
High Precision PSR Constant Current LED Driver

FEATURES

- Built-in 700V power NPN
- PSR constant current control without secondary sense and feedback circuit
- Patents of demagnetization sensing and self power-supply technology
- Ultra low operating current for high efficiency
- Universal input voltage
- $\pm 3\%$ LED current accuracy
- Programmable precision OVP voltage for best LED open circuit protection
- LED short circuit protection
- Patent of CS resistor short circuit protection
- VCC under-voltage protection
- Over temperature compensation
- Available in SOP8 and DIP8 packages

APPLICATIONS

- Isolated solid state lighting
- GU10/E27 LED bulb, spot light
- Other LED lighting

DESCRIPTION

FT8350x is a high precision primary-side feedback and regulation constant current driver for LED lighting applications. It operates in inductor current discontinuous conduction mode (DCM) and is especially suitable for flyback converter under universal input. Under universal input voltage from 85V to 265V, the system output power is recommended from 3W to 24W respectively of different internal power switch.

The FT8350x integrates a 700V power NPN and eliminates secondary sense and feedback circuit. The loop compensation components are also removed while maintaining stability over all operating conditions. It uses a source drive architecture and patent demagnetization sensing technology with very low operating current, Patents of self power supply technology. The auxiliary winding for sensing the output and supplying the chip is therefore eliminated, resulting in low component counts and small system size.

With its highly accurate current sense method, the FT8350x realizes $\pm 3\%$ accuracy of LED current along with excellent line and load regulation.

The multi-protection function of FT8350x can greatly enhance the system reliability and safety. The FT8350x features LED open/short circuit protection, CS resistor short circuit protection, over temperature compensation and VCC UVLO protection. The industry leading OVP voltage accuracy ensures the best LED open circuit protection.

TYPICAL APPLICATION CIRCUIT

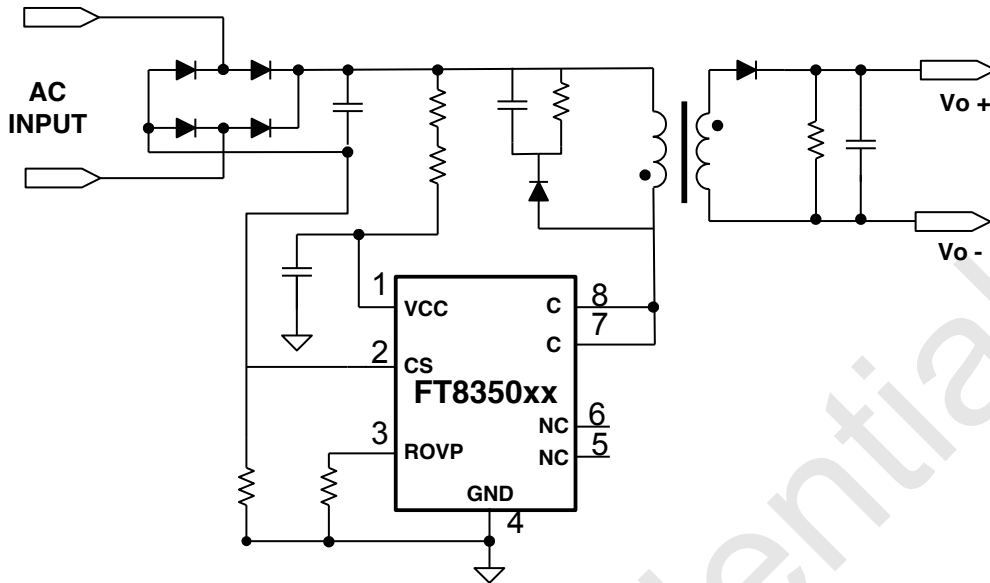


Figure 1: Typical Application Circuit

ABSOLUTE MAXIMUM RATINGS

VCC to GND.....	-0.3V to 8V
CS Pin Inputs and Outputs.....	-0.3V to 8V
Collector Pin Inputs and Outputs.....	-0.3V to 700V
ROVP Pin Inputs and Outputs.....	-0.3V to 8V
Operating Temperature Range.....	-40°C to +105°C
Junction Temperature.....	-40°C to +150°C
Storage Temperature Range.....	-60°C to +150°C
ESD Protection HBM.....	2000V
ESD Protection MM.....	200V

** Stresses exceed those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. Functional operation of the device at conditions beyond those listed in the specification is not guaranteed. Prolonged exposure to extreme conditions may affect device reliability or functionality.*

PIN CONFIGURATION

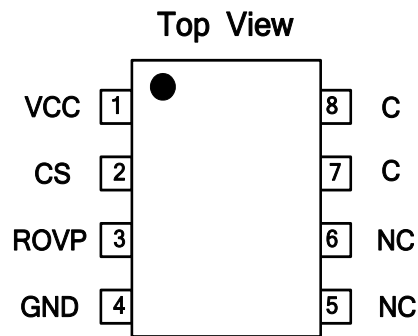


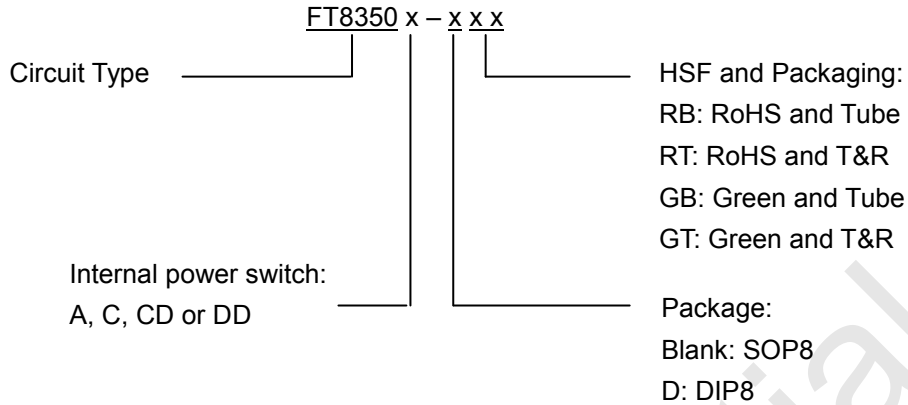
Figure 2: Pin Assignments

TERMINAL DESCRIPTION

No.	PIN	FUNCTION
1	VCC	Power supply
2	CS	Current sense. This pin connects a current sense resistor to GND to detect the transformer primary current.
3	ROVP	Output OVP voltage program PIN.
4	GND	Ground
5,6	NC	No connection, must be floating
7,8	C	Internal high voltage NPN Collector

Table 1

ORDERING INFORMATION



Internal Power Switch	Package	Maximum Output Power		HSF	Packaging	Ordering Code
		90V-265V	176V-265V			
A	SOP8	9W	12W	RoHS	Tube	FT8350A -RB
					T&R	FT8350A1 -RB
					Tube	FT8350A -RT
					T&R	FT8350A1 -RT
				Green	Tube	FT8350A -GB
					T&R	FT8350A -GT
					Tube	FT8350A1 -GB
					T&R	FT8350A1 -GT
C	SOP8	16W	22W	RoHS	Tube	FT8350C-RB
					T&R	FT8350C-RT
				Green	Tube	FT8350C-GB
					T&R	FT8350C-GT
CD	DIP8	18W	24W	RoHS	Tube	FT8350CD-DRB
				Green	Tube	FT8350CD-DGB
DD	DIP8	24W	30W	RoHS	Tube	FT8350DD-DRB
				Green	Tube	FT8350DD-DGB

MARKING RULE

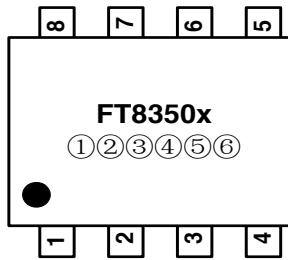


Figure 3: Marking Rule

①②③④⑤⑥ for internal reference

BLOCK DIAGRAM

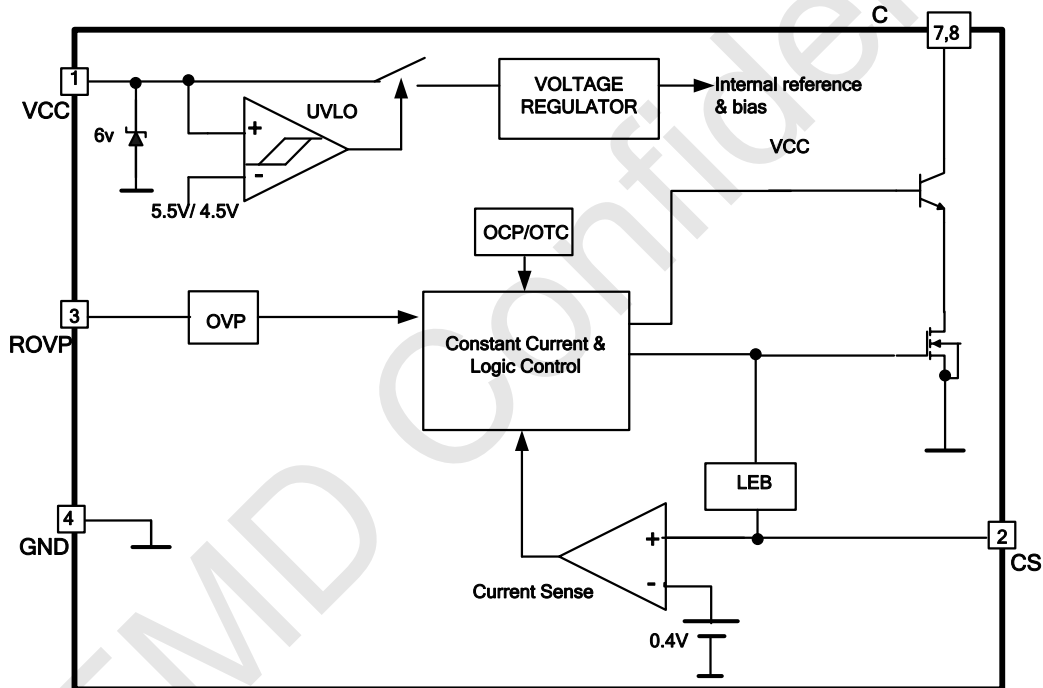


Figure 4: Block Diagram

ELECTRICAL CHARACTERISTICS

(Tj = 25°C, VCC = 14V, unless otherwise specified)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
SUPPLY VOLTAGE						
VCC _{ON}	Turn-on threshold	VCC rising		5.5		V
VCC _{OFF}	Turn-off threshold	VCC falling		4.5		V
VCC _{CLAMP}	VCC clamp voltage	Clamp current= 9mA		6		V
SUPPLY CURRENT						
I _{start-up}	Start-up current	Before turn-on, VCC= VCC _{on} -0.5V		100		uA
I _q	Quiescent Current			280		uA
CURRENT SENSE						
V _{CS_TH}	Threshold voltage for peak current limit		-412	-400	-388	mV
T _{LEB}	Leading edge blanking time for current sense			500		ns
T _{DELAY}	Switch off delay time			1.2		us
MINIMUM SWITCH FREQUENCY						
F _{MIN}	Minimum working frequency			5		kHz
MAXIMUM DUTY CYCLE						
D _{MAX}	Maximum duty cycle			48		%
MAXIMUM ON TIME						
TON _{MAX}	Maximum on time			50		us
OUTPUT OVER VOLTAGE PROTECTION						
T _{DIS_MIN}	Secondary minimum discharge time	Rp=0 Ω		4.0		us
		Rp=2 KΩ ± 5%		4.5		
		Rp=4.3 KΩ ± 5%		5.0		
		Rp=9.1 KΩ ± 5%		5.5		
		Rp=18 KΩ ± 5%		6.0		
		Rp=36 KΩ ± 5%		7.0		
		Rp>100KΩ or Open		8.0		
INTERNAL MOS						
R _{dson}	Static internal MOS on-resistance			0.5		Ω
INTERNAL POWER SWITCH						
BV _{CBO}	Collector-emitter breakdown voltage (base connect to gnd)	V _{BE} =0V, I _C =250uA	700			V
BV _{CEO}	Collector-emitter breakdown voltage (base floating)	Base floating, I _C =250uA	400			V

I_{CEO}	Collector-emitter leakage current	$V_{BE}=0V, V_{CE}=700V$			10	μA
FT8350A						
I_{peak}	Recommended Primary side I_{pk}		0.25	0.33	0.36	A
FT8350A1						
I_{peak}	Recommended Primary side I_{pk}		0.36	0.44	0.5	A
FT8350C						
I_{peak}	Recommended Primary side I_{pk}		0.45	0.55	0.63	A
FT8350CD						
I_{peak}	Recommended Primary side I_{pk}		0.45	0.55	0.70	A
FT8350DD						
I_{peak}	Recommended Primary side I_{pk}		0.50	0.70	0.90	A

Table2

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FUNCTIONAL DESCRIPTION

Startup Control

The start-up current in FT8350x is designed to be as low as 100uA. The VCC capacitor is charged through the start-up resistor when the system is powered on. Once the VCC voltage reaches the start-up threshold, the FT8350x starts to switch. The self supply circuit starts to supply VCC. The VCC voltage of FT8350x is clamped at 6V, Due to the ultra-low operating current, the auxiliary winding is not needed to supply the IC.

Constant Current Control

Cycle-by-cycle current sense is adopted in FT8350x, and the voltage on CS is compared with the internal 400mV reference voltage through the current sense comparator, the NPN is switched off when the voltage on CS reaches the threshold.

The primary peak current is given by: $I_{P_PK} = \frac{400}{R_{CS}} (mA)$

The current in LED can be calculated by the equation: $I_{LED} = \frac{I_{P_PK}}{2} * \frac{N_P}{N_S} * \frac{T_{DIS}}{T}$

Where,

N_P : primary winding turns of transformer,

N_S : secondary winding turns of transformer

I_{P_PK} : peak current in NPN

T_{DIS}/T : ratio of secondary discharge time and switching period, or duty cycle.

Leading Edge Blanking (LEB)

A turn on spike on CS pin will inevitably appear when the power NPN is switched on. At the beginning of each switching pulse, the current sense comparator is disabled for around 500ns to avoid premature termination. The power NPN cannot be switched off during the blanking period.

Operating Switching Frequency

The FT8350x is designed to work in discontinuous conduction mode and no external loop compensation component is required while maintaining stability. The maximum switching frequency is set by the resistance of the Rovp according to table2. If the maximum frequency is set too high, it will limit the number of maximum series LED lamps. If set too low, the LED open circuit voltage will be too high.

The maximum and minimum switching frequency is limited in FT8350x to ensure the stability of system.

The switching frequency can be set by the formula:

$$f = \frac{D_{MAX}^2 * N_P^2 * V_{LED}}{2 * N_S^2 * L_P * I_{LED}}$$

Where, L_P is the primary winding inductance of transformer.

Over Voltage Protection (OVP)

FT8350x features the industry leading output OVP accuracy. Output LED open circuit will trigger the over-voltage protection logic and latch, the system stops switching immediately. VCC will be pulled down and charged up again, the system works in a hiccup mode. The output over voltage protection threshold is

set by the resistance of the Rovp according to table2.

$$V_{OVP} \approx \frac{Lm \times Vcs}{Nps \times Rcs \times Tovp}$$

$$Tovp \leq \frac{Lm \times Vcs}{Nps \times Rcs \times V_{OUT}}$$

Select Rovp from table2 based on Tovp value.

LED Short Circuit Protection

When LED short circuit is detected, the system works at minimum frequency (Fop=5KHz), so the power consumption is low.

CS Resistor Short or Transformer Saturation

In these catastrophic fault conditions, the internal patent of fast fault detection circuit will trigger and latch, the system stops switching immediately. VCC will be pulled down and charged up again, the system works in a hiccup mode.

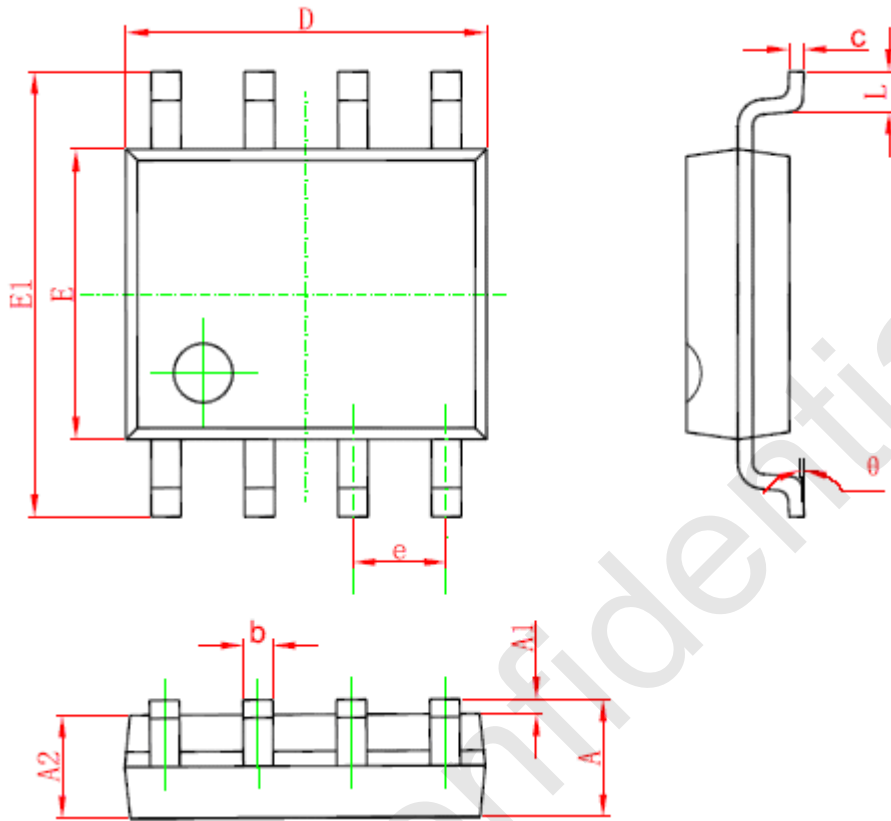
Over Temperature Compensation

FT8350x senses the die temperature after start up, and the thermal compensation threshold is set to 140°C. When FT8350x temperature rises and reaches the threshold, the output current will be reduced continually until the IC temperature stop rising. There is an audible noise risk during current reducing. And when the IC temperature falls below the thermal compensation trigger point, the output current will recover to 100% of its designed target.

Over Temperature Protection

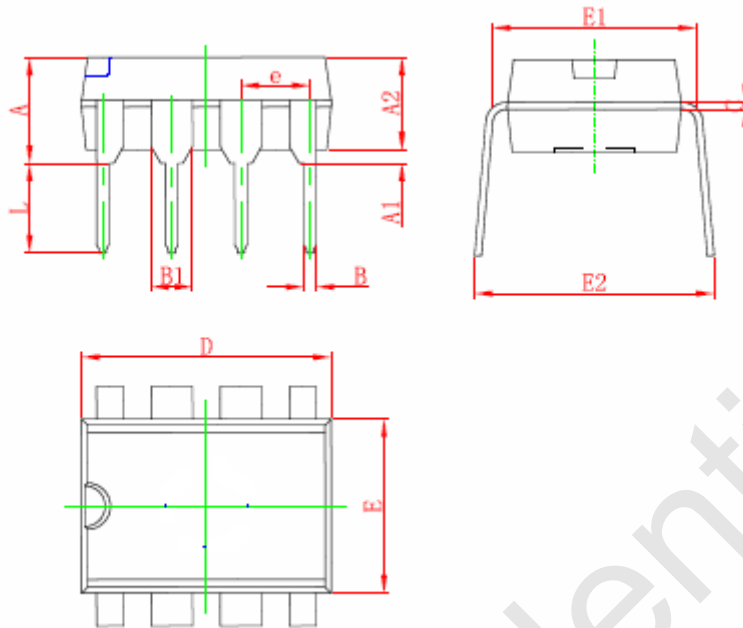
If temperature keeps rising beyond 150°C even with temperature compensation described above, Over Temperature Protection will kick in. The OTP threshold is set to 150°C with 20°C hysteresis. When temperature reaches 150°C, FT8350x will stop switching until the IC temperature falls 20°C below the thermal protection trigger point.

SOP8 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.006	0.010
D	4.700	5.100	0.185	0.200
E	3.800	4.000	0.150	0.157
E1	5.800	6.200	0.228	0.244
e	1.270 (BSC)		0.050 (BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

DIP8 PACKAGE OUTLINE DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	3.710	4.310	0.146	0.170
A1	0.510		0.020	
A2	3.200	3.600	0.126	0.142
B	0.380	0.570	0.015	0.022
B1	1.524 (BSC)		0.060 (BSC)	
C	0.204	0.360	0.008	0.014
D	9.000	9.400	0.354	0.370
E	6.200	6.600	0.244	0.260
E1	7.320	7.920	0.288	0.312
e	2.540 (BSC)		0.100 (BSC)	
L	3.000	3.600	0.118	0.142
E2	8.400	9.000	0.331	0.354

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