

Green-Mode PWM Controller

General Description

The LD7550-B is a low cost, low startup current, current mode PWM controller with green-mode power-saving operation. The integrated functions such as the leading-edge blanking of the current sensing, internal slope compensation and the small SOT-26 package provide the users a high efficiency, low external component counts, and low cost solution for AC/DC power applications.

Compared with LD7550, LD7550-B has different parameters or functions on the following characteristics ---

- Enlarger the hysteresis range of UVLO by lowering down the UVLO(off) from 11.4V to 10V.
- Add OVP (Over Voltage Protection) function on Vcc Pin.
- Shorten the OCP delay time to 100nS to reduce the difference of OCP trip level under high line & low line.

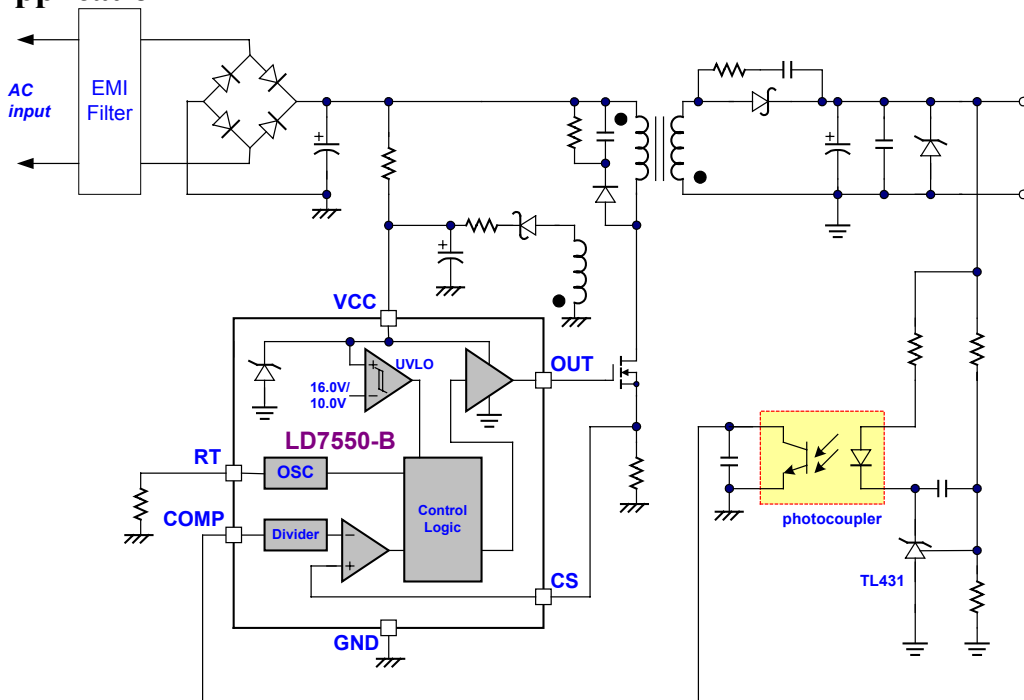
Features

- High-Voltage CMOS Process with Excellent ESD protection
- Very Low Startup Current (<20 μ A)
- Under Voltage Lockout (UVLO)
- Current Mode Control with Cycle-by-Cycle Peak Current Limiting
- Leading-Edge Blanking on CS Pin
- Programmable Switching Frequency
- Internal Slope Compensation
- Proprietary Green-Mode Control for Power Saving
- Non-audible-noise Green Mode Control
- 300mA Driving Capability
- OVP (Over Voltage Protection) on Vcc Pin

Applications

- Switching AC/DC Adaptor and Battery Charger
- Open Frame Switching Power Supply
- 384X Replacement

Typical Application

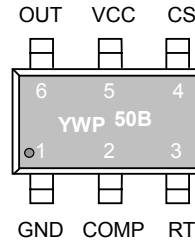


Pin Configuration

DIP-8 (TOP VIEW)



SOT-26 (TOP VIEW)



YY, Y: Year code
 WW, W: Week code
 P : LD75..
 (Product family code)
 ## : Production code

Ordering Information

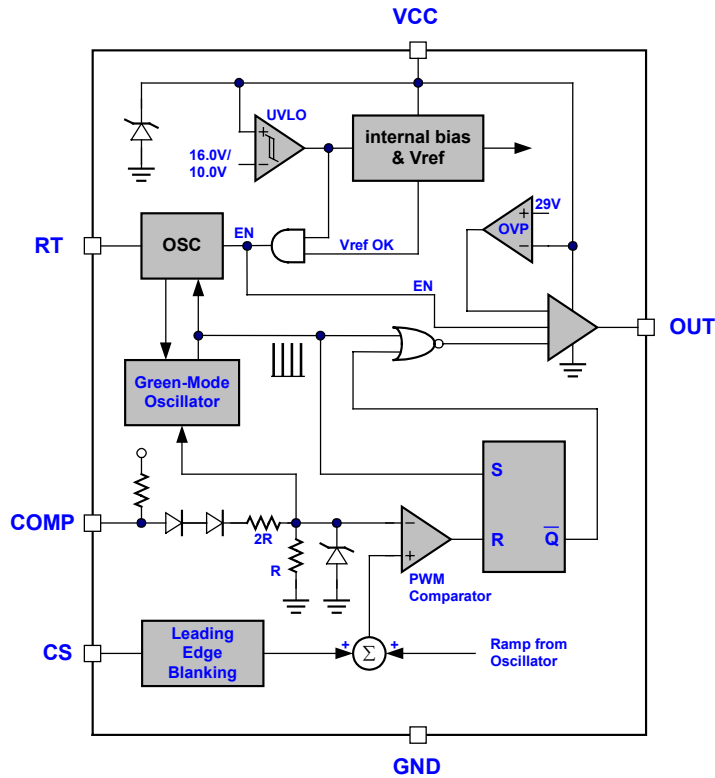
| Part number | Package | TOP MARK | Shipping |
|-------------|------------------|-------------|-------------------|
| LD7550-B IL | SOT-26 | YWP/50B | 3000 /tape & reel |
| LD7550-B IN | DIP-8 | LD7550BIN | 3600 /tube |
| LD7550-B BL | SOT-26 (PB free) | (*) YWP/50B | 3000 /tape & reel |
| LD7550-B BN | DIP-8 (PB free) | LD7550BBN | 3600 /tube |

(*) Identified in different laser ink

Pin Descriptions

| PIN (DIP-8) | PIN (SOT-26) | NAME | FUNCTION |
|-------------|--------------|------|--|
| 1 | 6 | OUT | Gate drive output to drive the external MOSFET |
| 2 | 5 | VCC | Supply voltage pin |
| 3 | | NC | Unconnected pin |
| 4 | 4 | CS | Current sense pin, connect to sense the MOSFET current |
| 5 | 3 | RT | This pin is to program the switching frequency. By connecting a resistor to ground to set the switching frequency. |
| 6 | | NC | Unconnected pin |
| 7 | 2 | COMP | Voltage feedback pin (same as the COMP pin in UC384X), By connecting a photo-coupler to close the control loop and achieve the regulation. |
| 8 | 1 | GND | Ground |

Block Diagram



Absolute Maximum Ratings

| | |
|--|----------------|
| Supply Voltage VCC..... | 36V |
| COMP, RT, CS..... | -0.3 ~7V |
| Junction Temperature..... | 150°C |
| Operating Ambient Temperature..... | -40°C to 85°C |
| Storage Temperature Range..... | -65°C to 150°C |
| Package Thermal Resistance (SOT-26)..... | 250°C/W |
| Package Thermal Resistance (DIP-8)..... | 100°C/W |
| Power Dissipation (SOT-26, at Ambient Temperature = 85°C)..... | 250mW |
| Power Dissipation (DIP-8, at Ambient Temperature = 85°C)..... | 650mW |
| Lead temperature (SOT-26 & DIP-8, Soldering, 10sec)..... | 230°C |
| Lead temperature (All PB Free Packages, Soldering, 10sec)..... | 260°C |
| ESD Voltage Protection, Human Body Model..... | 3.5KV |
| ESD Voltage Protection, Machine Model..... | 300V |
| Gate Output Current..... | 300mA |

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 limited.

Electrical Characteristics

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

| PARAMETER | CONDITIONS | MIN | TYP | MAX | UNITS |
|------------------------------------|-------------------------------|------|------|------|-------|
| Supply Voltage (Vcc Pin) | | | | | |
| Startup Current | | | 8 | 20 | μA |
| Operating Current | V _{COMP} =0V | | 3 | 4 | mA |
| | V _{COMP} =3V | | 2 | | mA |
| | V _{COMP} =open | | 0.7 | | mA |
| UVLO (off) | | 9.0 | 10.0 | 11.0 | V |
| UVLO (on) | | 15.0 | 16.0 | 17.0 | V |
| OVP Level | | 27 | 29 | 32 | V |
| Voltage Feedback (Comp Pin) | | | | | |
| Short Circuit Current | V _{COMP} =0V | | 2.2 | 3.0 | mA |
| Open Loop Voltage | COMP pin open | | 5.0 | | V |
| Green Mode Threshold VCOMP | | | 2.35 | | V |
| Current Sensing (CS Pin) | | | | | |
| Maximum Input Voltage, Vcs(off) | | 0.80 | 0.85 | 0.90 | V |
| Leading Edge Blanking Time | | | 350 | | nS |
| Input impedance | | | 50 | | KΩ |
| Delay to Output | | | 100 | | nS |
| Oscillator (RT pin) | | | | | |
| Frequency | RT=100KΩ | 60.0 | 65.0 | 70.0 | KHz |
| Green Mode Frequency | Fs=65.0KHz | | 20 | | KHz |
| Temp. Stability | (-40°C ~105°C) | | | 3 | % |
| Voltage Stability | (VCC=11V-25V) | | | 1 | % |
| Gate Drive Output (OUT Pin) | | | | | |
| Output Low Level | VCC=15V, I _o =20mA | | | 1 | V |
| Output High Level | VCC=15V, I _o =20mA | 8 | | | V |
| Rising Time | Load Capacitance=1000pF | | 50 | 200 | nS |
| Falling Time | Load Capacitance=1000pF | | 30 | 100 | nS |

Typical Performance Characteristics

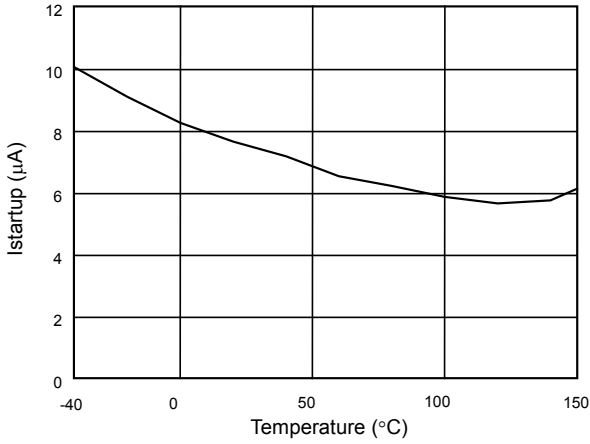


Fig. 1 Startup Current (I_{startup}) vs. Temperature

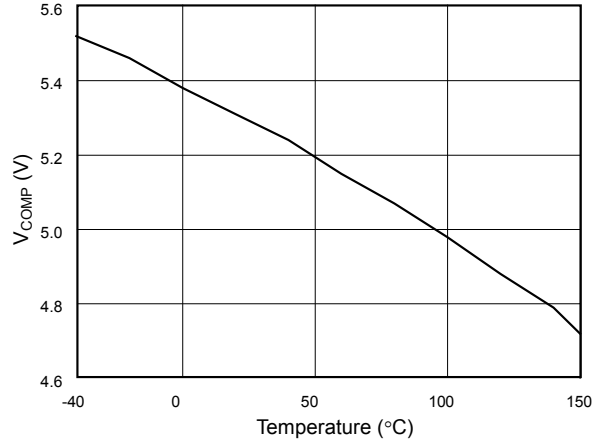


Fig. 2 V_{COMP} open loop voltage v.s. Temperature

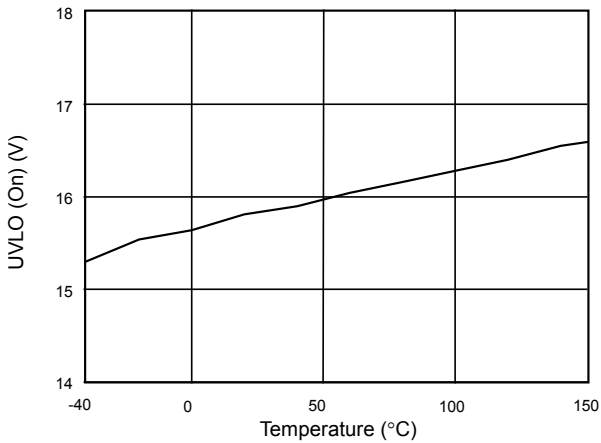


Fig. 3 UVLO (On) vs. Temperature

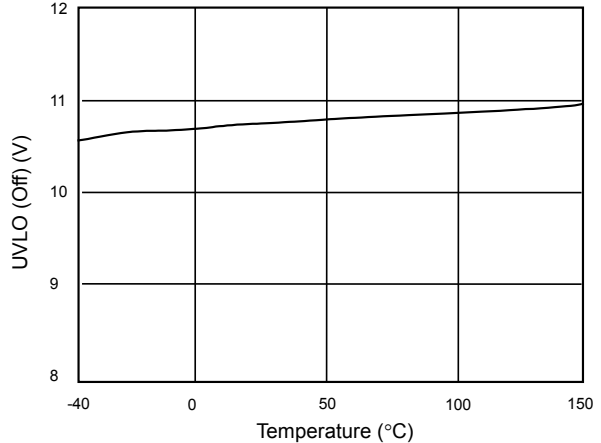


Fig. 4 UVLO Off v.s. Temperature

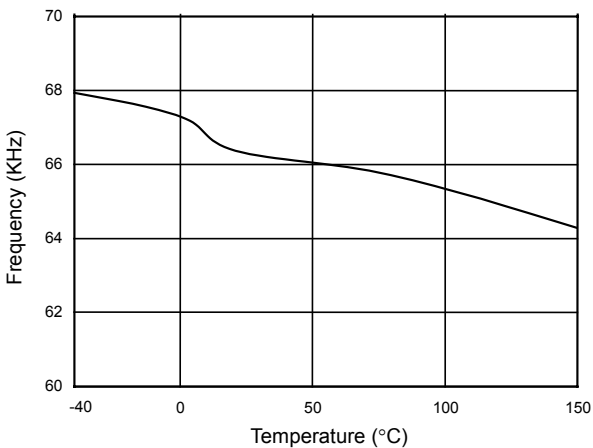


Fig. 5 Frequency v.s. Temperature

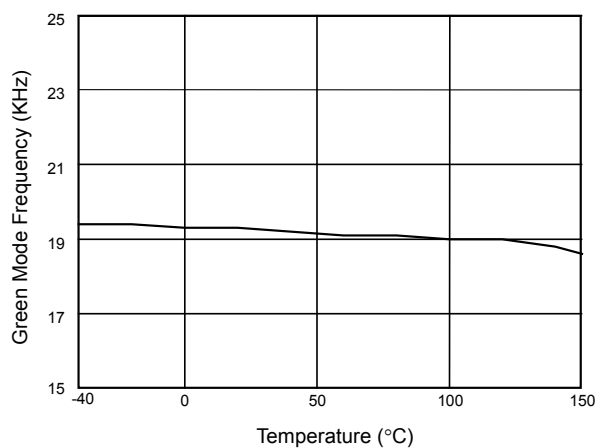


Fig. 6 Green Mode Frequency v.s. Temperature

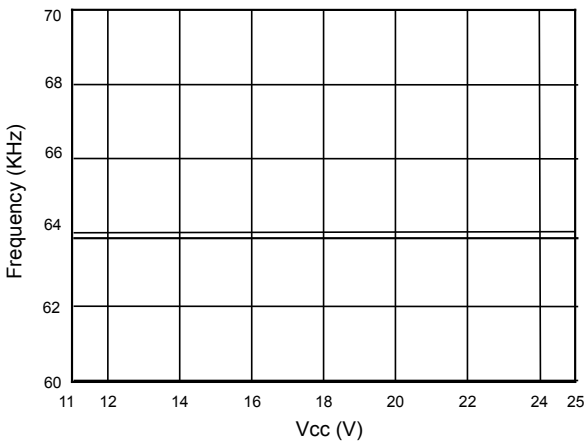


Fig. 7 Frequency v.s. Vcc

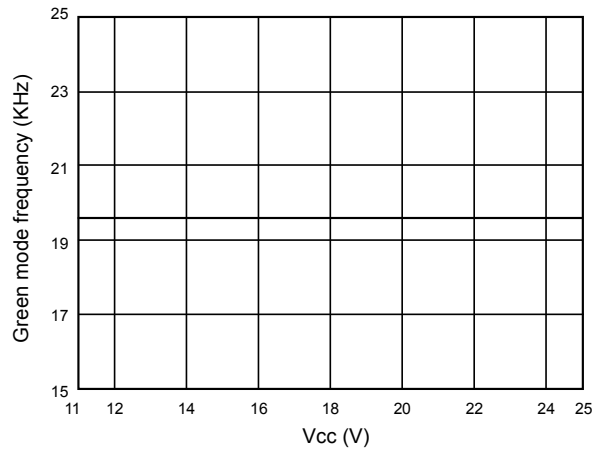


Fig. 8 Green mode frequency v.s. Vcc

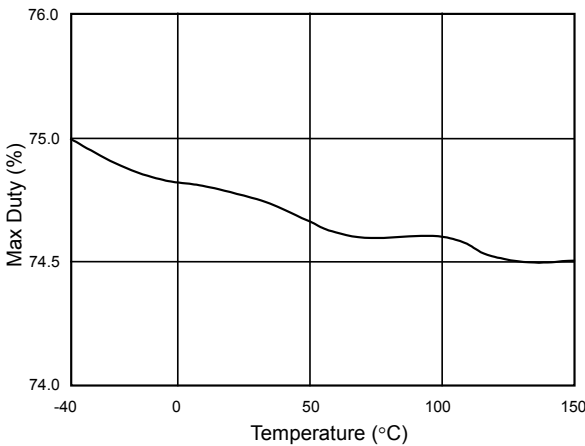


Fig. 9 Max Duty v.s. Temperature

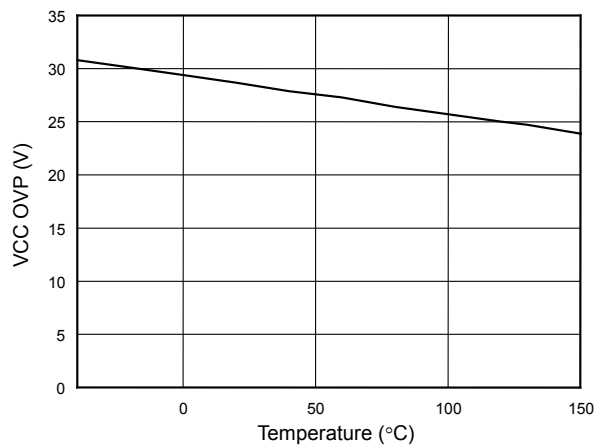


Fig. 10 VCC OVP v.s. Temperature

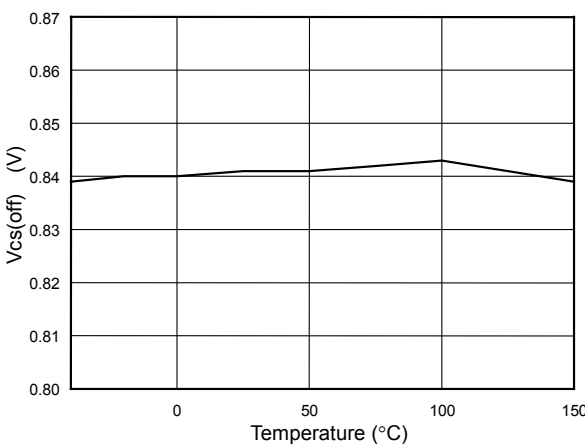


Fig. 11 Vcs (off) v.s. Temperature

Application Information

Operation Overview

The LD7550B meets the green power requirement and is intended for use in those switching power supplies and switching adaptors, demanding higher power efficiency and power saving. It integrated more functions to reduce the external components counts and the size. Its major features are described as below.

Under Voltage Lockout (UVLO)

An UVLO comparator is implemented to detect the voltage on the VCC pin to ensure the supply voltage is enough to power on the LD7550-B PWM controller and further to drive the power MOSFET. As shown in Fig. 12, a hysteresis is implemented to prevent the shutdown from the voltage dip during startup. The turn-on and turn-off threshold level are set at 16V and 10.0V, respectively.

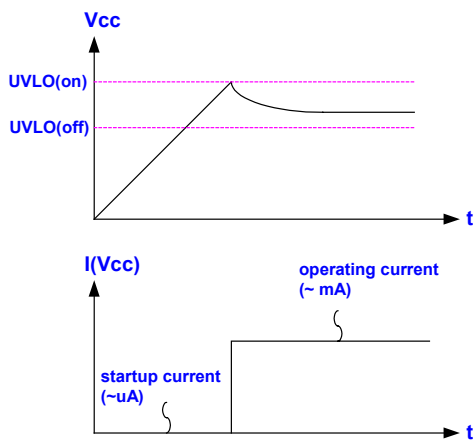


Fig. 12

Startup Current and Startup Circuit

The typical startup circuit to power up the LD7550-B is shown in Fig. 13. During the startup transient, the Vcc is lower than the UVLO threshold thus there is no gate pulse generated from LD7550-B to drive power MOSFET. Therefore, the current through R1 will provide the startup current as well as charge the capacitor C1. Whenever the Vcc voltage is higher enough to power on the LD7550-B and

further to deliver the gate drive signal, the supply current is provided from the auxiliary winding of the transformer. The lower startup current requirement on the PWM controller will help to increase the R1 value and then reduce the power consumption on R1. By using CMOS process and the special circuit design, the maximum startup current of LD7550-B is only 20μA.

If a higher resistance value of the R1 is picked, it will usually take more time to startup. To carefully select the value for R1 and C1 will optimize the power consumption and startup time.

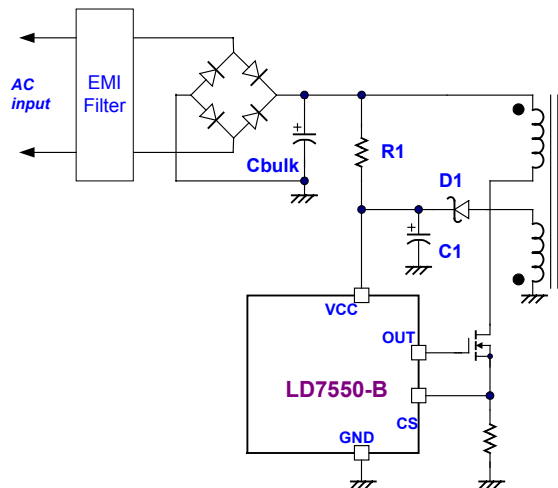


Fig. 13

Current Sensing and Leading-edge Blanking

The typical current mode PWM controller feedbacks both current signal and voltage signal to close the control loop and achieve regulation. As shown in Fig. 14, the LD7550-B detects the primary MOSFET current from the CS pin, which is not only for the peak current mode control but also for the pulse-by-pulse current limit. The maximum voltage threshold of the current sensing pin is set at 0.85V. From above, the MOSFET peak current can be calculated as:

$$I_{PEAK(MAX)} = \frac{0.85V}{R_S}$$

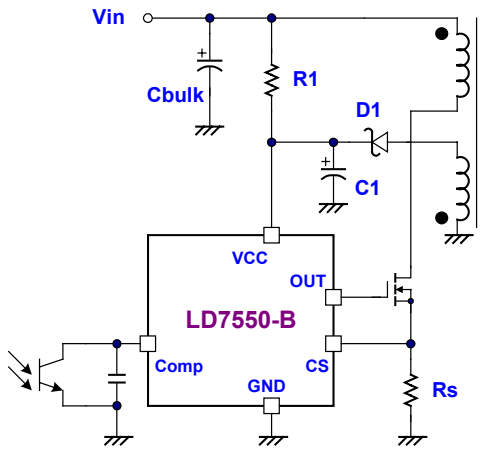


Fig. 14

A 350nS leading-edge blanking time is included in the input of CS pin to prevent the false-trigger caused by the current spike and further to eliminate the need of R-C filter which is usually needed in the typical UC384X application (Fig. 15).

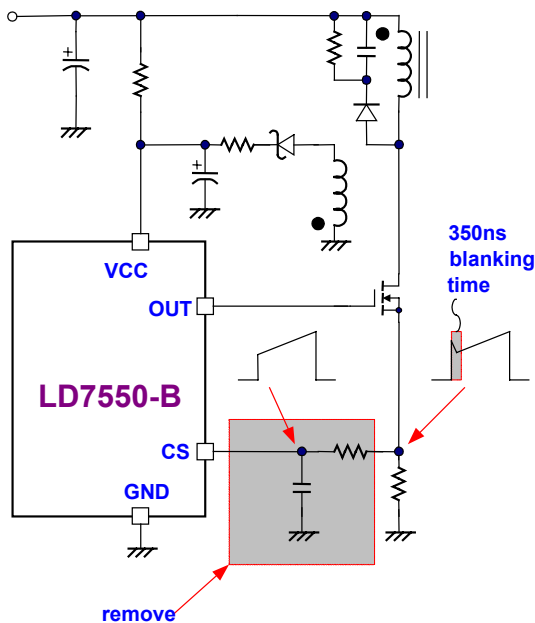


Fig. 15

Output Stage and Maximum Duty-Cycle

An output stage of a CMOS buffer, with typical 300mA driving capability, is incorporated to drive a power MOSFET directly. And the maximum duty-cycle of LD7550-B is limited to 75% to avoid the transformer saturation.

Oscillator and Switching Frequency

Connecting a resistor from RT pin to GND according to the equation can program the normal switching frequency:

$$f_{SW} = \frac{65.0}{RT(K\Omega)} \times 100(KHz)$$

The suggested operating frequency range of LD7550-B is within 50KHz to 130KHz.

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 LD7550-B. The input stage of LD7550-B, like the UC384X, is with 2 diodes voltage offset then to feed the voltage divider with 1/3 ratio, that is,

$$V_{+(PWM_{COMPARATOR})} = \frac{1}{3} \times (V_{COMP} - 2V_F)$$

A pull-high resistor is embedded internally, it can therefore be eliminated from the external circuit.

Internal Slope Compensation

In conventional application, the problem for the stability is a critical issue for current mode controlling, when it operates more than 50% of the duty-cycle. As UC384X, It takes slope compensation from injecting the ramp signal from the RT/CT pin through a coupling capacitor. On the other hand, there is no extra external component needed for the LD7550-B since it has integrated this function with it already.

On/Off Control

The LD7550-B can be turned off by pulling COMP pin lower than 1.2V. The gate output pin of the LD7550-B will be disabled immediately under such condition. The off-mode can be released when the pull-low signal is removed.

Dual-Oscillator Green-Mode Operation

There are many difference topologies has been implemented in different chips for the green-mode or power saving requirements such as “burst-mode control”, “skipping-cycle Mode”, “variable off-time control “...etc. The basic operation theory of all these approaches intended to

reduce the switching cycles under light-load or no-load condition either by skip some switching pulses or reduce the switching frequency.

What LD7550-B used to implement the power-saving operation is Leadtrend Technology's own IP. In such approaching, as shown in the block diagram, there are 2 oscillators implemented in LD7550-B. The first oscillator is to provide the normal switching frequency, which can be set by the RT pin through an external resistor. Under this operation mode, as shown in Fig. 16, the 2nd oscillation (green-mode oscillator) is not activated. Therefore, the rising-time and the falling-time of the internal ramp will be constant to achieve good stability over all temperature range. Under the normal operation, this oscillator will dominate the switching frequency.

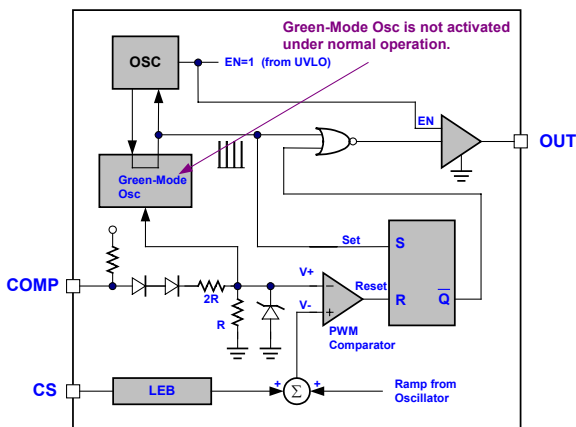


Fig. 16

The green-mode oscillator detects the signal of COMP pin to determine if it is within the green-mode operation. When the detected signal $V+$ is lower than the green-mode threshold V_{GREEN} , the green-mode oscillator is on. The green-mode oscillator, implemented by a VCO (voltage controlled oscillator), is a variable frequency oscillator. By using this dual-oscillator control, the green-mode frequency can be well controlled and further to avoid the generation of audible noise.

OVP (Over Voltage Protection) on Vcc

Most of the V_{GS} ratings of the modern power MOSFETs are 30V maximum. To prevent the V_{GS} from the fault condition, LD7550-B also integrates an OVP function on Vcc. Whenever the Vcc voltage is higher than the threshold voltage, the output gate drive circuit will be shut down simultaneously to stop the switching of the power MOSFET. Whenever the Vcc level gets back to lower level, the output will automatically return to the normal operation.

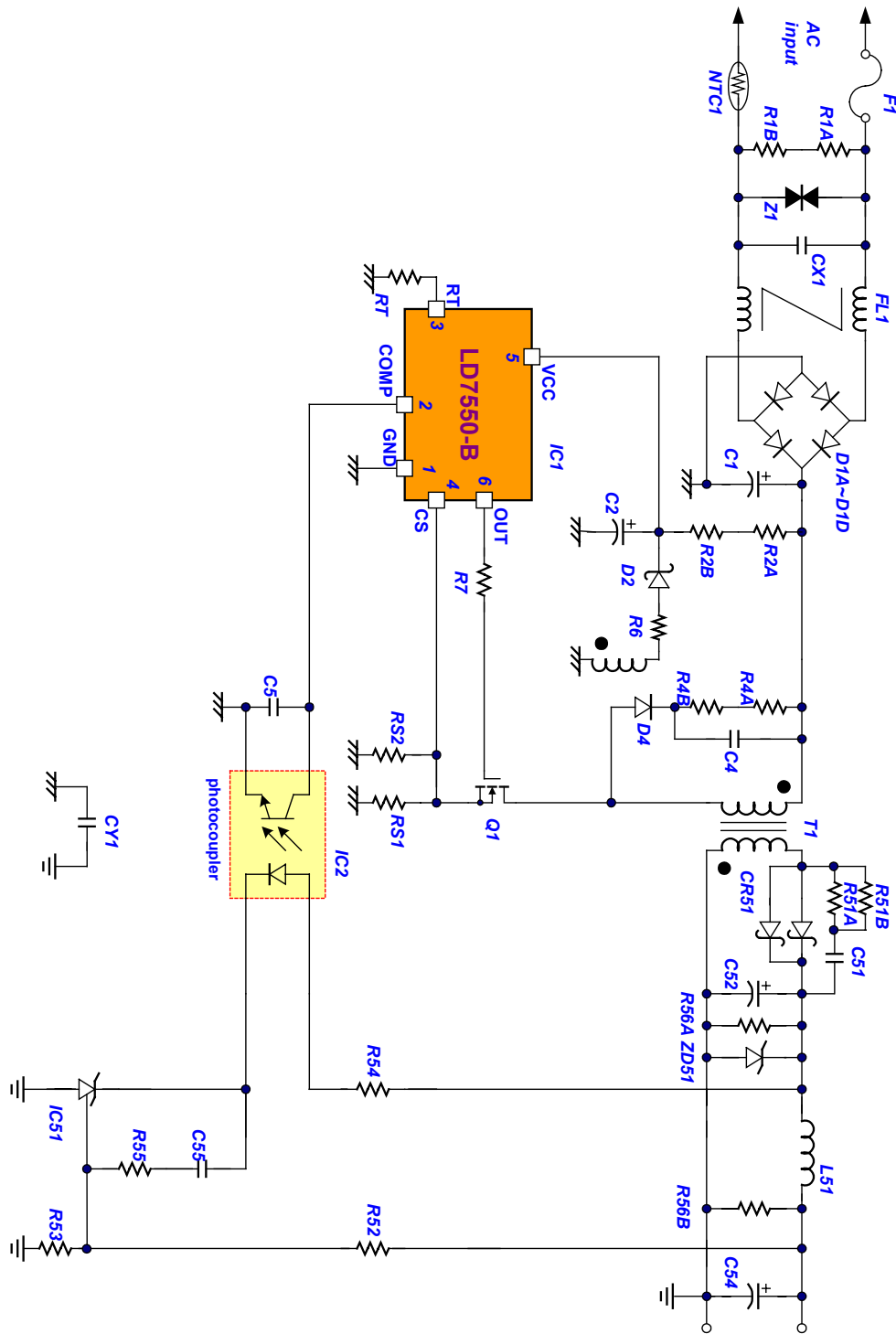
Fault Protection

Several curtail protection features have been integrated in the LD7550-B to protect the power supply or adapter from being damaged. Those damages usually come from open or short condition on the pins of LD7550-B. Under the conditions listed below, the gate output will active off immediately to protect the power circuit ---

- RT pin short to ground
- RT pin floating
- CS pin floating

Reference Application Circuit #1 --- 10W (5V/2A) Adapter

Schematic



Reference Application Circuit #1 --- 10W (5V/2A) Adapter

BOM

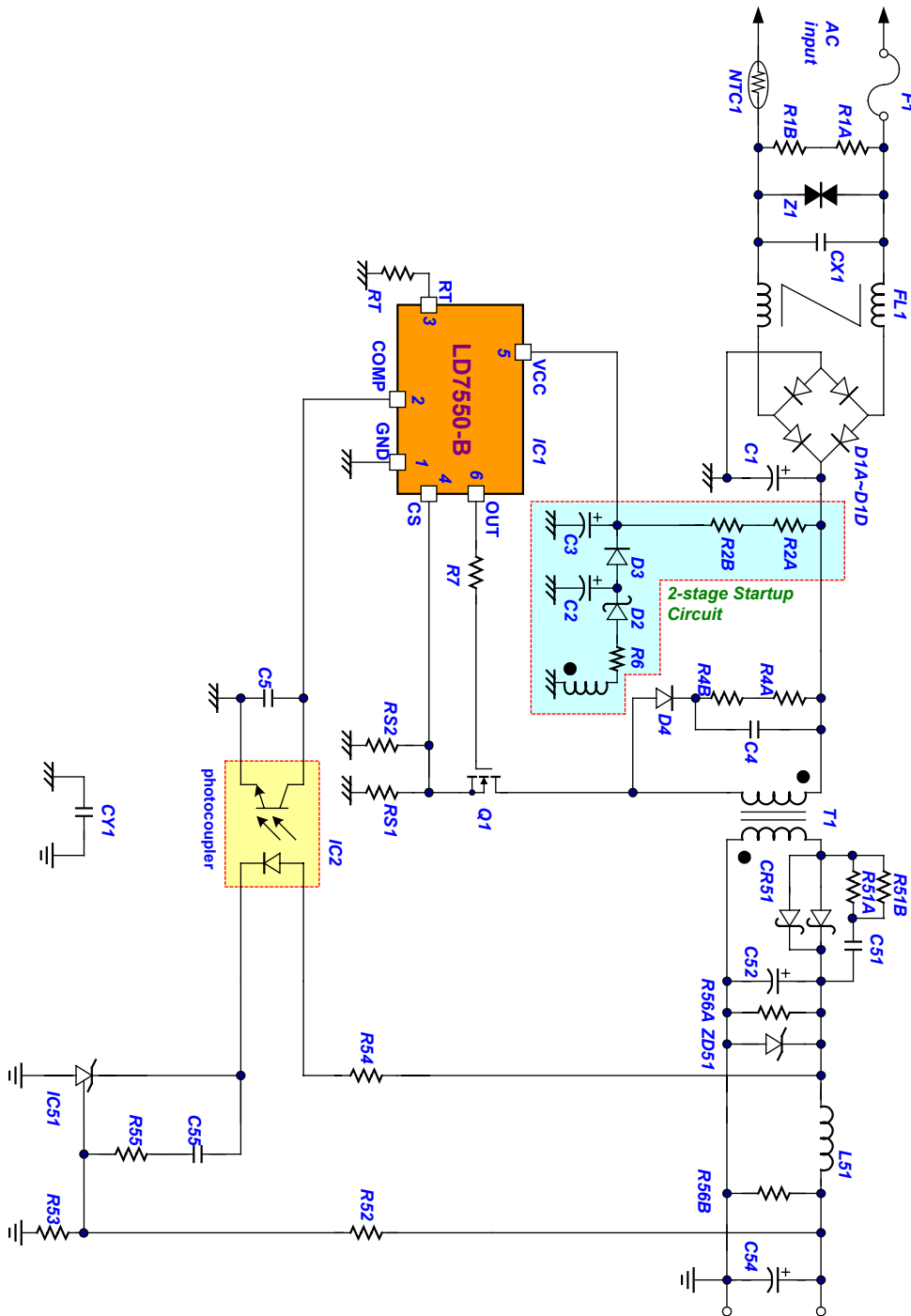
| P/N | Component Value | Original |
|------|---------------------------|----------|
| R1A | N/A | |
| R1B | N/A | |
| R2A | 750K Ω , 1206 | |
| R2B | 750K Ω , 1206 | |
| R4A | 39K Ω , 1206 | |
| R4B | 39K Ω , 1206 | |
| R6 | 10 Ω , 1206 | |
| R7 | 10 Ω , 1206 | |
| RS1 | 2.74 Ω , 1206, 1% | |
| RS2 | 2.74 Ω , 1206, 1% | |
| RT | 100K Ω , 0805, 1% | |
| R51A | 100 Ω , 1206 | |
| R51B | 100 Ω , 1206 | |
| R52 | 2.49K Ω , 0805, 1% | |
| R53 | 2.49K Ω , 0805, 1% | |
| R54 | 220 Ω , 0805 | |
| R55 | 10K Ω , 0805 | |
| R56A | 510 Ω , 1206 | |
| R56B | N/A | |
| NTC1 | 5 Ω , 3A | 08SP005 |
| FL1 | 20mH | UU9.8 |
| T1 | EI-22 | |
| L51 | 2.7 μ H | |

| P/N | Component Value | Note |
|------|-----------------------------|-----------|
| C1 | 22 μ F, 400V | L-tec |
| C2 | 10 μ F, 50V | L-tec |
| C4 | 1000pF, 1000V, 1206 | Holystone |
| C5 | 0.01 μ F, 16V, 0805 | |
| C51 | 1000pF, 50V, 0805 | |
| C52 | 1000 μ F, 10V | L-tec |
| C54 | 470 μ F, 10V | L-tec |
| C55 | 0.01 μ F, 16V, 0805 | |
| CX1 | 0.1 μ F | X-cap |
| CY1 | 2200pF | Y-cap |
| D1A | 1N4007 | |
| D1B | 1N4007 | |
| D1C | 1N4007 | |
| D1D | 1N4007 | |
| D2 | PS102R | |
| D4 | 1N4007 | |
| Q1 | 2N60B | 600V/2A |
| CR51 | SB540 | |
| ZD51 | 6V2C | |
| IC1 | LD7550-B IL | SOT-26 |
| IC2 | EL817B | |
| IC51 | TL431 | 1% |
| F1 | 250V, 1A | |
| Z1 | N/A | |

Reference Application Circuit #2 --- 10W Adapter with 2-Stage Startup Circuit

$P_{in} < 0.25W$ when $P_{out} = 0W$

Schematic



Reference Application Circuit #2 --- 10W Adapter with 2-Stage Startup Circuit

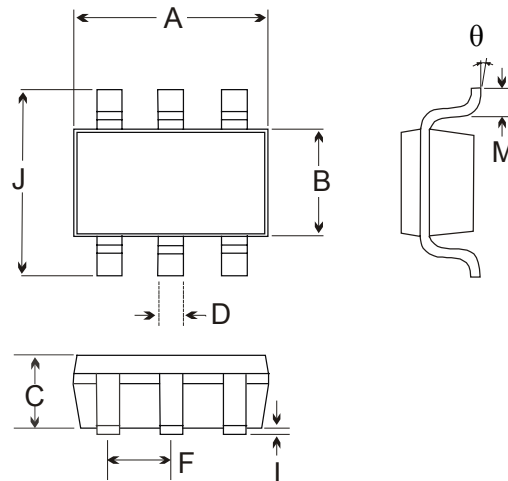
BOM

| P/N | Component Value | Original |
|------|---------------------------|----------|
| R1A | N/A | |
| R1B | N/A | |
| R2A | 2.2M Ω , 1206 | |
| R2B | 2.2M Ω , 1206 | |
| R4A | 39K Ω , 1206 | |
| R4B | 39K Ω , 1206 | |
| R6 | 2.2 Ω , 1206 | |
| R7 | 10 Ω , 1206 | |
| RS1 | 2.74 Ω , 1206, 1% | |
| RS2 | 2.74 Ω , 1206, 1% | |
| RT | 100K Ω , 0805, 1% | |
| R51A | 100 Ω , 1206 | |
| R51B | 100 Ω , 1206 | |
| R52 | 2.49K Ω , 0805, 1% | |
| R53 | 2.49K Ω , 0805, 1% | |
| R54 | 220 Ω , 0805 | |
| R55 | 10K Ω , 0805 | |
| R56A | 1K Ω , 1206 | |
| R56B | N/A | |
| NTC1 | 5 Ω , 3A | 08SP005 |
| FL1 | 20mH | UU9.8 |
| T1 | EI-22 | |
| L51 | 2.7 μ H | |

| P/N | Component Value | Note |
|------|-----------------------------|-----------|
| C1 | 22 μ F, 400V | L-tec |
| C2 | 10 μ F, 50V | L-tec |
| C3 | 2.2 μ F, 50V | |
| C4 | 1000pF, 1000V, 1206 | Holystone |
| C5 | 0.01 μ F, 16V, 0805 | |
| C51 | 1000pF, 50V, 0805 | |
| C52 | 1000 μ F, 10V | L-tec |
| C54 | 470 μ F, 10V | L-tec |
| C55 | 0.01 μ F, 16V, 0805 | |
| CX1 | 0.1 μ F | X-cap |
| CY1 | 2200pF | Y-cap |
| D1A | 1N4007 | |
| D1B | 1N4007 | |
| D1C | 1N4007 | |
| D1D | 1N4007 | |
| D2 | PS102R | |
| D3 | 1N4148 | |
| D4 | 1N4007 | |
| Q1 | 2N60B | 600V/2A |
| CR51 | SB540 | |
| ZD51 | 6V2C | |
| IC1 | LD7550-B IL | SOT-26 |
| IC2 | EL817B | |
| IC51 | TL431 | 1% |
| F1 | 250V, 1A | |
| Z1 | N/A | |

Package Information

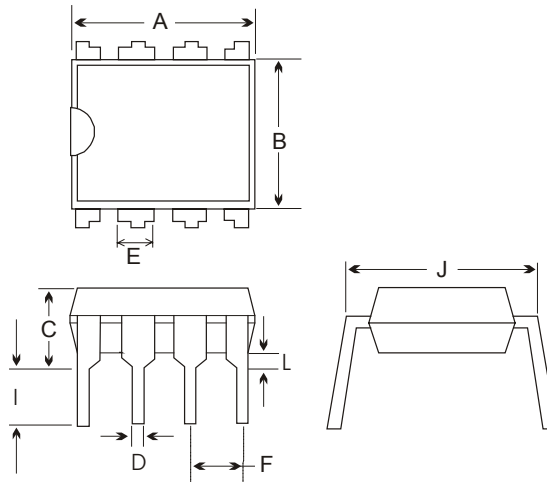
SOT-26



| Symbol | Dimension in Millimeters | | Dimensions in Inches | |
|----------|--------------------------|-------|----------------------|-------|
| | Min | Max | Min | Max |
| A | 2.692 | 3.099 | 0.106 | 0.122 |
| B | 1.397 | 1.803 | 0.055 | 0.071 |
| C | ----- | 1.450 | ----- | 0.058 |
| D | 0.300 | 0.550 | 0.012 | 0.022 |
| F | 0.838 | 1.041 | 0.033 | 0.041 |
| I | 0.050 | 0.150 | 0.002 | 0.006 |
| J | 2.600 | 3.000 | 0.102 | 0.118 |
| M | 0.300 | 0.600 | 0.012 | 0.024 |
| θ | 0 | 10° | 0 | 10° |

Package Information

DIP-8



| 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 | 0.290 | 0.325 |
| L | 0.381 | ----- | 0.015 | ----- |

Important Notice

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