

Green-Mode PWM Controller with Integrated Protections

Preliminary

General Description

The LD7550-B-O 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-B, LD7550-B-O has different parameters or functions on the following characteristics ---

- Add OLP (Over Load Protection) function to provide better protection performance for fault conditions like short circuit or over load.
- Modify the OVP (Over Voltage Protection) mechanism from the cycle-by-cycle mode to the hiccup mode.

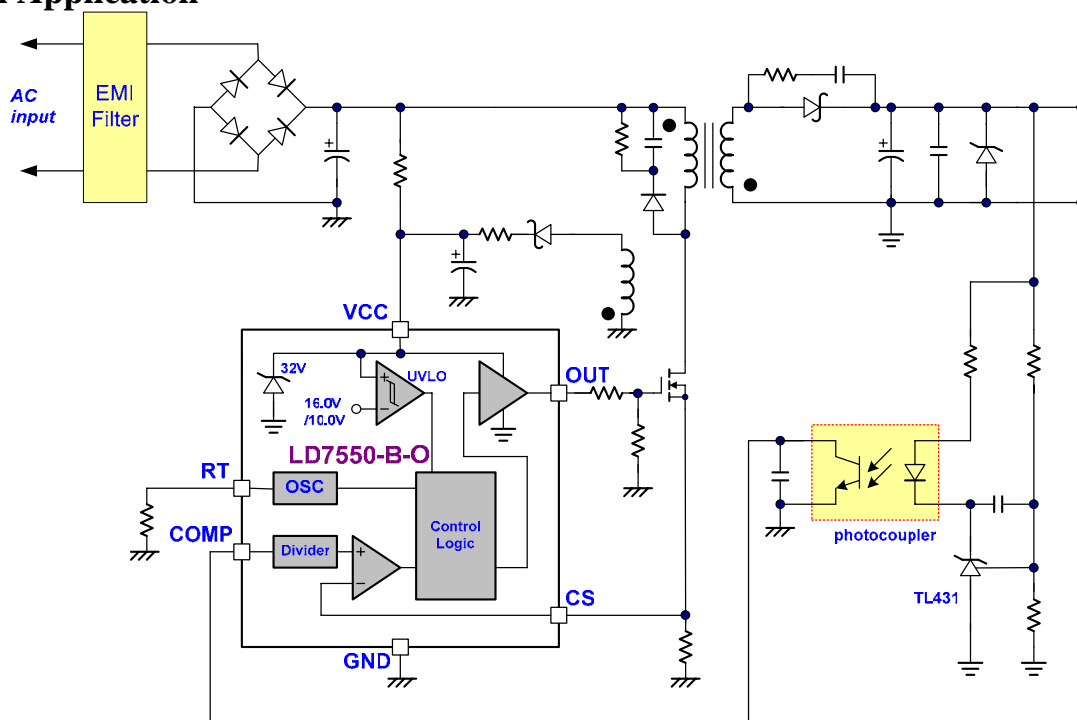
Features

- High-Voltage CMOS Process with Excellent ESD protection
- Very Low Startup Current ($<20\mu\text{A}$)
- Under Voltage Lockout (UVLO)
- Current Mode Control
- LEB (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
- OLP (Over Load Protection)

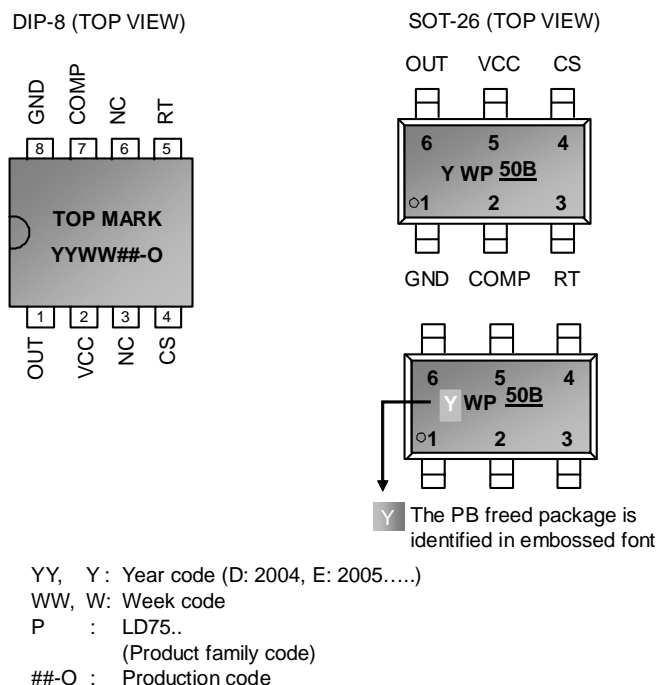
Applications

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

Typical Application



Pin Configuration



Ordering Information

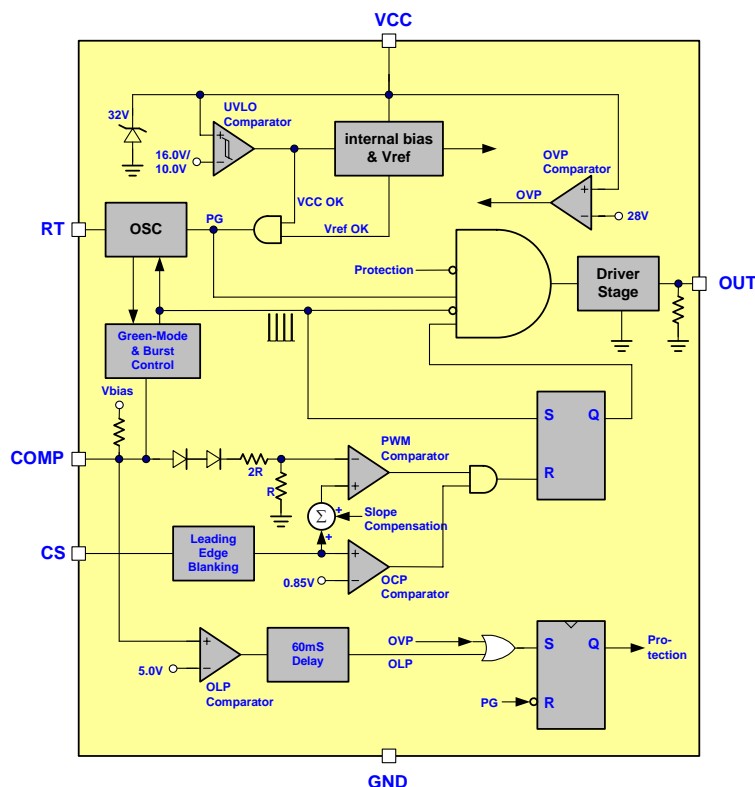
Part number	Package	TOP MARK	Shipping
LD7550-B-O IL	SOT-26	YWP/50B	3000 /tape & reel
LD7550-B-O IN	DIP-8	LD7550BIN	3600 /tube /Carton
LD7550-B-O BL	SOT-26 (PB free)	(*) YWP/50B	3000 /tape & reel
LD7550-B-O BN	DIP-8 (PB free)	LD7550BBN	3600 /tube /Carton

(*) printed in different font

Pin Descriptions

PIN (SOT-26)	NAME	FUNCTION
1	GND	Ground
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.
3	RT	This pin is to program the switching frequency. By connecting a resistor to ground to set the switching frequency.
4	CS	Current sense pin, connect to sense the MOSFET current
5	VCC	Supply voltage pin
6	OUT	Gate drive output to drive the external MOSFET

Block Diagram



Absolute Maximum Ratings

Supply Voltage VCC.....	30V
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.....	250°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.....	TBD
ESD Voltage Protection, Machine Model.....	TBD
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	28	29	V
Voltage Feedback (Comp Pin)					
Short Circuit Current	V _{COMP} =0V		2.2	3.0	mA
Open Loop Voltage	COMP pin open		6.0		V
Green Mode Threshold VCOMP			2.35		V
Open Loop Protection (OLP Latch)			5.0		V
OLP Delay Time			60		mS
Current Sensing (CS Pin)					
Maximum Input Voltage, Vcs(off)		0.80	0.85	0.90	V
Leading Edge Blanking Time			350		nS
Input impedance		1			MΩ
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

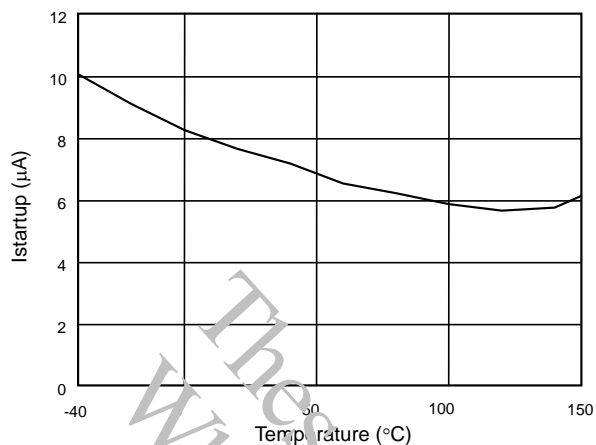


Fig. 1 Start up Current (I_startup) vs. Temperature

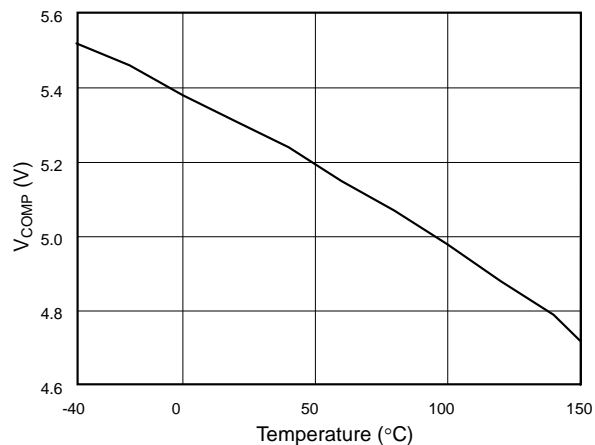


Fig. 2 V_COMP open loop voltage v.s. Temperature

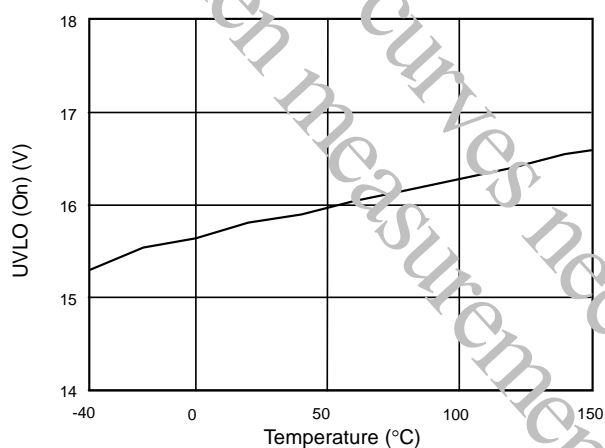


Fig. 3 UVLO (On) vs. Temperature

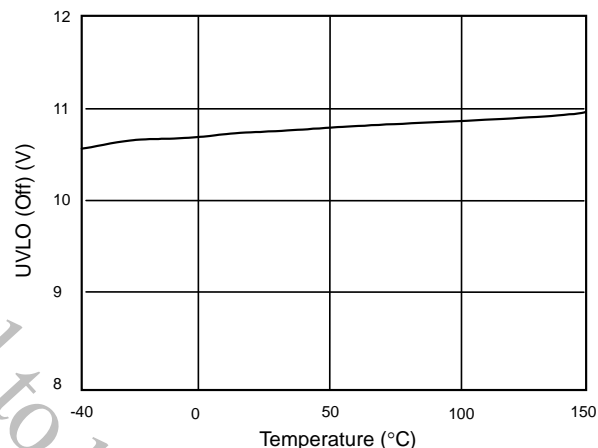


Fig. 4 UVLO Off v.s. Temperature

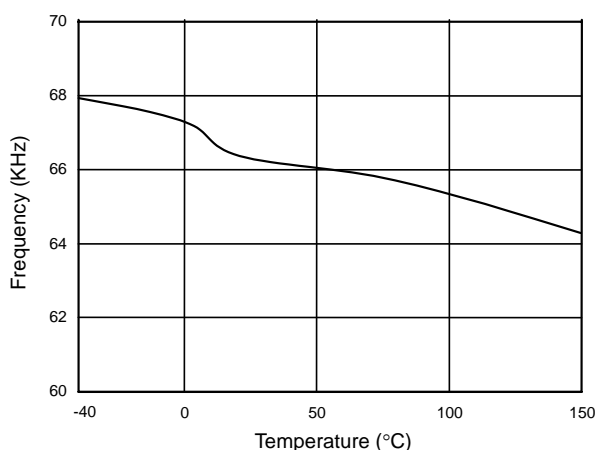


Fig. 5 Frequency v.s. Temperature

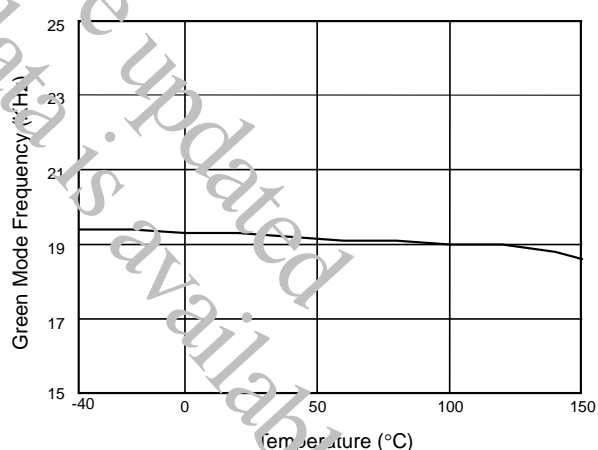


Fig. 6 Green Mode Frequency v.s. Temperature

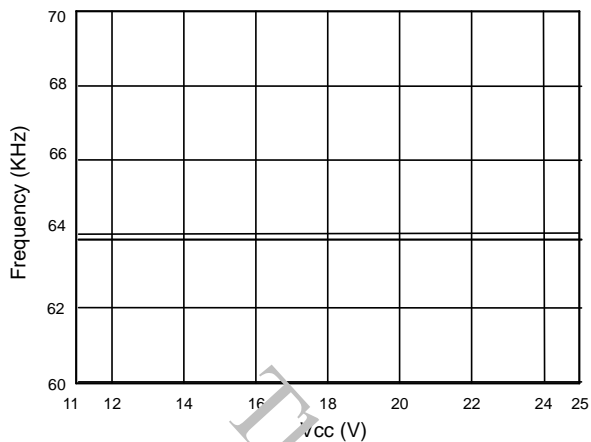


Fig. 7 Frequency v.s. Vcc

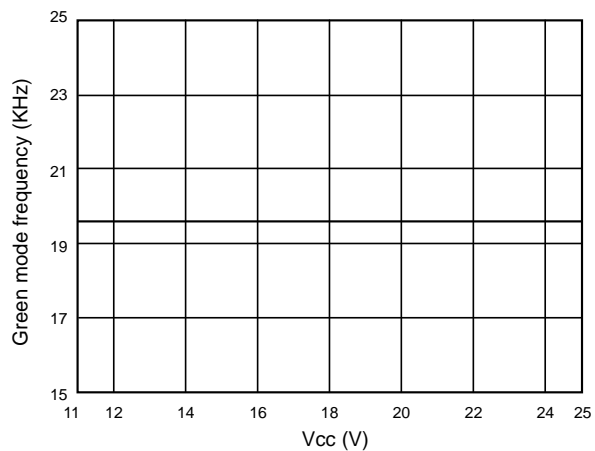


Fig. 8 Green mode frequency v.s. Vcc

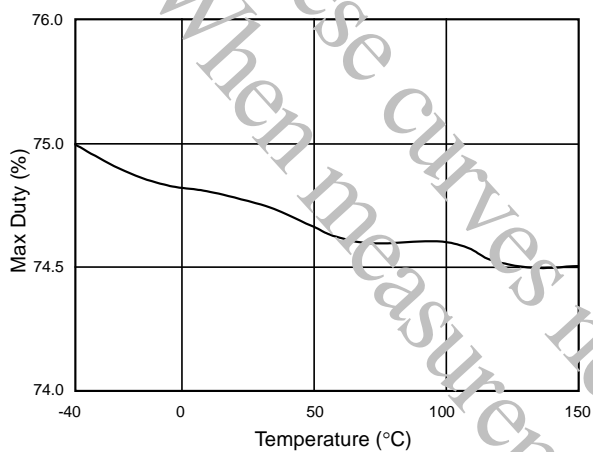


Fig. 9 Max Duty v.s. Temperature

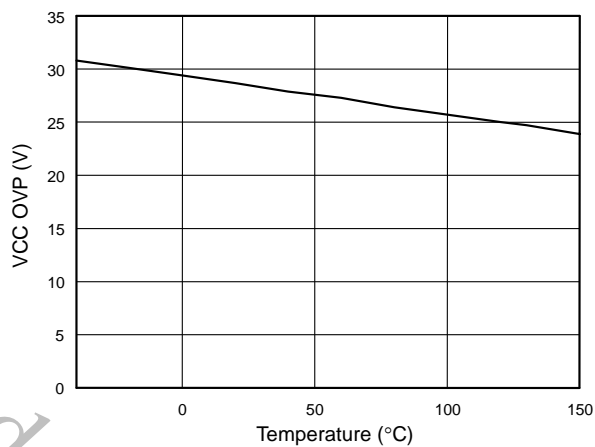


Fig. 10 VCC OVP v.s. Temperature

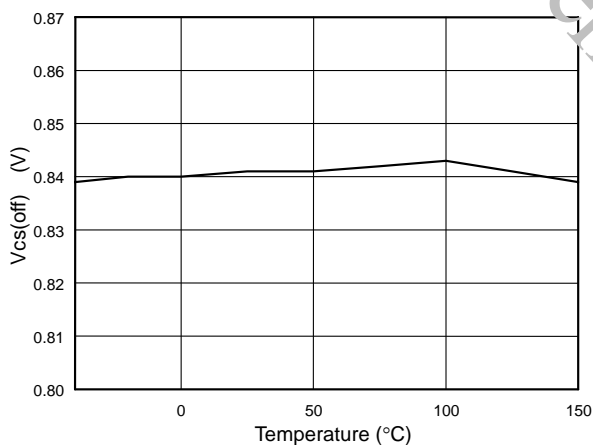


Fig. 11 Vcs (off) v.s. Temperature

Application Information

Operation Overview

The LD7550-B-O meets the green power requirement and is intended for the use in those modern switching power suppliers 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 turn on the LD7550-B-O 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.

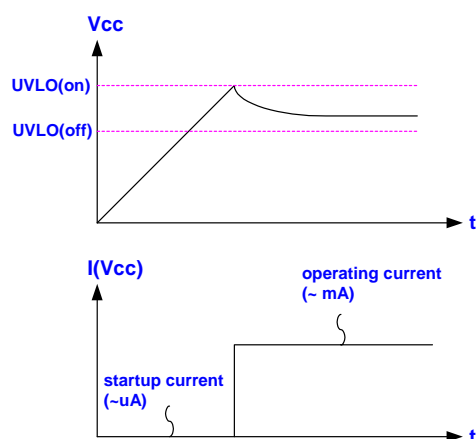


Fig. 12

Startup Current and Startup Circuit

The typical startup circuit to generate the LD7550-B-O is shown in Fig. 13. During the startup transient, the Vcc is lower than the UVLO threshold thus there is no gate pulse produced from LD7550-B-O to drive power MOSFET. Therefore, the current through R1 will provide the startup current and to charge the capacitor C1. Whenever the Vcc voltage is high enough to turn on the LD7550-B-O and further to deliver the gate drive signal, the supply current is provided from the auxiliary winding of the transformer.

Lower startup current requirement on the PWM controller will help to increase the value of R1 and then reduce the power consumption on R1. By using CMOS process and the special circuit design, the maximum startup current of LD7550-B-O is only 20μA.

If a higher resistance value of the R1 is chosen, it usually takes more time to start up. To carefully select the value of R1 and C1 will optimize the power consumption and startup time.

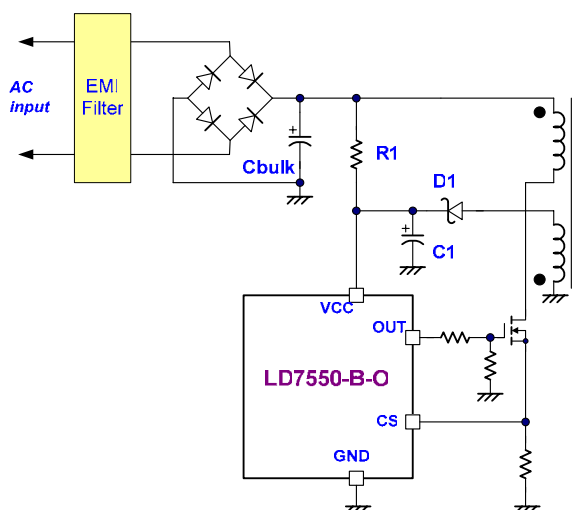


Fig. 13

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. As shown in Fig. 14, the LD7550-B-O 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 obtained from below.

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

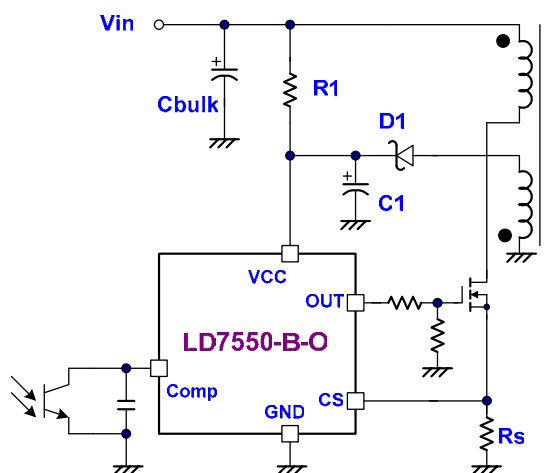


Fig. 14

A 350nS leading-edge blanking (LEB) time is included in the input of CS pin to prevent the false-trigger from the current spike. In the low power application, if the total pulse width of the turn-on spikes is less than 350nS and the negative spike on the CS pin doesn't exceed -0.3V, it could eliminated the R-C filter (as shown in the figure15).

However, the total pulse width of the turn-on spike is decided by the output power, circuit design and PCB layout. It is strongly recommended to adopt a smaller R-C filter (as shown in figure 16) for higher power application to avoid the CS pin being damaged by the negative turn-on spike.

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-O is limited to 75% to avoid the transformer saturation.

Oscillator and Switching Frequency

Connect a resistor from RT pin to GND according to the equation below to program the normal switching frequency:

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

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

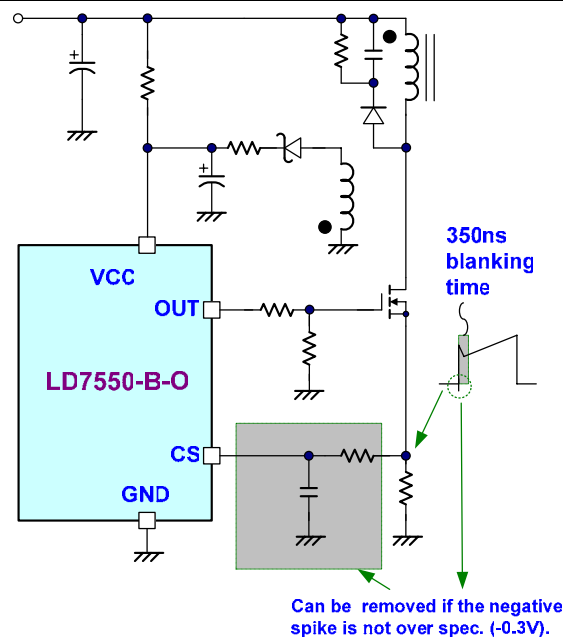


Fig. 15

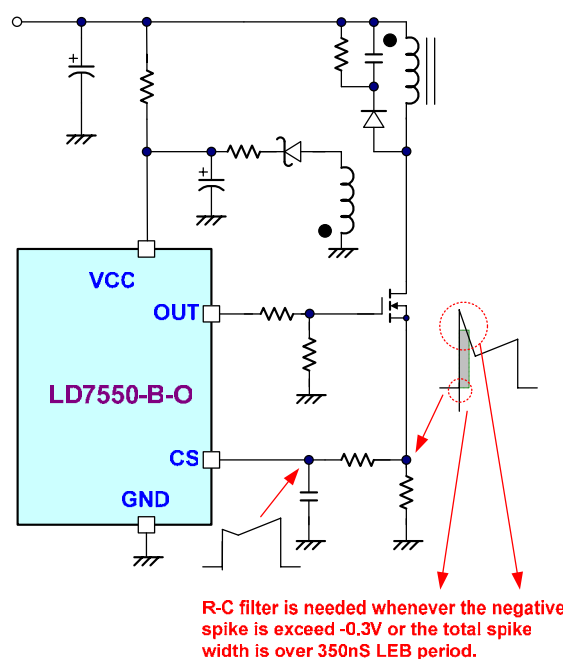


Fig. 16

Voltage Feedback Loop

The voltage feedback signal is provided from the TL431 at the secondary side through the photo-coupler to the COMP pin of LD7550-B-O. The input stage of LD7550-B-O, like the UC384X, carries 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 and can be eliminated externally.

Internal Slope Compensation

In the conventional application, the problem of the stability is a critical issue for current mode controlling, when it operates in higher than 50% of the duty-cycle. As UC384X, It takes slope compensation from injecting the ramp signal of the RT/CT pin through a coupling capacitor. It therefore requires no extra design for the LD7550-B-O since it has integrated 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-O 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 different 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 skipping some switching pulses or reduce the switching frequency.

What LD7550-B-O uses 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 are implemented in LD7550-B-O. The first oscillator is to set the normal switching frequency, which can be set by the RT pin through an external resistor. In such operation mode, as shown in Fig. 17, the 2nd oscillation (green-mode oscillator) does not activate. 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.

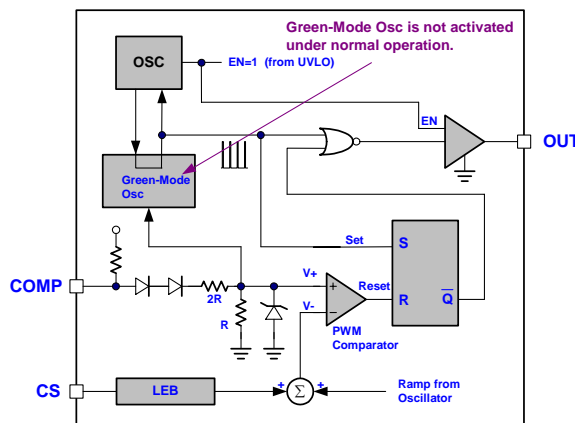


Fig. 17

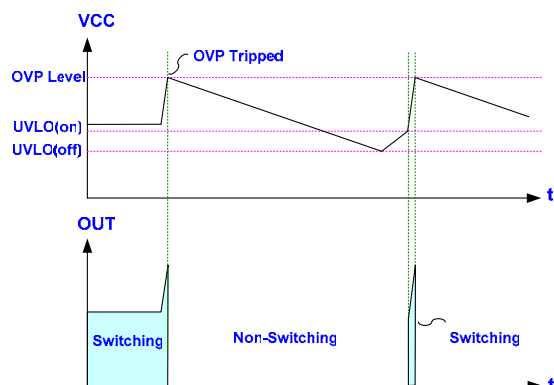
The green-mode oscillator will detect the signal of COMP pin to determine if it meets the requirement of operation. When the signal of V₊ is lower than the green-mode threshold V_{GREEN}, the green-mode oscillator will activate. The green-mode oscillator, implemented by a VCO (voltage controlled oscillator), 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

The V_{gs} ratings of the nowadays power MOSFETs are often limited up to max. 30V. To prevent the V_{gs} from the fault condition, LD7550-B-O is implemented an OVP function on V_{cc}. Whenever the V_{cc} voltage is higher than the OVP threshold voltage, the output gate drive circuit will be shutdown simultaneously thus to stop the switching of the power MOSFET until the next UVLO(on).

The V_{cc} OVP function in LD7550-B-O is an auto-recovery type protection. If the OVP condition, usually caused by the feedback loop opened, is not released, the V_{cc} will tripped the OVP level again and re-shutdown the output. The V_{cc} is working as a hiccup mode. The figure 18 shows its operation.

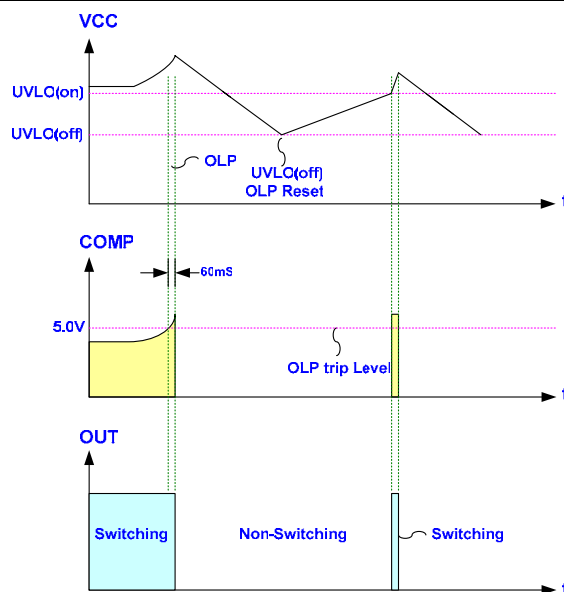
On the other hand, if the OVP condition is removed, the V_{cc} level will get back to normal level and the output will automatically return to the normal operation.


Fig. 18

Over Load Protection (OLP)

To protect the circuit from being damaged under over load condition or short condition, a smart OLP function is implemented in the LD7550-B-O. The figure 19 shows the waveforms of the OLP operation. In this case, the feedback system will force the voltage loop proceed toward the saturation and then pull up the voltage on COMP pin (Vcomp). Whenever the Vcomp trips up to the OLP threshold 5V and stays longer than 60mS, the protection will activate and then turn off the gate output to stop the switching of power circuit. The 60mS delay time is to prevent the false trigger from the power-on and turn-off transient.

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


Fig. 19

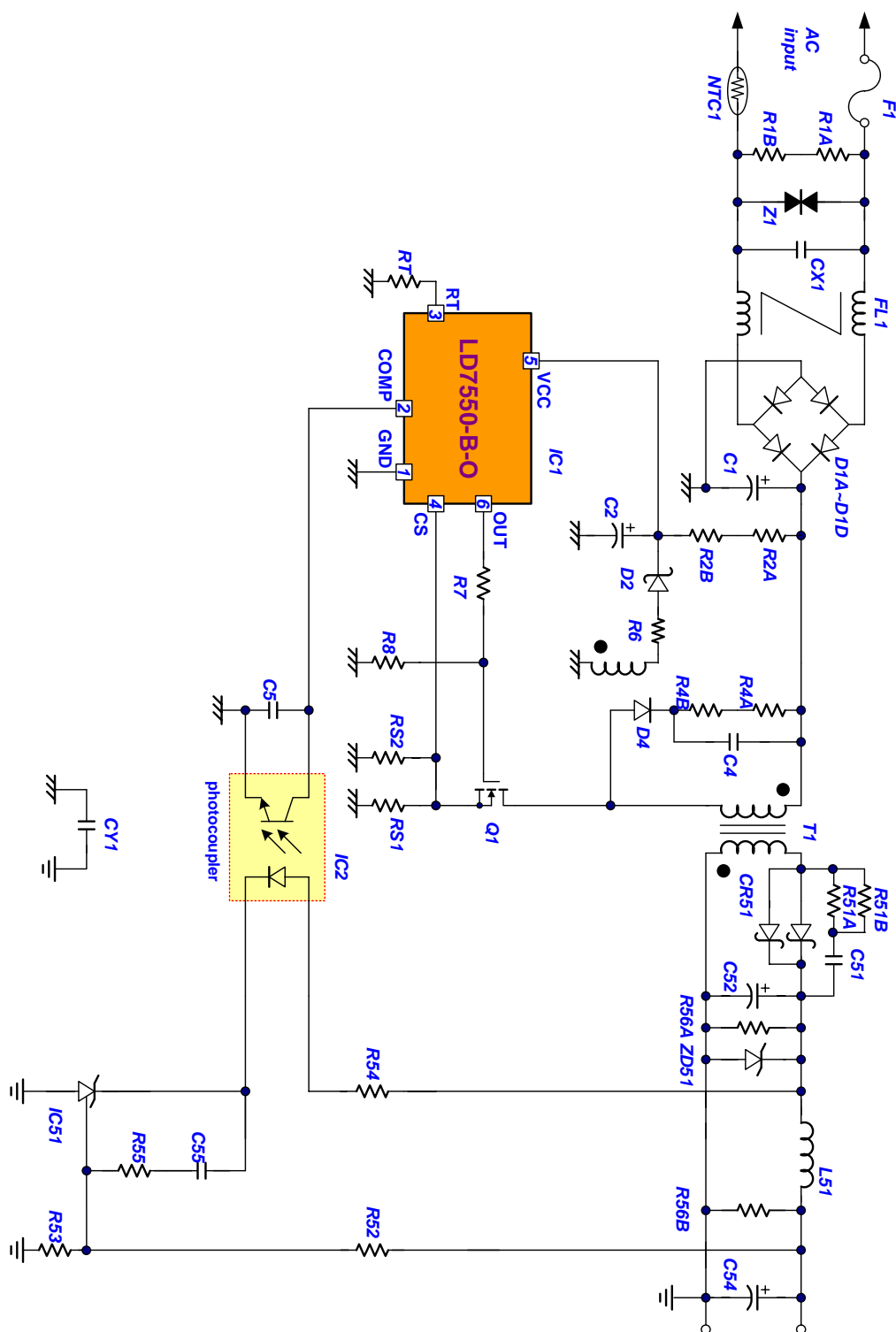
Fault Protection

Several curtail protection features have been integrated in the LD7550-B-O 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-O. Under the conditions listed below, the gate output will turn off immediately to protect the power circuit ---

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

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

Schematic



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

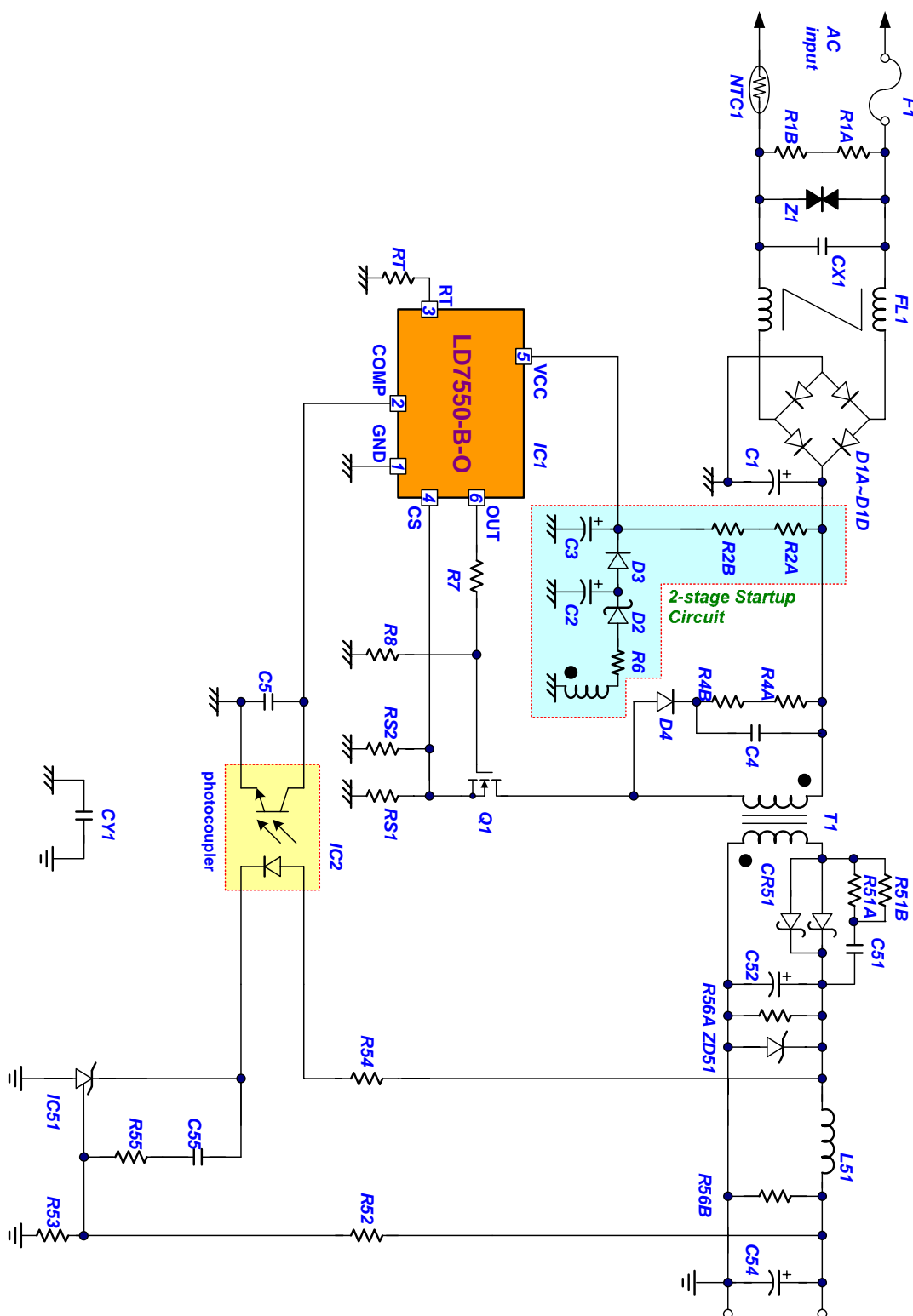
BOM

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	
R8	10K Ω , 1206	
RS1	2.70 Ω , 1206, 1%	
RS2	2.70 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	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	
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-O 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

Pin < 0.25W when Pout = 0W

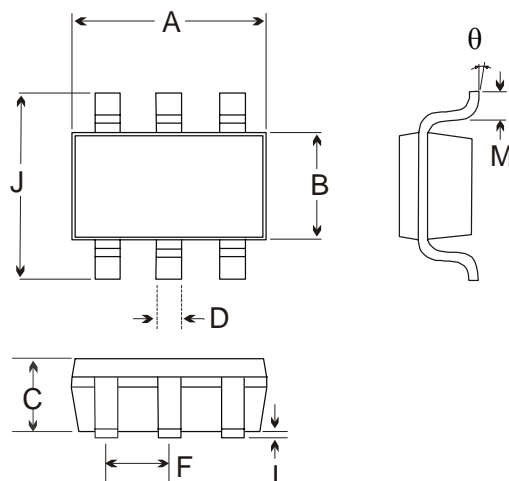


Reference Application Circuit #2 --- 10W Adapter with 2-Stage Startup Circuit

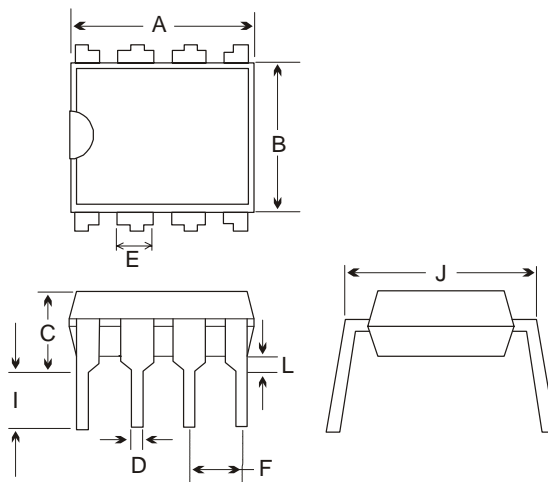
BOM

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	
R8	10K Ω , 1206	
RS1	2.70 Ω , 1206, 1%	
RS2	2.70 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-O 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	0.29	0.325
L	0.381	-----	0.015	-----

Important Notice

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