS |
|-----------------------------------|--------------------------|-----|-----|-----|-------|
| Frequency Temp. Stability         | -25~85°C                 | -   | 5   | -   | %     |
| Voltage Stability                 | V <sub>CC</sub> =11~25V) | -   | -   | 1   | %     |
| Maximum Duty                      |                          | -   | 75  | -   | %     |
| <b>OLP (Over Load Protection)</b> |                          |     |     |     |       |
| OLP Trip Level                    |                          | 4.8 | 5.0 | 5.2 | V     |
| OLP Delay Time                    |                          | -   | 84  |     | ms    |
| <b>Soft Start</b>                 |                          |     |     |     |       |
| Soft Start Duration               |                          | -   | 4   | -   | ms    |
| <b>On Chip OTP</b>                |                          |     |     |     |       |
| OTP Level                         |                          | -   | 140 | -   | °C    |
| Hysteresis                        |                          | -   | 30  | -   | °C    |

## Electrical Characteristics for MOSFET

| PARAMETER                                | CONDITIONS  | MIN | TYP | MAX | UNITS |
|--|---|-----|-----|-----|-------|
| <b>Drain to Source Breakdown Voltage</b> |   |     |     |     |       |
| Breakdown Voltage BV <sub>DSS</sub>      | V <sub>CC</sub> =0V, COMP=0V, I <sub>D</sub> =250μA | 700 |     |     | V     |
| <b>Drain on Resistance</b>               |   |     |     |     |       |
| Drain to S pin On-Resistance             | I <sub>D</sub> =2A; V <sub>CC</sub> =15V; Tj=25°C   |     |     | 2.8 | Ω     |

## Typical Performance Characteristics

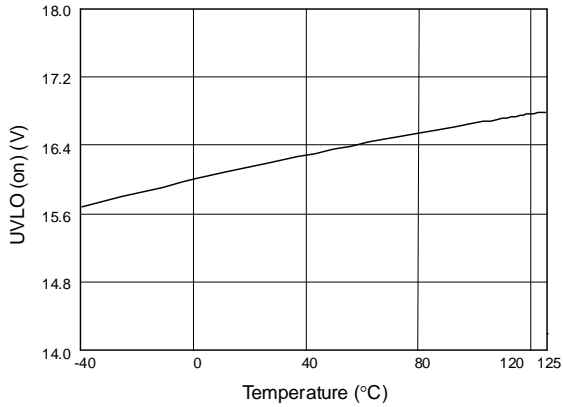


Fig. 1 UVLO (on) vs. Temperature

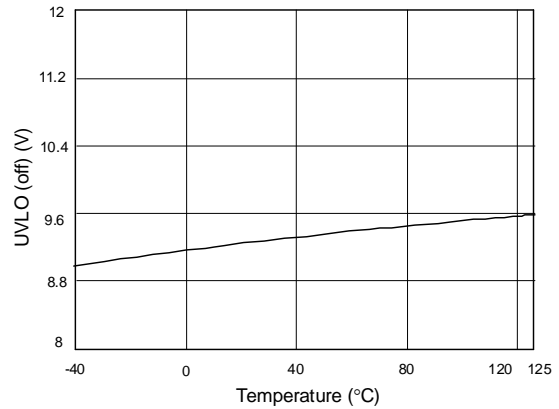


Fig. 2 UVLO (off) vs. Temperature

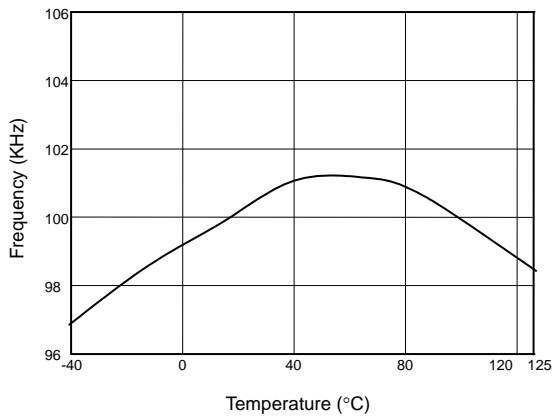


Fig. 3 Frequency vs. Temperature

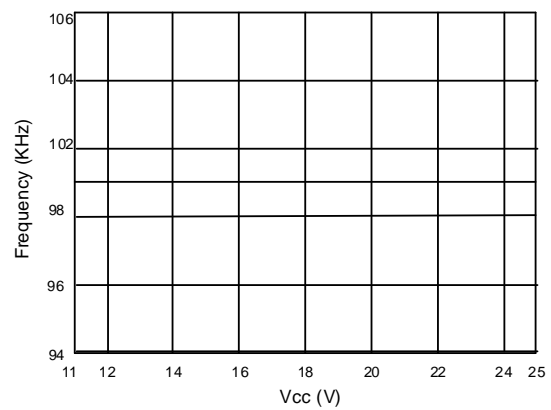


Fig. 4 Frequency vs. Vcc

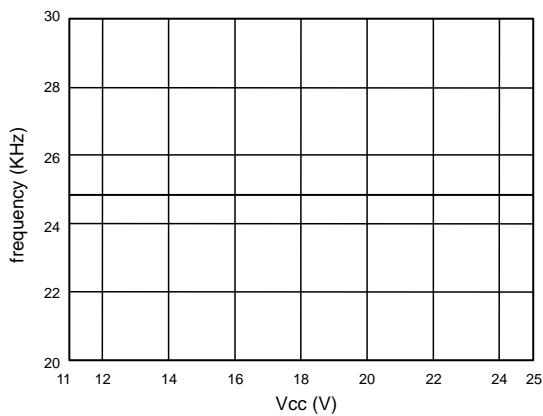


Fig. 5 Green mode frequency vs. Vcc

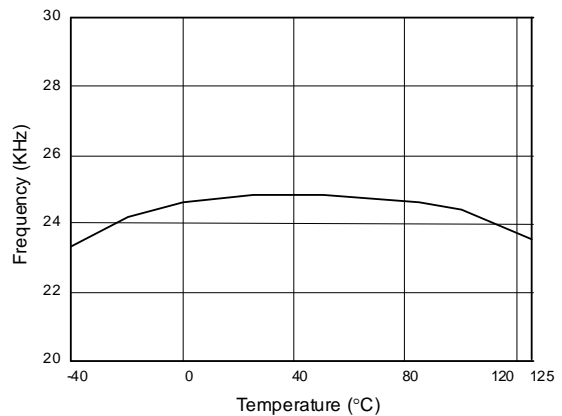


Fig. 6 Green Mode Frequency vs. Temperature



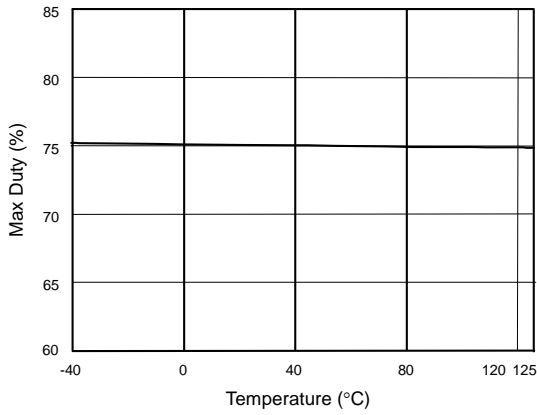


Fig. 7 Max Duty vs. Temperature

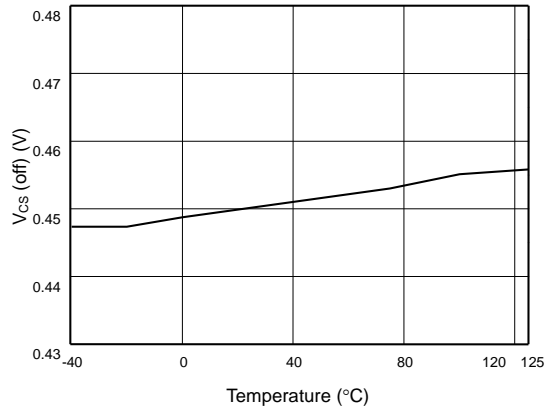


Fig. 8 V<sub>CS</sub> (off) vs. Temperature

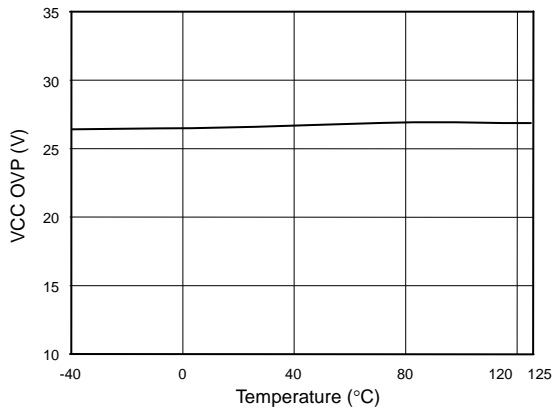


Fig. 9 VCC OVP vs. Temperature

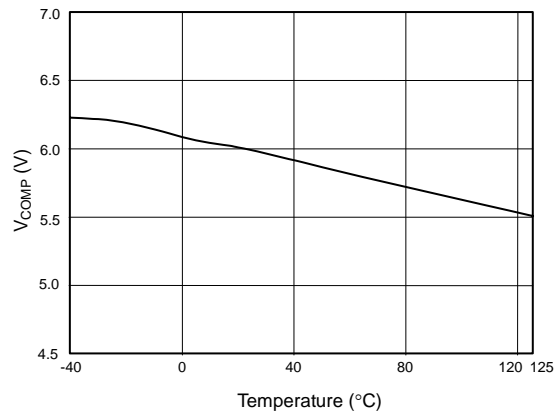


Fig. 10 V<sub>COMP</sub> open loop voltage vs. Temperature

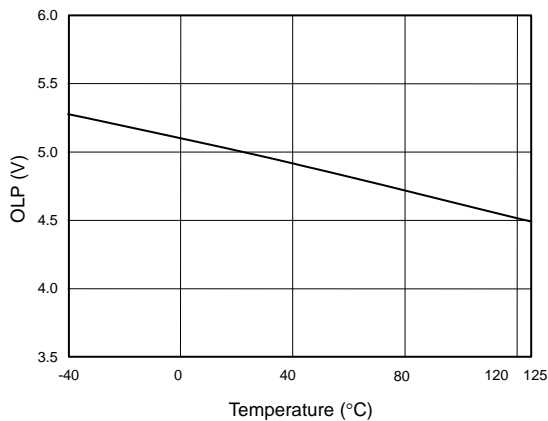


Fig. 11 OLP-Trip Level vs. Temperature

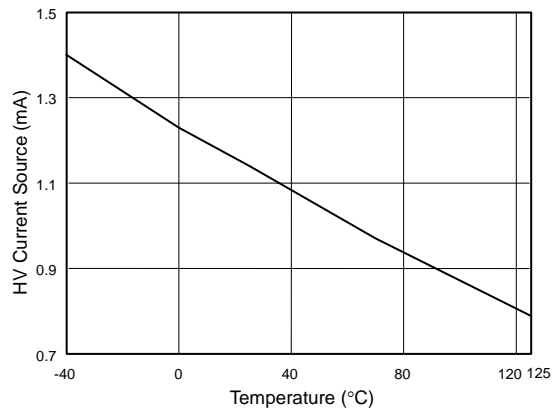


Fig. 12 HV Current Source vs. Temperature (HV=500V, V<sub>CC</sub>=0V)

## Application Information

### Operation Overview

The LD7904JGP7 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 LD7904JGP7 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 LD7904JGP7 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 LD7904JGP7 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 LD7904JGP7 to detect the voltage on the VCC pin. It would assure the supply voltage enough to turn on the LD7904JGP7 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.

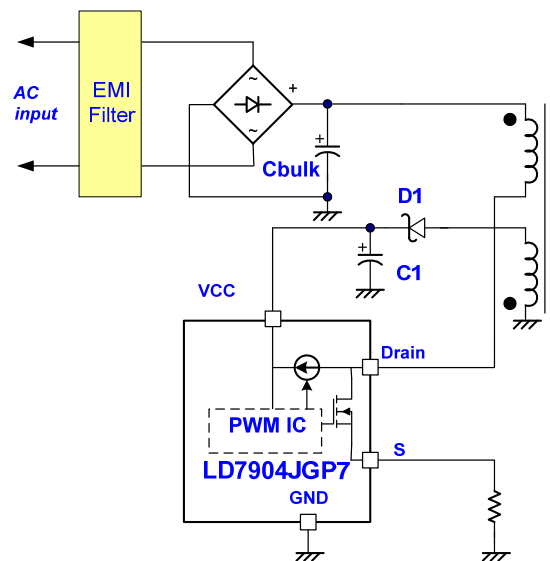


Fig. 13

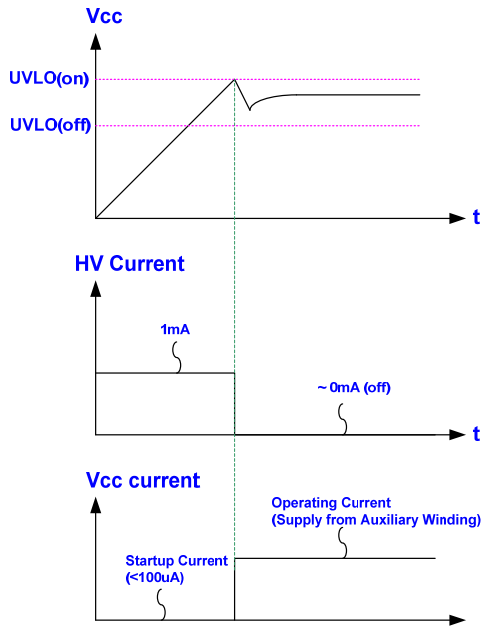


Fig. 14

## 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 LD7904JGP7 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 obtain from below equation.

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

Due to 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 LD7904JGP7, the internal slope compensation circuit has been implemented to simplify the external circuit design.

## On/Off Control

The gate driver of LD7904JGP7 can be disabled immediately by pulling COMP pin voltage level lower than Zero Duty Trip Level. The disable-mode can be released when Comp pin voltage level higher than Zero Duty Trip Level.

## Oscillator and Switching Frequency

The switching frequency of LD7904JGP7 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  $\pm 6.2$ 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 LD7904JGP7 is limited to 75% to avoid the transformer saturation.

## Voltage Feedback Loop

The voltage feedback signal is provided from the TL431 in the secondary side through the photo-coupler to the COMP pin of LD7904JGP7. The input stage of LD7904JGP7, like the UC384X, is incorporated with 2 diodes voltage offset circuit and a voltage divider with 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

LD7904JGP7 is implemented 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 fault condition is removed, the LD 7904 will automatic restart at the next UVLO(on).

If the fault condition is not removed, at the next UVLO(on) the Vcc will tripped the OVP level again and re-shutdown the output. Then the Vcc is working as a hiccup mode. The Figure 16 shows its operation.

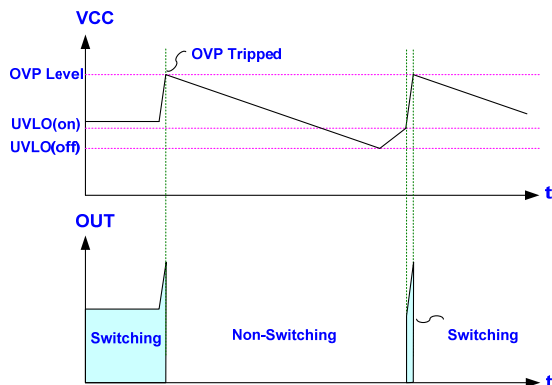


Fig. 16

### Over Load Protection (OLP)

To protect the circuit from being damaged under over load condition or short circuit condition, a OLP function is implemented in the LD7904JGP7. The Figure 17 shows the waveforms of the OLP operation. While 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 LD7904JGP7 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.

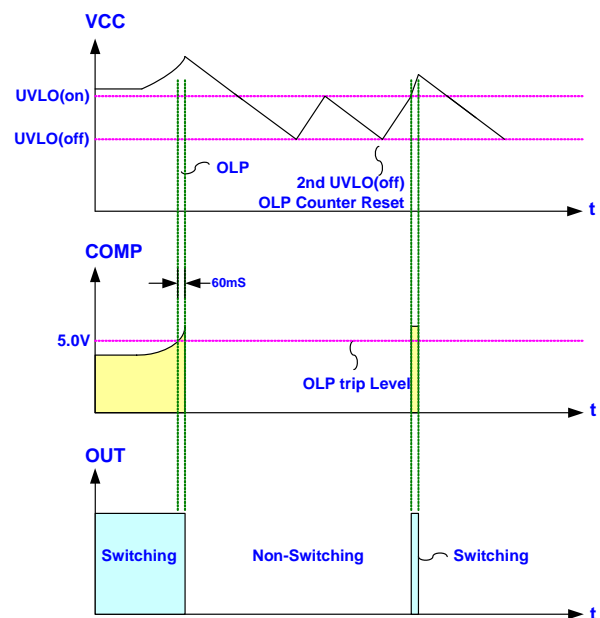


Fig. 17

### Open/Short fault Protection

Some critical protections were integrated in the LD7904JGP7 to prevent the power supply damaged while open/short fault condition. The LD7904JGP7 will shunt 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 LD7904JGP7 will shut down. While its temperature cools down gradually to 110°C(Typ.) the LD7904JGP7 will restart again.

**Power Dissipation and Thermal Management**

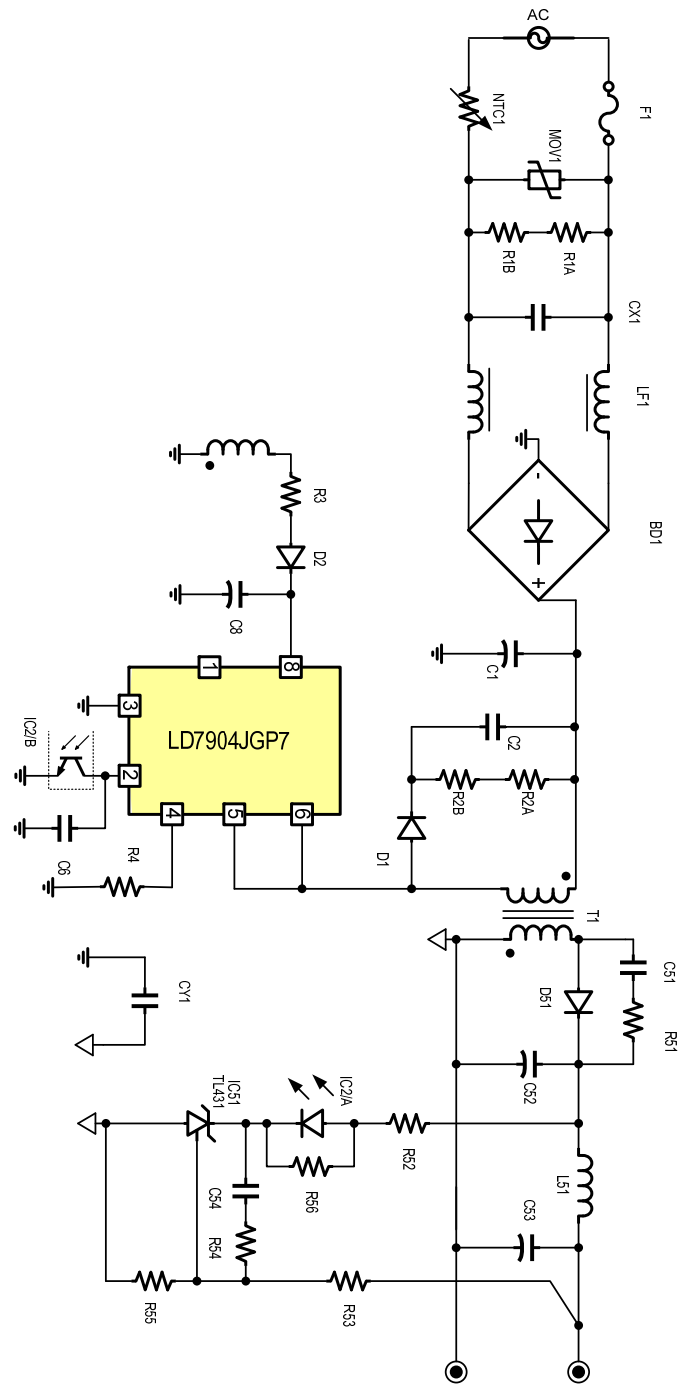
The power supply designer should carefully consider the operating case temperature and operating junction temperature for the LD7904JGP7. The maximum operating junction temperature is 125°C. The switcher should NOT operate in any condition over this limitation.

Junction Temp.(T<sub>J</sub>)

= Case Temp.(T<sub>C</sub>) + Power loss \* thermal resistance( $\theta_{JC}$ )

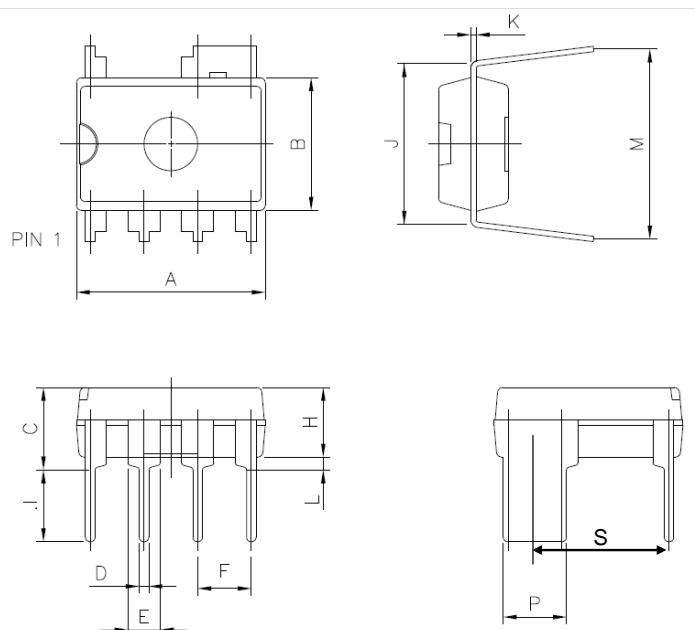
## Reference Application Circuit- 12V/2A

Pin <math>< 0.1W</math> @ $P_o=0W</math> & AC264V $_{in}</math>$$



## 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      | 6.096                    | 7.112  | 0.240                | 0.280 |
| C      | ---                      | 5.334  | ---                  | 0.210 |
| D      | 0.356                    | 0.584  | 0.014                | 0.023 |
| E      | 1.143                    | 1.778  | 0.045                | 0.070 |
| F      | 2.337                    | 2.743  | 0.092                | 0.108 |
| I      | 2.921                    | 3.556  | 0.115                | 0.140 |
| J      | 7.366                    | 8.255  | 0.29                 | 0.325 |
| K      | 0.254 TYP.               |        | 0.010 TYP.           |       |
| L      | 0.381                    | ---    | 0.015                | ---   |
| M      | 8.509                    | 9.525  | 0.335                | 0.375 |
| P      | 2.769 TYP.               |        | 0.11 TYP.            |       |
| S      | 6.35 TYP.                |        | 0.25 TYP.            |       |

**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 |