

DW8551

Primary-Side Regulator LED Controller
With Active PFC for LED Drivers

Preliminary

Ver. 0.1
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1. General Description

The DW8551 is a primary-side control offline flyback controller with active power factor correction. It is especially designed for LED lighting system. The DW8551 controls the LED current accurately without using an opto-coupler, which can significantly simplify the design of LED lighting system. Utilizing an on-chip multiplier, the DW8551 achieves high power factor over wide line and load ranges.

The multi-protection function largely enhances the safety and reliability of the system, including over voltage protection; short circuit protection, LED open protection, cycle-by-cycle current limit, VCC UVLO and over-temperature protection.

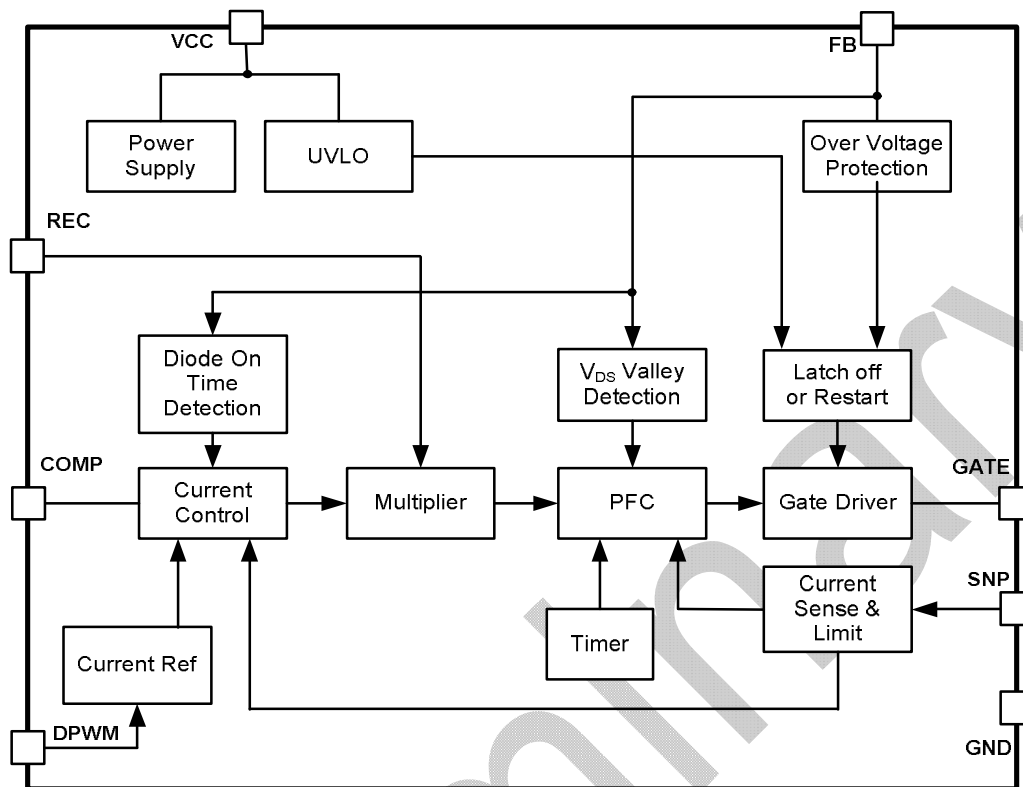
■ Features

- Real current control without secondary feedback circuit
- High current accuracy of line regulation
- Active power factor correction
- Low harmonic content
- External PWM dimming
- High efficiency over wide operating range
- Cycle by cycle current limit
- Input over-voltage protection
- LED short protection
- LED open protection
- Over-temperature protection
- 8-Pin SOP package

■ Applications

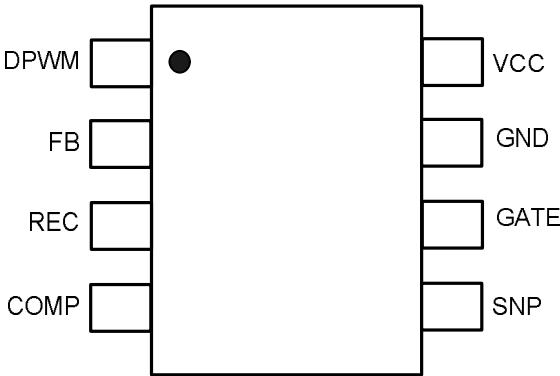
- Isolated type LED driver applications
- Bulb light
- General lighting of flat panel displays
- RGB backlight
- General purpose constant current source
- In/Outdoor Lighting, Street, Roadway, Parking, Construction Lamp

2. Block Diagram



3. Pin Information

■ Pin Placement



SOP8

■ Pin Description

No.	Pin Name	Description	Note
1	DPWM	Apply a PWM signal on this pin for external PWM dimming.	
2	FB	Voltage Loop Feedback Pin. VFB is used to detect open LED conditions by sampling the third winding voltage.	
3	REC	Rectified Voltage Sense Pin. The pin is used for sensing the AC line voltage to perform power factor correction.	
4	COMP	Compensation Pin for Internal Error Amplifier. Connect a capacitor between the pin and GND to compensate the internal feedback loop.	
5	SNP	Primary current sense Pin. The pin is used for cycle-by-cycle peak current control and limit.	
6	GATE	Gate Driver for the External Main MOSFET Switch.	
7	GND	Power Ground.	
8	VCC	Power Supply Pin. This pin supplies current to the internal start-up circuit. This pin must be bypassed with a capacitor nearby.	

4. Absolute Maximum Ratings⁽¹⁾

Symbol	Parameter	Ratings
VCC	VCC Voltage	40V
GATE	GATE Voltage	24V
DPWM,FB,REC,COMP,SNP	DPWM, FB, REC, COMP, SNP Voltage	-0.3V ~ 4.5V
θ_{JA}	Package Thermal Resistance ⁽²⁾	96 °C/W
θ_{JC}	Package Thermal Resistance ⁽²⁾	45 °C/W
T _{STG}	Storage Temperature	-65 ~ 150 °C
T _J	Junction temperature ^{(3),(4)}	150 °C

- Note**
1. Exceeding these ratings may damage the device.
 2. Measured on JESD51-7, 4-layer PCB.
 3. The DW8551 guarantees robust performance from -40°C to 150°C junction temperature. The junction temperature range specification is assured by design, characterization and correlation with statistical process controls.
 4. The DW8551 includes thermal protection that is intended to protect the device in overload conditions. Thermal protection is active when junction temperature exceeds the maximum operating junction temperature. Continuous operation over the specified absolute maximum operating junction temperature may damage the device.

■ Absolute Maximum Ratings

Use of the IC in excess of absolute maximum ratings such as the applied voltage or operating temperature range (T_J) may result in IC damage. Assumptions should not be made regarding the state of the IC (short mode or open mode) when such damage is suffered. The implementation of a physical safety measure such as a fuse should be considered when use of the IC in a special mode when the absolute maximum ratings may be exceeded is anticipated.

5. Recommended Operating Condition

Symbol	Parameter	Min.	Typ.	Max.	Unit
VCC	Supply voltage	10		30	V
FB	FB voltage	1.6		4.3	V
T _J	Junction Temperature			125	°C

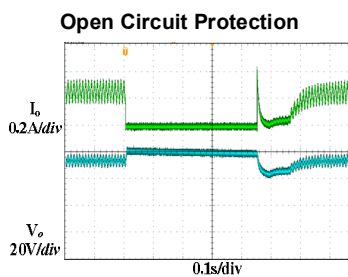
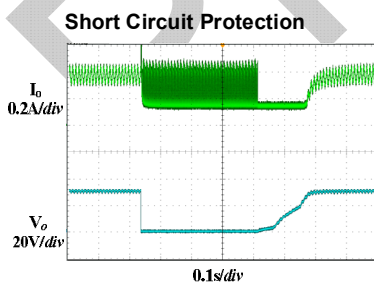
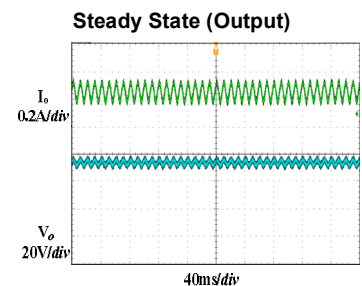
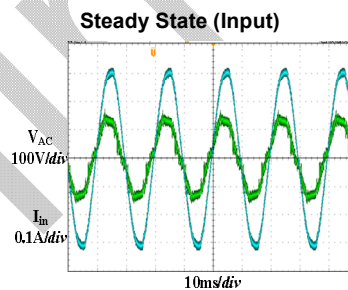
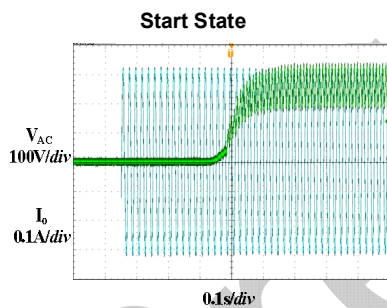
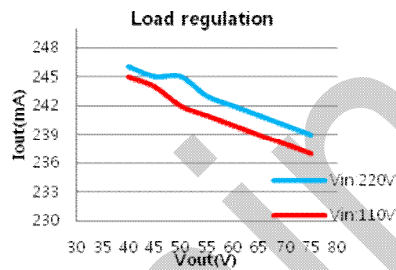
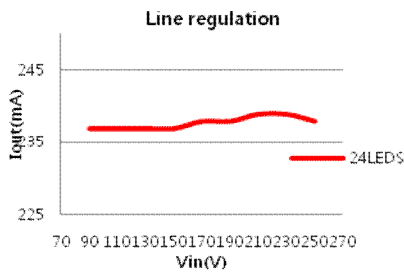
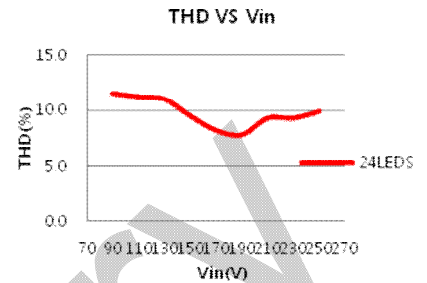
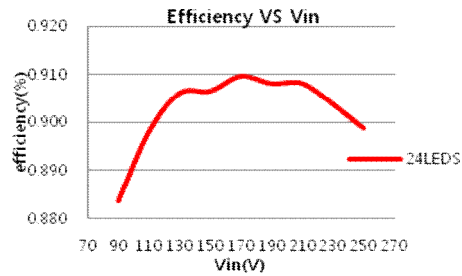
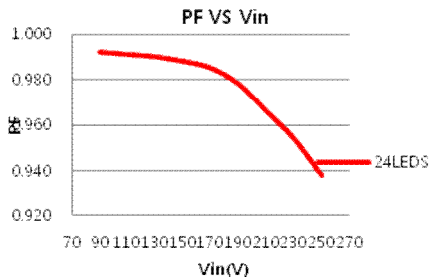
6. Electrical Specification

($V_{CC}=20V$, Typical value at $T_A=T_J=+25^{\circ}C$, unless other less)

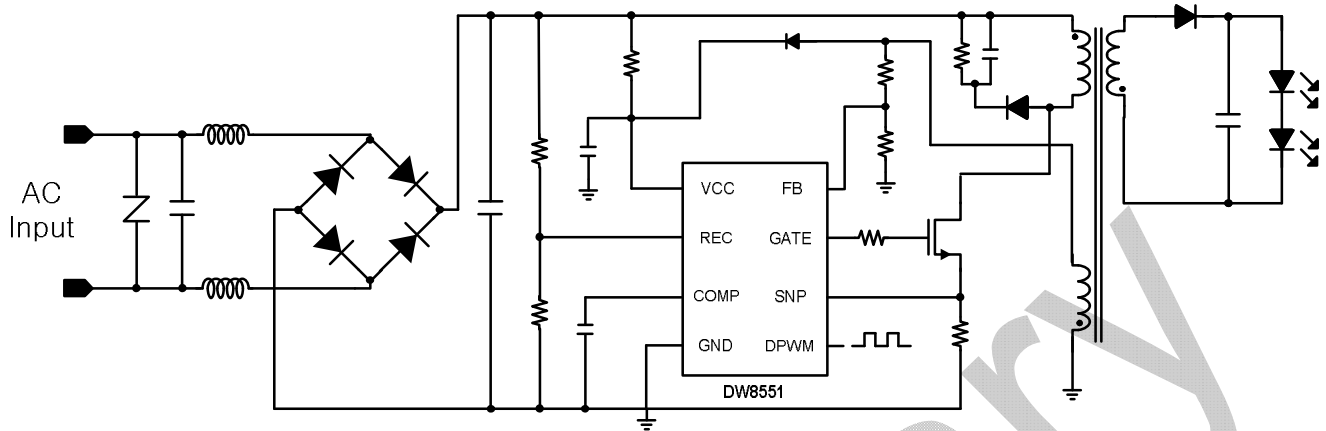
Characteristic	Symbol	Condition	Min	Typ	Max	Unit
V_{CC} Turn-On Voltage	V_{CC_ON}		15.5	18.0	20.5	V
V_{CC} Turn-off Low Voltage	V_{CC_OFF}		7.0	8.0	9.5	V
V_{CC} Hysteresis	V_{CC_HYS}	$V_{CC_ON}-V_{CC_OFF}$		10		V
V_{CC} Shunt Regulator Voltage	V_{CC_SHUNT}			30		V
V_{CC} Turn-off High Voltage	$V_{CC_OFF_H}$		31	36	40	V
V_{CC} Turn-on High Voltage	$V_{CC_ON_H}$		23.5	27.5	31.5	V
V_{CC} Shunt Regulator Pull-Down Current	I_{CC_PD}	$V_{CC}=40V$	7	10	15	mA
V_{CC} Quiescent Current	I_Q	$V_{CC}=10V$	17	29	41	uA
V_{CC} Quiescent Current with Switching	I_{Q_SW}	Switching frequency =20kHz; Min on time; Gate floating		500		uA
V_{REC} Brown-Out Threshold	V_{REC_BO}		177	210	243	mV
V_{REC} Brown-Out Hysteresis	V_{REC_BOHYS}		40	50	60	mV
V_{REC} Sense Over Voltage	V_{REC_OVP}		3.0	3.4	3.8	V
V_{REC} Sense Over Voltage Hysteresis	V_{REC_OVHYS}			320		mV
FB Pin High Threshold	V_{FB_H}		3.4	3.8	4.2	V
V_{REF} Voltage	V_{REF}		102		108	mV
SNP Sense Current Limit	V_{SNP_H}			530		mV
Comp Max Sourcing Current	I_{SOURCE}		32		40	uA
Maximum Oscillator Frequency	F_{MAX}		110	130	160	kHz
DPWM Signal High Level	PWM_H		3.5			V
DPWM Signal Low Level	PWM_L				0.5	V
Gate Output High	V_{GATE_H}		9.6	12	14.4	V
Gate Output Low	V_{GATE_L}				50	mV
Leading Edge Blanking Time	T_{LEB}		480	600	720	ns
t_r Gate Driver Output Rise Time	T_{GATE_R}	$C_L=4.7nF$ 1V to 8V		38		ns
t_f Gate Driver Output Fall Time	T_{GATE_F}	$C_L=4.7nF$ 8V to 1V		24		ns

7. Typical Operating Characteristics

VCC=20V, V_{IN}=90VAC~265VAC, V=75V, I_O=240mA, unless otherwise noted



8. Typical Application Circuit



9. Detailed Descriptions

The DW8551 is a primary side control offline LED controller optimized for LED lighting. It uses a novel method to calculate the output current of a flyback converter without the need of opto-coupler. Utilizing an on-chip multiplier, the DW8551 achieves high power factor to eliminate the pollution to the AC line.

■ Primary-Side Current Control

The DW8551 control the output current from the information of primary side. The output LED mean current can be calculated as:

$$I_o = V_{ref} \times N / (2R_s)$$

Where

N : Turns ratio of primary winding to secondary winding;

V_{ref} : Reference voltage, 103mV typically;

R_s : Sensing resistor connected between SNP and ground.

■ Start Up

The DW8551 uses a hysteretic start-up to operate from high offline voltages. A resistor connected to the supply voltage protects the part from high voltages. When the DC line charges VCC up to 16V, the gate drive signal begins to switch. The third winding provides power to the VCC pin along with the resistor in steady state. VCC should be higher than 8.6V at normal operation. An internal voltage clamp helps to prevent VCC from being too high. An internal 10mA current pulls the VCC down when it's above 29.5V. The DW8551 stops switching if VCC is higher than 32V, and restarts when VCC is lower than 27V.

■ PWM Dimming

When the PWM signal is injected to pin 1, the output current is proportional to the PWM duty cycle. 100% duty means the highest brightness while 0% means the lowest one. Considering the minimum duty cycle limit of DW8551, the recommended dimming range is 5%-100%.

9.1. Detailed Descriptions (Continued)

■ Critical Conduction Mode Operation

Critical conduction mode is a variable frequency switching scheme that always returns the secondary current to zero with each cycle. The DW8551 relies on this mode to calculate the output current. When the external MOSFET turns off, the energy stored in the inductor forces the secondary diode to turn on, and the current of the inductor begins to decrease linearly from peak to zero. When the current decreases to zero, the resonance, caused by the inductor and all the parasitic capacitance, makes the MOSFET drain-source voltage decreases, this decreasing is also reflected at the third winding. The turn on signal is generated when the drain-source voltage is approximately at the valley. This switching technique can reduce the MOSFET turn-on losses and diode reverse recovery losses, thus improves efficiency and decreases EMI noise.

■ Loop Compensation

An integrator is applied to the output current feedback loop with a capacitor connected to the COMP pin. For offline applications, the crossover frequency should be set much less than the line frequency of 120Hz or 100Hz. To have a good PFC performance, a capacitor of 4.7μF connected to COMP pin is recommended.

■ Input Over Voltage Protection

VREC pin senses the rectified input voltage with a resistor divider. DW8551 stops switching when VREC voltage is higher than 3.3V, and effectively protects the MOSFET and secondary diode from over voltage break down.

■ LED Over Temperature Protection

When DW8551 is hotter than 150°C, the COMP voltage is pulled down by an internal current thus reduces the output current.

■ LED Open Protection

The output voltage can be detected by the third winding when the main power switch is off, and the secondary diode turns on. A resistor divider from the third winding is connected to the FB pin. When the FB voltage is higher than 3.6V, LED open protection is triggered and the GATE stops switching, and the internal 10mA current will pull the VCC down to 8.6V to reset the circuit. Then, the Vcc is charged by the external resistor up to 17V, and it restarts.

■ LED Short Protection

When the output is shorted, the third winding voltage is zero. DW8551 reduces the internal command current to a very low level and slows down the switching frequency to 3kHz to decrease the output current.

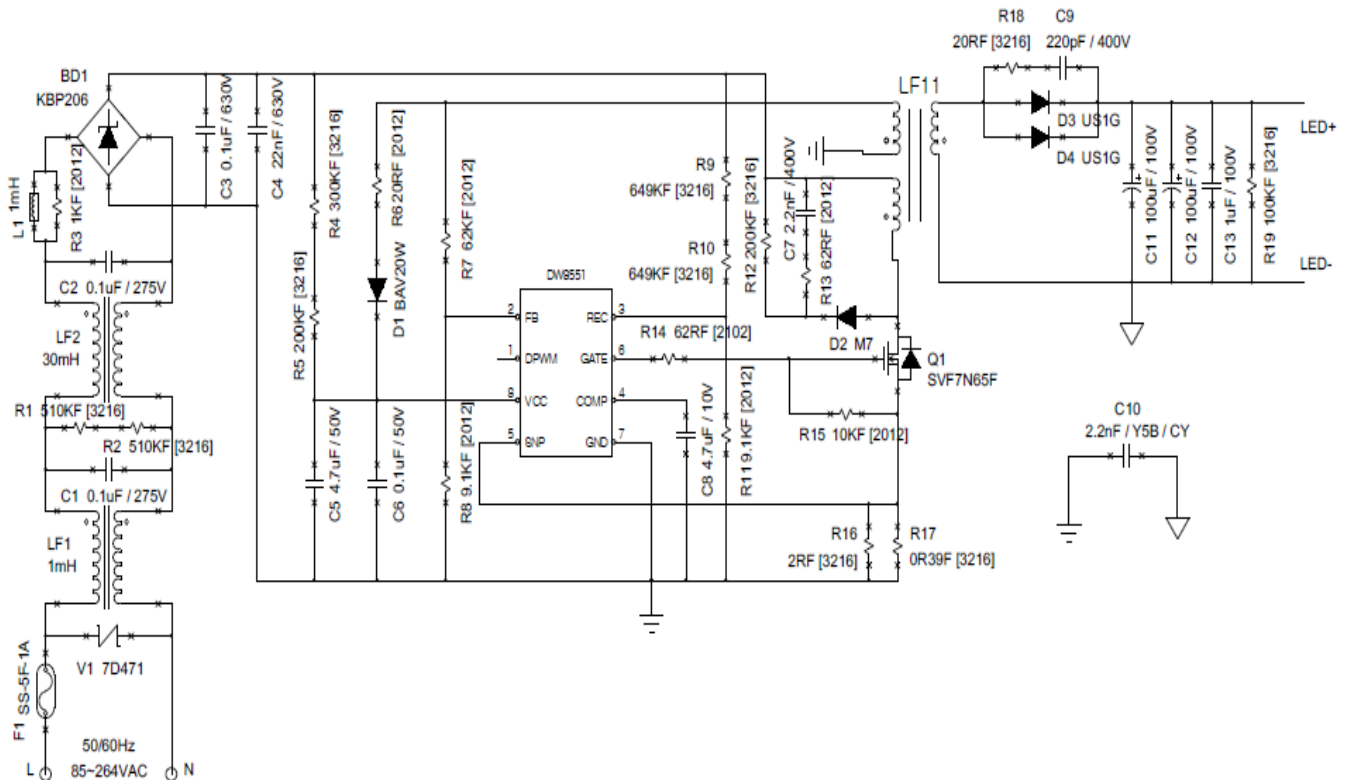
■ PCB Layout Guidelines

1. The bypass ceramic capacitor of VCC should be nearby the VCC and GND as close as possible.
2. To reduce EMI noise, the power loop area should be as small as possible.
3. DW8551 should be kept away from noisy and heating components, such as MOSFET, transformer and diode.
4. FB pin should be kept away from sources of interference; a 20pF capacitor could be paralleled if necessary.

10. Application Reference

This reference design is suitable for 9 ~ 20W isolated flyback LED driver, using DW8551, with high efficiency, high PF, excellent line regulation.

VIN: 90VAC~260VAC
VOUT: 45~75V
IOUT: 240mA
PF: >0.9



11. Package Dimension

Package Dimension

- Package Name : SOP8
- Package Size : 5.0mm * 6.0mm, Thickness : 1.75mm
- Pin Pitch : 1.27mm

