Overview

The TP8533D is a high-efficiency non-isolated step-down LED constant current driver IC. It is suitable for non-isolated step-down LED constant current driver with 85VAC~265VAC full voltage input range.

The TP8533D integrates a high-precision current detection and constant current driver circuit, enabling highly accurate LED constant current output and excellent line voltage regulation. At the same time, the TP8533D operates in the peak current turn-off, and the zero-current conduction inductor current critical mode, the LED output current does not change with the inductance and the LED output voltage, thus has excellent load regulation and changes in the inductance Sensitive advantages.

The TP8533D integrates a 500V power transistor and uses a source driver. The operating current of the chip is very low. No auxiliary winding detection and power supply are required. No compensation components are required. Only a few external components are needed to achieve high efficiency LED constant current. The output greatly saves the cost and volume of the system.

The TP8533D has a wide operating voltage range and is suitable for AC input voltages from 85VAC to 265VAC over the full voltage range. At the same time, TP8533D integrates multiple protection functions to ensure the stability and reliability of the system. Including LED open circuit, short circuit protection, CS resistance short circuit protection, chip temperature control and chip supply under voltage protection.

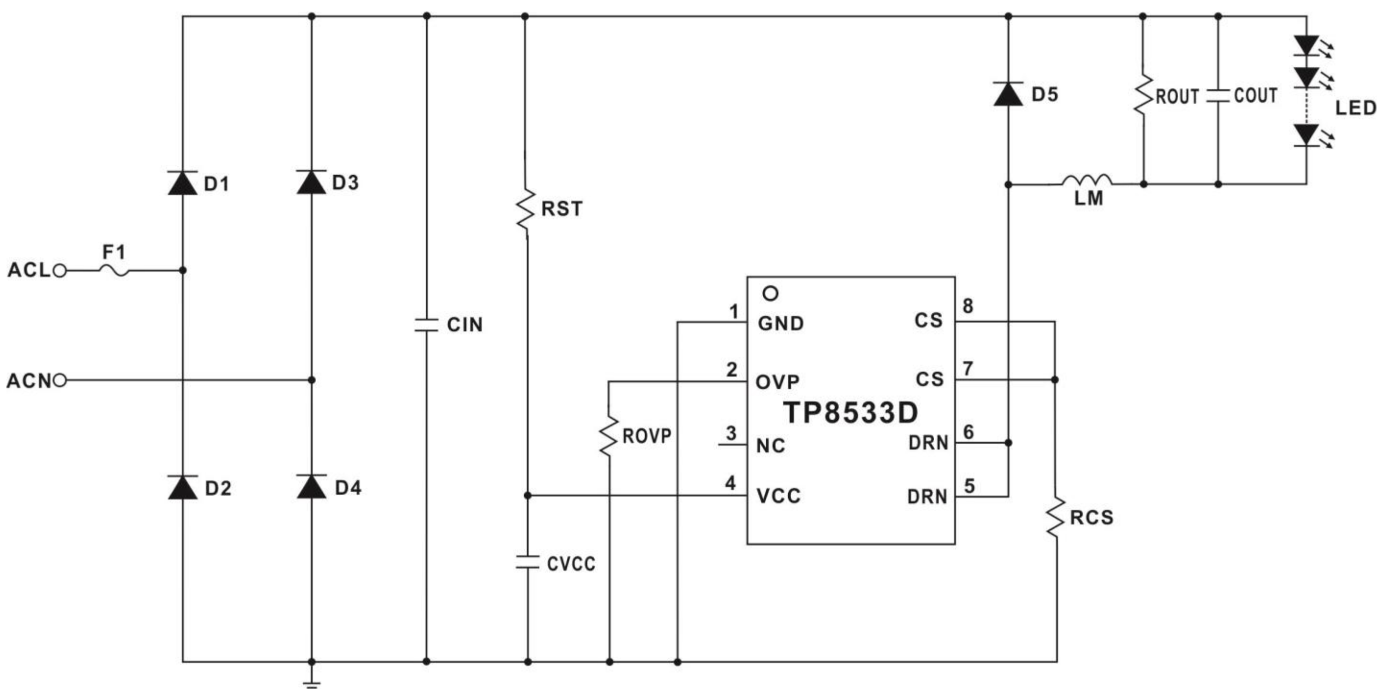
Features

- Internal integrated 500V power tube
- Inductive current critical mode
- Ultra low operating current
- No need for auxiliary winding detection and power supply
- Wide input voltage
- High system work efficiency
- ±5% LED output current accuracy
- LED open/short circuit
- CS Resistor Short Circ
- Chip Supply Undervoltage Protection
- Chip temperature intelligent control
- Insensitive to inductance changes
- Automatic restart function
- Low system BOM cost
- DIP8L package

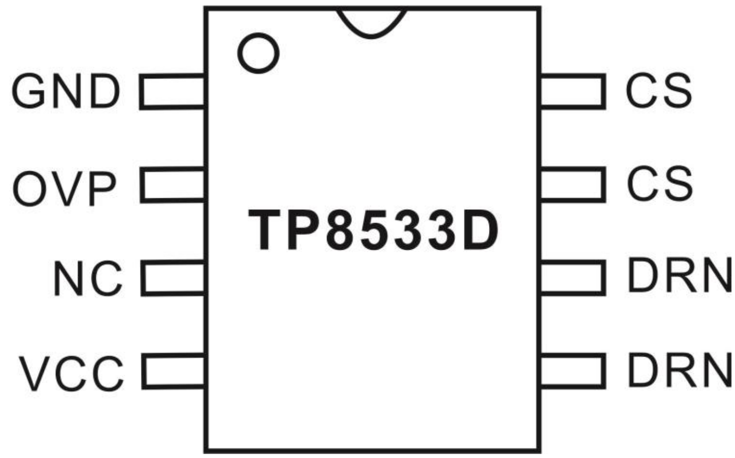
Application

- LED bulb light, candle
- LED fluorescent light, PAR
- Other LED lighting

Typical application circuit



Pin



DIP8L

Pin description

Pin number	Pin name	Description
1	GND	Chip ground
2	OVP	LED output open circuit protection voltage setting pin, connect resistor to ground
3	NC	no connection
4	VCC	Chip voltage pin
5,6	DRN	Internal high voltage power
7,8	CS	Inductance peak current detection section, connecting resistance to ground

Limit parameters (Note 1)

Parameter	Rated value	unit
VIN to GND voltage	-0.3~+20	V
DRN to GND voltage	-0.3~+500	V
CS ,OVP to GND voltage	-0.3~+6	V
VCC pin supply current	5	mA
Power loss	1	W
Storage environment temperature	-50~+150	℃
Operating junction temperature range	-40~+150	℃
ESD Level (HBM)	2000	V
ESD Level (MM)	200	V

Recommended working area

parameter	symbol	Working conditions	Recommended value	unit
Output Power	P_{OUT}	V_{VIN}=175VAC~265VAC;V_{OUT}=80V	<24	W
Minimum LED output voltage	V_{LED}	normal work	>30	V

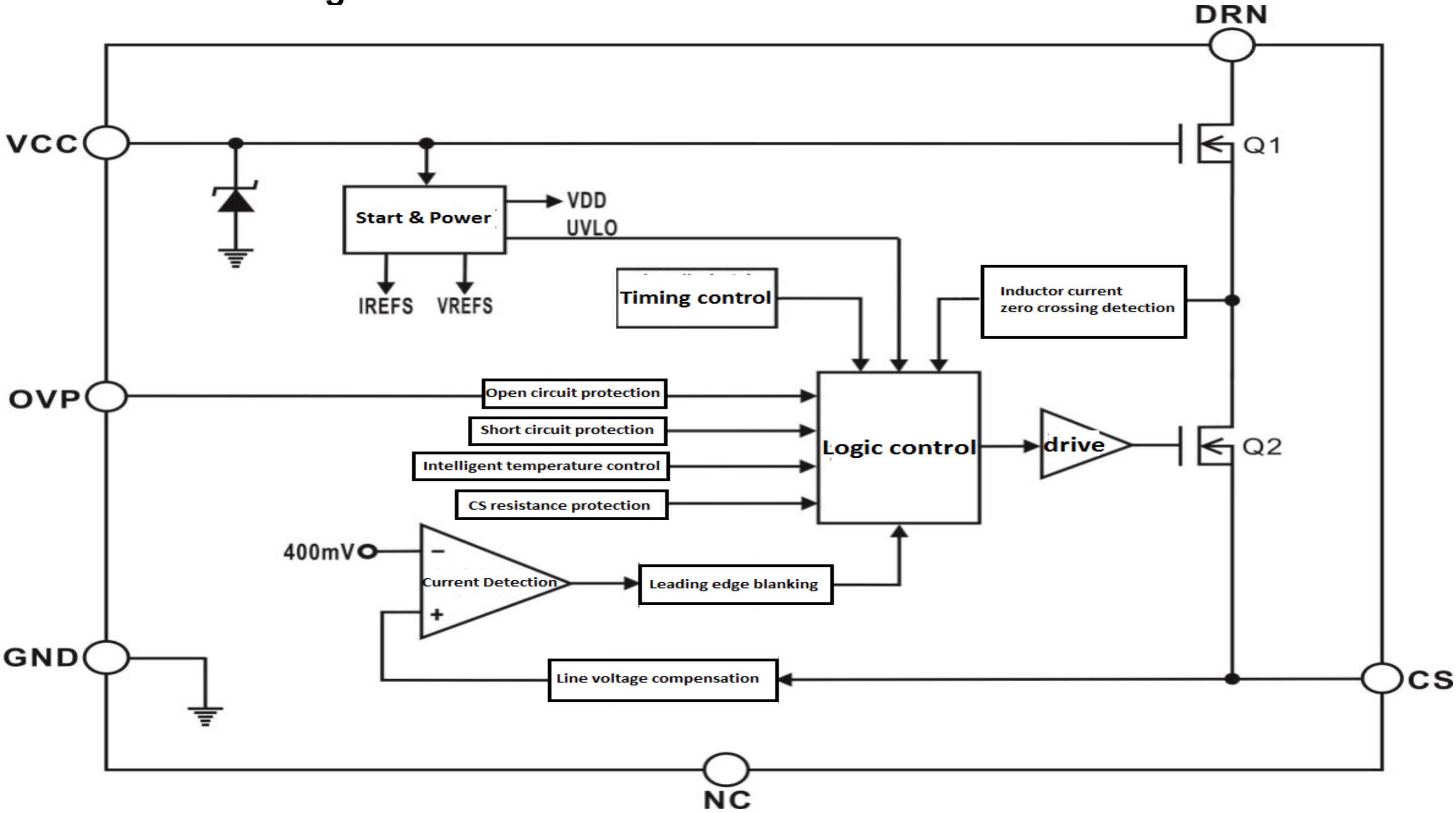
Note 1: The maximum limit means that the chip may be damaged beyond this working range. The recommended operating range is that the chip works well within this range but does not fully guarantee that the individual performance metrics are met. The electrical parameters define the DC and AC electrical parameter specifications of the device within the operating range and under test conditions that guarantee specific performance specifications. For unspecified upper and lower limit parameters, the specification does not guarantee its accuracy, but its typical value reflects the device performance.

Electrical parameters

(No special instructions，Ta=25℃，VCC=18V)

symbol	parameter	Test Conditions	Min	Typical value	Maximum	unit
Power start						
V_{ST}	VDD startup voltage	VDD rise		17		V
V_{UV}	VDD undervoltage lockout	VDD down		9.3		V
V_{CLP}	VDD clamp voltage	I_{VCC}=1mA		18.8		V
I_{ST}	VDD startup current	V_{VCC}=V_{ST}-1V		200		μA
I_{OP}	VDD operating current	F_{OSC}=60KHZ		165		μA
Current control						
V_{REF}	Inductance Peak Current Detection Threshold		388	400	412	mV
V_{CS_SHORT}	Inductor peak current detection threshold at LED short-circuit	LED short circuit		100		mV
T_{LEB}	Current detection leading edge blanking time			350		ns
T_{DELAY}	Chip turn-off delay			200		ns
Timing control						
T_{ON_MAX}	Maximum on-time			60		μs
T_{OFF_MIN}	Minimum off-time			3.5		μs
T_{OFF_MAX}	Maximum off-time			240		μs
V_{OVP}	OVP pin voltage			0.5		V
Power tube						
R_{ON}	Power tube on resistance	V_{GS}=18V/I_{DS}=0.5A		5		Ω
BV_{DSS}	Power tube breakdown voltage	V_{GS}=0/I_{DS}=250μA	500			V
I_{LEAK}	Power tube leakage current	V_{GS}=0/I_{DS}=500V			1	μA
Intelligent temperature control						
T_{RED}	Output current intelligent temperature control start temperature			150		℃

Internal block diagram



Application note

The TP8533D is a high-efficiency non-isolated step-down LED constant current driver chip for non-isolated step-down LED constant current driver with 85VAC~265VAC full voltage input range. The TP8533D operates at the peak current turn-off and in the critical current mode of inductor current with zero current conduction, the LED output current does not change with the inductance and the LED output voltage. The TP8533D integrates a 500V power transistor and uses a source driver. It does not require auxiliary winding detection and power supply. It requires only a few external components to achieve constant-current output of high-efficiency LEDs, saving system cost and size.

Boot process

After the system is powered on, the bus voltage charges the VCC capacitor through the startup resistor. When the VCC voltage reaches the turn-on threshold of the chip, the control circuit inside the TP8533D starts to operate. The operating current required for the chip to work is very low, so no auxiliary winding power is needed. When VCC voltage rises to the chip's clamp voltage, VCC will be clamped. When the VCC voltage drops to the off-voltage of the chip, the TP8533D undervoltage locks.

Output current setting

When the power tube begins to conduct, the current on the inductor begins to ramp up, and the voltage at the CS pin also ramps up. When the CS pin voltage reaches the peak current detection threshold voltage, the power transistor turns off. After the power transistor is turned off, the electricity

The sensed current begins to ramp down, and when the inductor current drops to zero, the power transistor resumes conduction. Therefore, the average LED output current is half the inductor peak current:

$$I_{LED} = \frac{I_{LPK}}{2} = \frac{V_{REF}}{2\times R_{CS}} = \frac{400}{2\times R_{CS}}(mA)$$

Among them, ILPK is the peak current of the inductor; VREF is the peak current detection voltage threshold of the inductor; RCS is the peak value of the inductor current sense resistor.

From the above equation, the average LED output current is determined by the CS resistor and the internal 400mV reference voltage of the chip, which is insensitive to the inductance.

Inductor selection

The TP8533D operates in critical inductor current mode. When the power transistor turns on, the inductor current ramps up from zero to its peak value. The turn-on time is:

$$T_{ON} = \frac{L\times I_{LPK}}{V_{DC}-V_{LED}}$$

Among them, L is the inductance; VDC is the bus voltage after input rectification; VLED is the output LED voltage.

When the power transistor is turned off, the inductor current drops from the peak to zero and the off-time is:

$$T_{OFF} = \frac{L \times I_{LPK}}{V_{LED}}$$

Therefore, the operating frequency of the system can be:

$$f_{osc} = \frac{V_{LED} \times (V_{DC} - V_{LED})}{L \times I_{LPK} \times V_{DC}}$$

From the above equation, the operating frequency of the system is related to the input voltage, LED output voltage, peak inductor current, and inductance. When the inductance is determined, the operating frequency of the system increases with the input voltage.

The TP8533D limits the system's maximum off-time and minimum off-time. If the inductor L is selected too small, TOFF will be less than the minimum off-time of the chip, the system will operate in the inductor current discontinuous mode; if the inductor L is selected too large, TOFF will be greater than the chip's maximum off-time, the system will work in the inductor Continuous current mode; this will cause the LED output current to deviate from the design value. Therefore, it is necessary to select a suitable inductor L so that the system can operate in a suitable frequency range, and the system efficiency and EMI can be taken into consideration.

Open circuit protection settings

When the LED output is open, the system will still charge the output capacitor and the output voltage will gradually increase. Therefore, it is necessary to limit the output voltage when the LED is open to ensure that the output capacitor will not be damaged by overvoltage when the LED is open.

When the LED output opens, the output voltage rises and the demagnetization time of the inductor decreases. The corresponding inductor demagnetization time TOVP can be calculated based on the required LED output open-circuit protection voltage.

$$T_{OVP} = \frac{V_{REF} \times L}{R_{CS} \times V_{OV}}$$

Among them, VOV is the set value of LED open protection voltage; VREF is the inductive peak current detection threshold.

Calculate the resistance of the OVP pin by TOVP time:

$$R_{OVP} \approx 2.3 \times T_{OVP} \times 10^6 (k\Omega)$$

When the LED output open circuit protection occurs, the system operates in the hiccup mode. Connecting an output resistor in parallel with the output terminal can consume the energy generated by the system repeatedly to limit the output voltage.

Protective function

The TP8533D integrates multiple protection functions to ensure the stability and reliability of the system. Including LED open circuit, short circuit protection, CS resistor short circuit protection, core

Chip temperature intelligent control and chip power supply undervoltage protection.

When the LED is short-circuited, the peak inductor current detection threshold is reduced to 100mV. The system operates at 4KHz and has low power consumption. When an abnormal condition such as an open LED or a short circuit of the CS sampling resistor occurs, the chip will quickly detect and trigger the protection logic, and the system will immediately stop working and enter the protection state.

Once the system is locked, the system will enter the automatic restart mode. After the system completes the automatic restart, if the abnormal condition still exists, the system will work in the hiccup mode until the abnormal condition is resolved.

TP8533D has intelligent temperature control function to avoid chip high temperature damage. When the chip temperature exceeds 150°C, the output current of the LED gradually decreases to zero as the temperature increases, thereby intelligently controlling the output power and temperature of the chip; at the same time, it avoids the traditional over-temperature shutdown mode. The LED flicker phenomenon improves the reliability of the system.

PCB layout

The TP8533D recommends PCB layout in accordance with the following rules:

Ground line

The power trace of the current sense resistor should be as short as possible and the power ground should be separated from the chip ground and other small signal grounds. Eventually these grounds merge to the ground of the input bus capacitance.

Bypass capacitor

The bypass capacitor of VCC needs to be close to the VCC pin and GND pin of the chip.

OVP resistance

The setting resistance of the LED open circuit protection voltage needs to be close to the OVP pin of the chip.

Power loop area

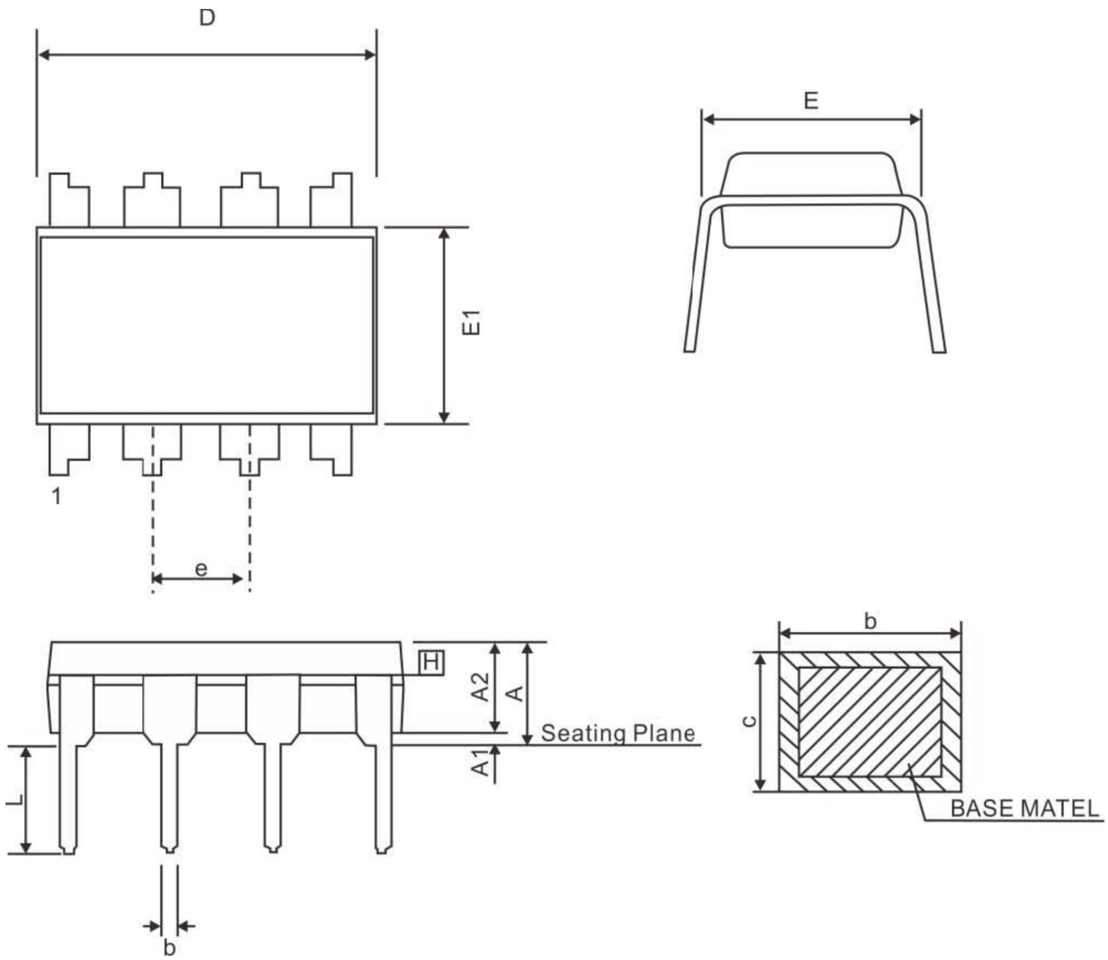
The area of the power loop should be as small as possible, such as the area of the current loop consisting of the inductor, power tube, CS resistor, input capacitor, and current loop area composed of inductor, freewheeling diode, and output capacitor. This improves the EMI characteristics of the system.

Thermal considerations

When PCB traces, it is recommended to increase the copper area of the DRN pin so that it is beneficial to the thermal dissipation of the TP8533D.

Package size

SOP8L



symbol	Mm		
	Min	standard value	Maximum
A	-	-	4.80
A1	0.50	-	-
A2	3.10	3.30	3.50
b	0.38	-	0.55
c	0.21	-	0.35
D	9.10	9.20	10.10
E	7.62	7.87	8.25
E1	6.25	6.35	6.45
e	2.54BSC		
L	2.92	3.30	3.81

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