

**BOOST/ BUCK-BOOST/ BUCK LED Driver IC with Internal MOSFET**

**GENERAL DESCRIPTION**

The T8382GN is designed to operate as a constant current source for driving high current LEDs. It is a highly integrated IC with internal MOSFET. It operates in current mode control which provides a good line transient response. The device can provide an excellent constant current accuracy of +/- 3% typically.

The T8382GN has integrated frequency dithering function which can help to improve the EMI performance of the LED lighting system. Moreover, the chip has various protections like VIN and VREG under-voltage, IC over-temperature, LED open circuit, LED short circuit, LED under-current and LED over-voltage which provide a highly reliable LED lighting solution.

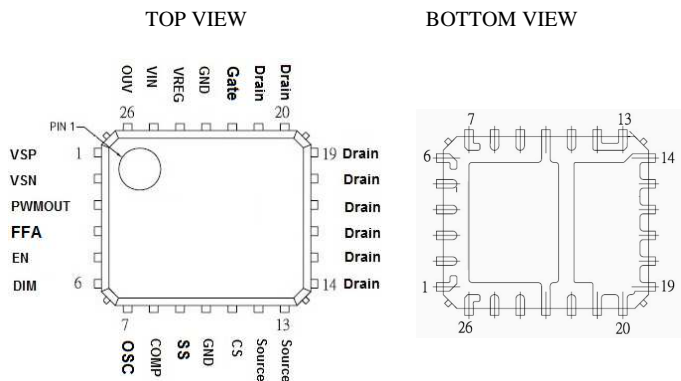
**FEATURES**

- 5 - 60V input voltage range
- Single resistor programmable constant current driver
- 20W output current for Buck-Boost / SEPIC topology
- 30W output current for Buck / Boost topology
- Excellent constant current accuracy  $\pm 3\%$  typically
- 0.1V feedback reference voltage tailor-made for LED application
- Support Boost/Buck/Buck-Boost/SEPIC configuration
- DC and PWM dimming
- On-chip thermal shutdown at 170°C
- Thermal derating by using external NTC
- Dithering in oscillator frequency to simplify the EMI design
- Cycle-by-cycle current limit
- Over-current protection
- Open LED overvoltage indication and protection
- 20 $\mu$ A shutdown current

**APPLICATIONS**

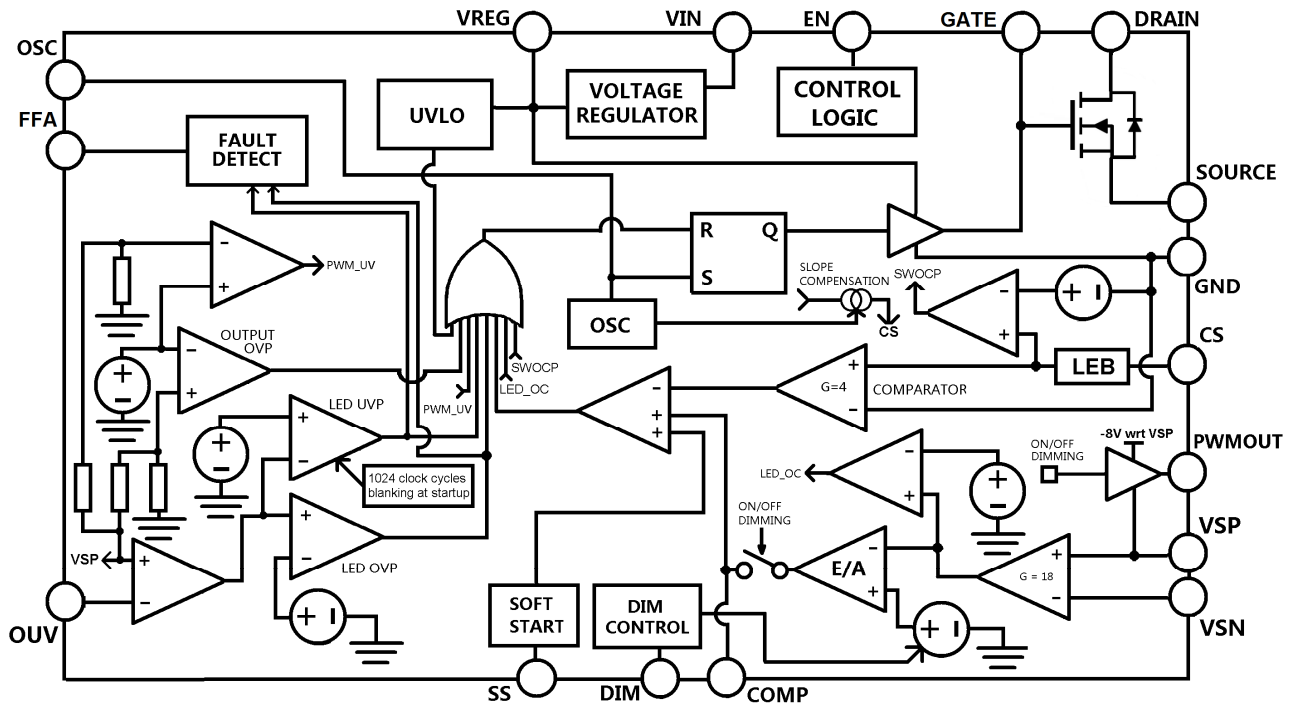
- High Power LED Driver
- LED illuminance
- LCD backlight illumination
- Automotive interior lighting
- Automotive Headlights

**PIN CONFIGURATION**



**T8382GN, PQFN26L**

**Block Diagram**



**PIN DESCRIPTION**

<b>Pin No.</b>	<b>Pin Name</b>	<b>Pin Description</b>
1	VSP	Load current sense +ve input
2	VSN	Load current sense -ve input
3	PWMOUT	PWM gate drive for external p-channel MOSFET (active low)
4	FFA	Fault indication flag
5	EN	Enable chip
6	DIM	DC Dimming
7	OSC	Frequency set
8	COMP	Compensation pin
9	SS	Soft start
10	GND	Ground Pin. IC ground. Thermal Pad
11	CS	Connect a resistor for the current mode control
12,13	SOURCE	Internal Power MOSFET Source
14-21	DRAIN	Internal Power MOSFET Drain
22	GATE	Switch gate drive
23	GND	Ground Pin. IC ground. Thermal Pad
24	VREG	Internal regulator
25	VIN	Main supply
26	OUV	Over-voltage and under-voltage protection pin, connect this pin to the output voltage of the LED through a resistor divider to detect the over voltage and under-voltage

## ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Value	Unit
VIN, VSP and OUV pin voltage relative to GND		-0.3 to +60	V
OUV		VSP - 5 to VSP	V
PWMOUT		VSP - 10 to VSP	V
GATE		-0.3 to +10	V
DRAIN		-0.3 to +60	V
SOURCE		-0.3 to +5	V
VSN		VSP - 1V to VSP	V
VREG		-0.3 to +12	V
DIM pin voltage relative to GND		-0.3 to +3.3.	V
EN, COMP, and CS pin voltage relative to GND		-0.3 to +5.5	V
Junction temperature range	$T_J$	-40 to +150	°C
Maximum soldering temperature (at leads, 10sec)	$T_{LEAD}$	300	°C
Storage temperature range	$T_S$	-65 to +150	°C
Junction to case thermal resistance	$\theta_{JC}$	3.5	°C/W
ESD Susceptibility, Except DRAIN & SOURCE Pin.			
HBM (Human Body Model)		2	KV
CDM (Charged Device Model)		500	V

**Notice:**

**Devices are ESD sensitive. Handling precaution is recommended.**

## ELECTRICAL CHARACTERISTICS

♦ Denotes the specifications which apply over the full operating temperature range  $T_J = -40^{\circ}\text{C}$  to  $+125^{\circ}\text{C}$ ,  $V_{IN} = 12\text{V}$ . Otherwise specifications are at  $T_A = 25^{\circ}\text{C}$ ,  $V_{IN} = 12\text{V}$ .

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit	
<b>Supply and Reference</b>							
$V_{OVP}$	Fixed Output Over-voltage Protection	Measured at VSP with respect to ground		65.5		V	
$V_{IN}$	Operating voltage range		**	5	60	V	
$V_{INUV}$	$V_{IN}$ under voltage	$V_{IN}$ Decreasing		4.25	4.52	V	
$\Delta V_{INUV}$	$V_{IN}$ under-voltage hysteresis			260		mV	
$I_Q$	Operating quiescent current	$f_{osc} = 430\text{kHz}$ ; Capacitor load = $1000\text{pF}$ at gate pin		2.5	3	mA	
$I_{OFF}$	Shutdown current	IC shutdown by $V_{EN} < V_{EN\ OFF}$		20	26	$\mu\text{A}$	
$V_{REG}$	Regulation pin voltage	$V_{IN}=12\text{V}$ , $I_{REG} = -10\text{mA}$	♦	6.5	7.3	8	V
$V_{REGUV}$	$V_{REG}$ under voltage	$V_{REG}$ Decreasing		3.8	4.2	V	
$\Delta V_{REGUV}$	$V_{REG}$ under-voltage hysteresis			350		mV	
$V_{REGCL}$	$V_{REG}$ current limit	$V_{REG}$ short to GND	♦	-25	-52	mA	
<b>Oscillator and Soft Start</b>							
$f_{osc\_dither}$	Oscillator frequency (with Dither ON)	$R_{osc} = 3.3\text{k}\bullet$			1000	kHz	
		$R_{osc} = 6.8\text{k}\bullet$			500	kHz	
		$R_{osc}$ short to GND			430	kHz	
		$R_{osc} = \text{open}$			80	kHz	
$f_{osc}$	Oscillator frequency (with Dither OFF)	$R_{osc}$ short to GND			384	kHz	
	Oscillator frequency range			80	1000	kHz	
$I_{SS}$	Soft start current	Current out of pin			11	$\mu\text{A}$	
$V_{RAMPUP}$	The Upper limit of the Soft Start Ramp Up Voltage Active Region				1.8	V	

Symbol	Description	Conditions	Min.	Typ.	Max.	Unit	
<b>LED Current Sense and Control</b>							
V <sub>IDL</sub>	Differential input voltage (Active)	EN=High, VSP - VSN	97	100	103	mV	
V <sub>OCLD</sub>	LED Over current threshold	EN=High, VSP - VSN	150	167	182	mV	
V <sub>DIM,ON</sub>	DC Dimming ON		0.116	0.156	0.196	V	
V <sub>DIM,MAX</sub>	DC Dimming Control for Full Brightness	DC voltage on the DIM pin		2.3		V	
V <sub>DIM,MIN</sub>	DC Dimming Control for Gate Driver OFF	DC voltage on the DIM pin	0.07	0.11	0.15	V	
<b>Gate Drive Output and Internal MOSFET</b>							
T <sub>R</sub>	Turn-On Rise Time	Rosc = open Loading Cap=2.2nF (from 10% to 90%)		30		ns	
T <sub>F</sub>	Turn-Off Fall Time	Rosc = open Loading Cap=2.2nF (from 10% to 90%)		30		ns	
V <sub>OL</sub>	Output low level		♦		0.2	V	
V <sub>OH</sub>	Output high level		♦	VREG		V	
D <sub>MIN_D</sub>	Maximum duty cycle		♦	88	92	96	%
R <sub>DSON</sub>	Drain-to-Source On-Resistance	Vgs=5V		60		mΩ	
<b>Switch Current Sense and Amplifier</b>							
V <sub>SWOCP</sub>	Switch over-current protection threshold voltage		440	500	560	mV	
A <sub>CS</sub>	Voltage Gain			4		V/V	
I <sub>BIASS</sub>	Input Bias Current		-24	-32	-40	μA	
<b>Logic Inputs and Outputs</b>							
V <sub>EN_ON</sub>	EN pin chip enable voltage	V <sub>EN</sub> rising	♦	2		V	
V <sub>EN_OFF</sub>	EN pin disable voltage		♦		0.8	V	
t <sub>DIS</sub>	Disable time	f <sub>OSC</sub> = 430kHz		38		ms	
FFA	Fault output (Open Drain)	I <sub>OL</sub> =1.2mA, fault not asserted			0.26	V	

$I_{FFA(SINK)}$	Fault output FFA sink current	$V_O=0.4V$ , fault not asserted		0.8	1.7		mA
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Symbol	Description	Conditions	Min.	Typ.	Max.	Unit
<b>Dither Generator</b>						
$f_{SPREAD}$	Dither Frequency Range	% of switching frequency		+/-12		%
<b>Slope Compensation</b>						
$I_{SLOPE}$	Slope Injection Current	Sawtooth current added to current sense (CS) pin		-97		$\mu A$
<b>Protection</b>						
$t_{FB}$	Fault blank timer	At start up, $f_{OSC} = 430kHz$		2.4		ms
$V_{SCL}$	LED short protection voltage	$V_{SP} - V_{OUV}$	260	300	330	mV
$V_{OCL}$	LED open protection voltage	$V_{SP} - V_{OUV}$	1.08	1.2	1.34	V
$PWM_{UV}$	PWMOUT Under-voltage	VSP Decreasing	5	5.5		V
$PWM_{HYS}$	PWMOUT Hysteresis			0.56		V
$T_{SD}$	Over-temperature warning threshold*	Measured at junction, temperature increasing	*	170		$^{\circ}C$
$T_{SDHYS}$	Over-temperature hysteresis*	Measured at junction, recovery = $T_{SD}-T_{SDHYS}$	*	35		$^{\circ}C$

♦ Function is correct but parameters are not guaranteed.

\*\* At VIN equals 5-6V and >50V, the part only guarantees GATE pin switching but not guarantee to follow the electrical parameters.

\*Parameters are not tested at production and guaranteed by design, characterization and process control.

## FUNCTIONAL DESCRIPTION

T8382GN is a constant current LED driver which can be configured as a Boost, Buck-Boost, Buck or SEPIC converter. It depends on the user's choice of the number of LEDs on the output. Typical converter application circuits of T8382GN are shown in the next section.

### VIN

The VIN is the power supply voltage pin for the supply to the control circuit of T8382GN. The pin has an UVLO function, once voltage on the pin reaches 4.78V; the IC is ready to start the operation. When the voltage on this pin falls below 4.52V, the IC will be shutdown.

(Note: A bypass capacitor must be connected close between this pin and GND.)

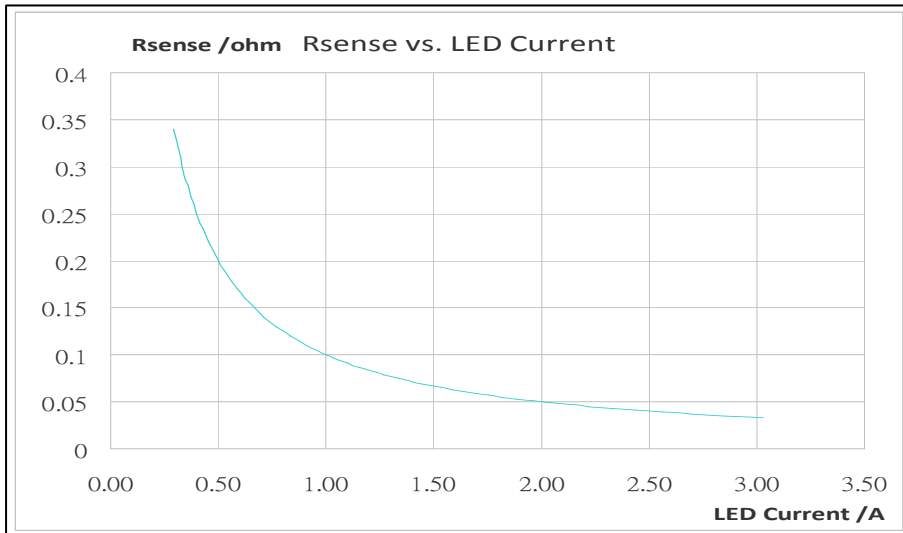
**VREG**

To provide a filtered output and to ensure the regulator is stable, a 2.2µF or above ceramic capacitor is required to be connected between VREG and GND. The ceramic type should be a quality type such as X5R, X7R, or X8R. The VREG pin voltage is for driving the internal switching MOSFET. Normally, at 12V VIN, the VREG voltage is 7.3V typically. The UVLO point of the VREG is around 4.2V. Once the VREG is under 4.2V, the gate driver will be turned off and it will resume back to normal when the VREG voltage rises back to around 4.55V.

**Output LED current setting**

The output LED current is determined by a combination of the LED sense resistor R<sub>SENSE</sub>, the LED current threshold voltage, V<sub>IDL</sub>, (100mV). For example, to program a 1A output current, the sensing resistor will be

$$R_{SENSE} = \frac{100mV}{1A} = 0.1\Omega$$



**Frequency Dithering**

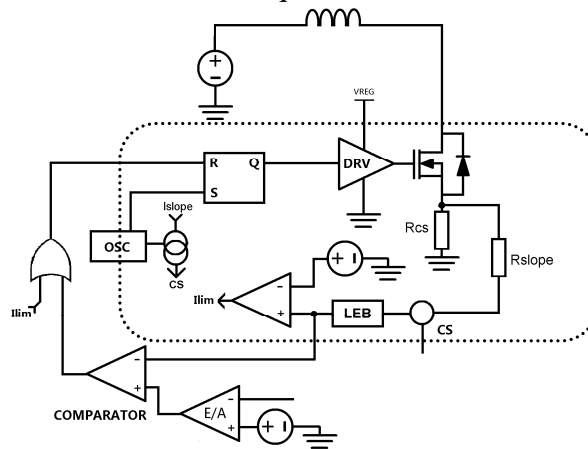
T8382GN has an internal frequency dither function to improve the EMI performance of the system. The internal frequency is hopping in a small frequency range to reduce the radiation at the switching frequency which simplifies the EMI design. The dither frequency range is ~ +/- 12% typically.

**Enable Pin Function**

The enable pin is to control the IC on/off operation. When the enable pin is pulled down over the disable time that stated in the datasheet (~16340 clock cycles which equivalent 38ms at switching frequency 430 kHz), the IC will completely shutdown and enter into the shutdown mode. The IC current consumption reduces to nearly 20µA. This pin can also be used as direct PWM input for LED dimming.

**Switch current limit and over-current protection**

T8382GN has a switch current limiting function. When the CS pin voltage reaches the current limit threshold (~0.5V), the IC begins to count for the switch over current. Once the switch over current is over 8 clock cycles, the IC will enter into hiccup mode. The hiccup mode turns off the gate driver for 8192 clock cycles. After the hiccup mode, the IC will resume to monitor for the switch over current, if the switch over current stills exist and over 8 switching clock cycles, the IC will go to the hiccup mode again. Of course, if the switch over current condition removed, the IC will resume to normal operation. The switch over current limit equation is shown below.



**Slope Compensation**

The slope compensation is to prevent subharmonic oscillations at duty cycles greater than 50% in continuous current conduction mode. A current source is provided at the CS pin as a sawtooth from 0 to 97µA. An external resistor,  $R_{SLOPE}$ , connected between the CS pin and the source connection of the MOSFET, is used to program the appropriate voltage level to scale the slope compensation for correct use with the appropriate topology and set up conditions that have been adopted.

**PWMOUT Under-voltage**

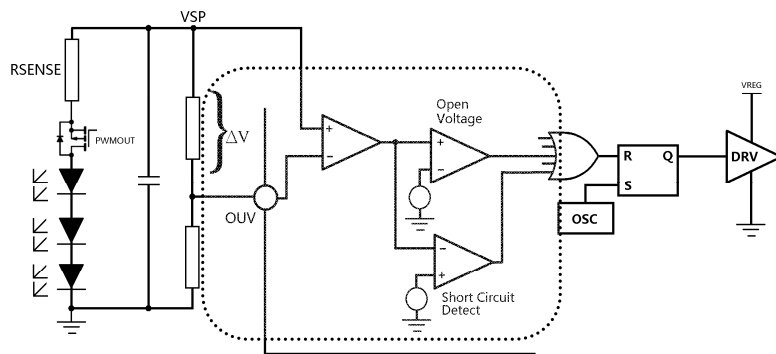
During startup, the VSP pin voltage is going to ramp up. When this voltage is under 6V, the PWMOUT will not provide any gate driving voltage to turn on a high side PMOS. When the VSP pin voltage exceeds 6V, the PWMOUT driver turns on and begins to provide a conduction path for the output LED. The PWMOUT will be disabled when the VSP pin voltage drops down to 5.5V (voltage hysteresis around 0.5V).

**Fixed Over Voltage Protection**

The T8382GN has a fixed over voltage protection which is implemented on the VSP pin. Once the VSP pin voltage over around 65.5V, the IC will stop the gate driver and the output voltage will drop. The hysteresis for the fixed over voltage protection is around 5V. Once the voltage on the VSP falls below around 60.5V, the IC will resume the switching on the gate driver.

**Open and short LED protection**

The open and short LED protection is implemented by placing a resistor divider on the output of the converter (VSP) with respect to the LED negative terminal. The divided sensing voltage is compared with the VSP voltage and formed  $\Delta V$  which shown in below picture. If the voltage difference is over 1.2V for more than 2 clock cycles, the LED string will be treated as over voltage condition. Then, T8382GN will stop the gate driving voltage to the internal MOSFET and entering into a hiccup mode. The hiccup mode will turn off both the gate driver and the PWMOUT for 8192 clock cycles. The IC gate driver will turn on again if the over voltage fault has been removed after the hiccup period. Normal voltage difference of VSP – OUV is within around 0.3V to 1.2V. If the over voltage stills exist after the hiccup period, no gate driver signal will coming out and the IC continues to count 8192 clock cycles for the hiccup mode again.



If the voltage difference is less than around 0.3V for 32 clock cycles (after the fault blanking time at IC startup, the blanking time is typically 1024 clock cycles), the LED will be treated as an output under voltage condition. T8382GN will stop the gate driving voltage to the internal MOSFET

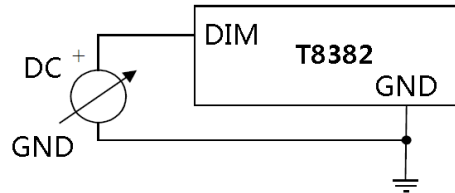
Note:

For 430kHz,

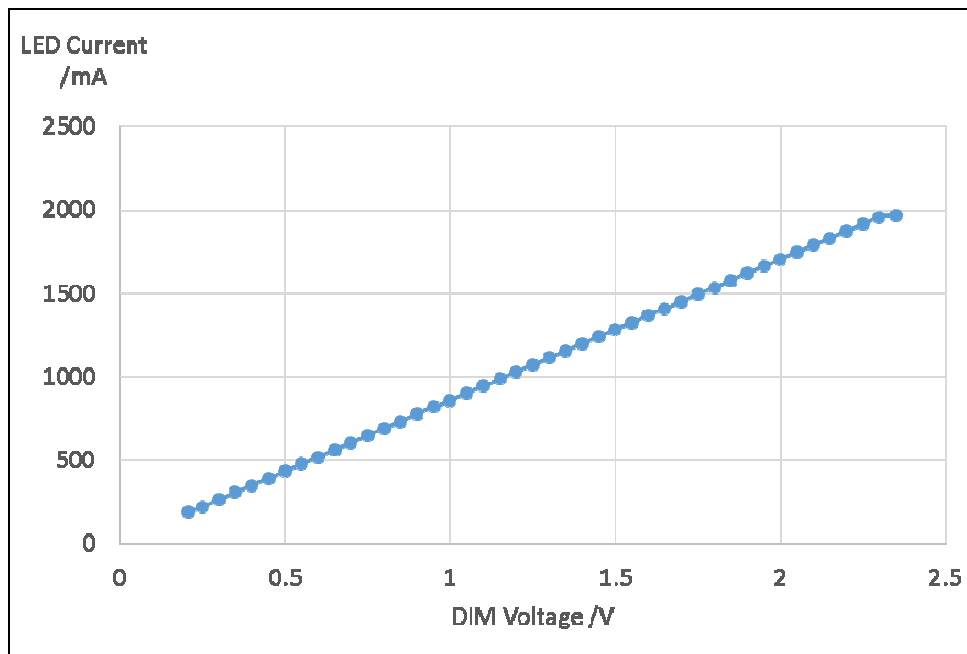
- 1024 clock cycles equivalent to 2.4ms.
- 8192 clock cycles equivalent to 19ms.

**Output current adjustment by external DC DIM control voltage**

The DIM pin can be driven by an external dc voltage, as shown, to adjust the output current to a value below the one programmed by  $R_{SENSE}$ .

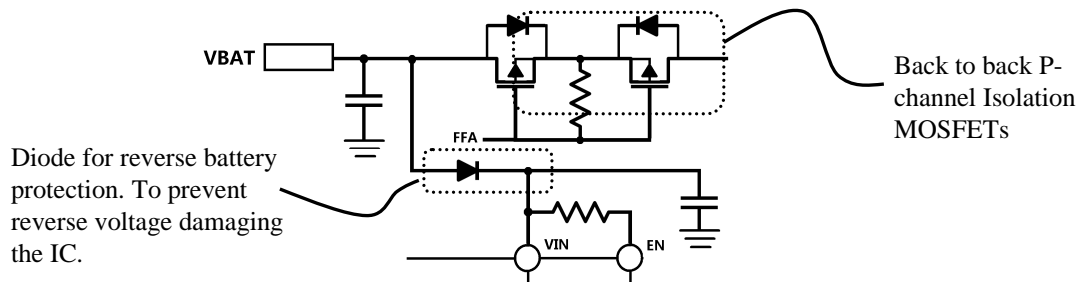


+Note that the DIM pin turns on voltage is 0.2V, 100% brightness setting corresponds to DIM pin above 2.3V. The DIM pin voltage < 0.16V, the LED controller will stop the gate driver.



**Reverse Supply Protection**

Protection for the T8382GN is provided by an external low current diode between the VBAT and the VIN pin, as shown in the picture below. This can prevent damaging the IC under reverse battery condition. Also, additional of isolation MOSFETs, it is possible to provide reverse battery protection to the switching elements and the LEDs. The additional MOSFETs should be connected, as shown in picture below, with the drain to the supply and the source to the source connection of the original isolation MOSFET.



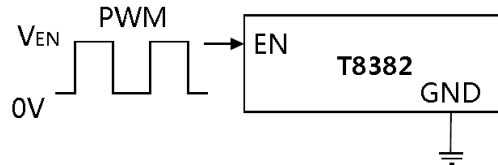
**Over-temperature Protection**

If the chip temperature exceeds the over-temperature threshold  $T_{SD}$  (~170°C), the IC will stop the gate driving. When the IC is shutting off, the IC's temperature will begin to drop. Once the temperature drops around 135°C (the temperature hysteresis is 35°C typically).The IC will resume to start switching again.

**Output current adjustment by PWM control**

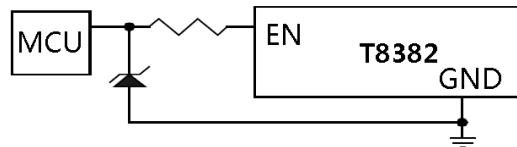
- **Directly driving EN input**

A pulse-width-modulation (PWM) signal with can be applied to the EN pin, as shown below, to adjust the output current to a value below the one programmed by  $R_{SENSE}$ .

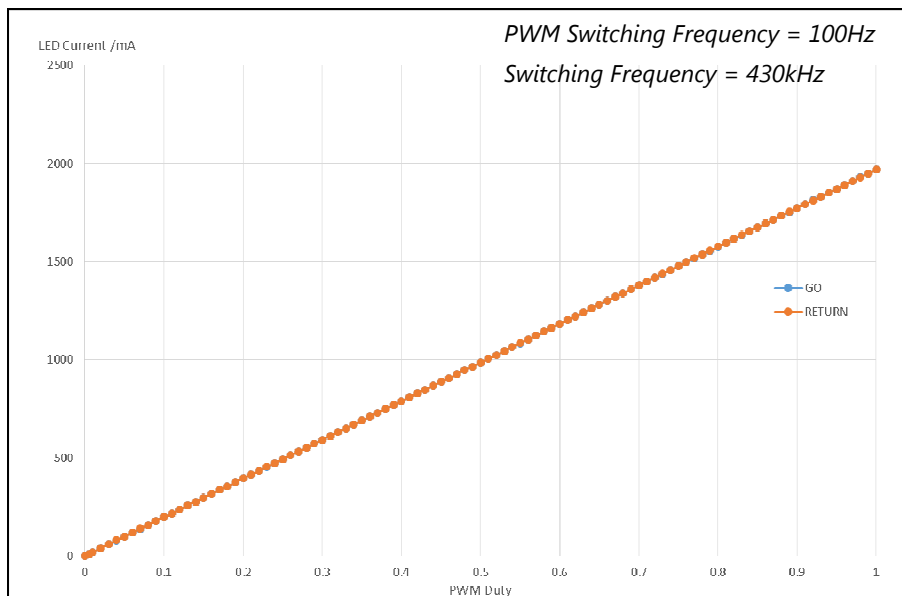


- **Driving the EN input from a microcontroller**

Another possibility is to drive the device from the open drain output of a microcontroller. The diagram below shows one method of doing this:



If the NMOS transistor inside the microcontroller has high drain capacitance / source capacitance, this arrangement can inject a negative spike into EN input of the T8382GN and cause erratic operation. The addition of a schottky clamp diode (cathode to EN) to ground and inclusion of a series resistor (10K) will prevent this.

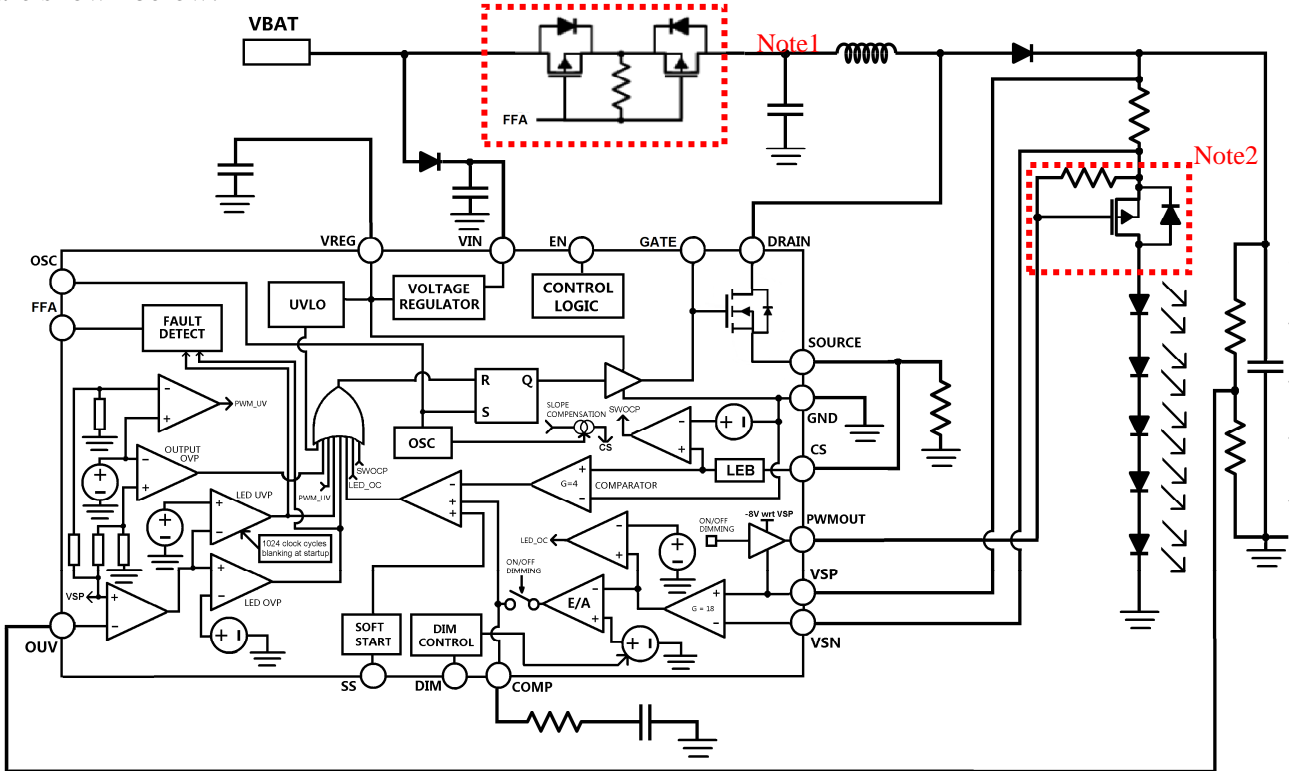


**PWM Dimming at 100Hz achieves 100:1 Dimming Ratio.**

**Testing Condition:  $V_{in} = 12V$ , LED voltage and full load current = 15V, 2A.**

**TYPICAL APPLICATION CIRCUITS**

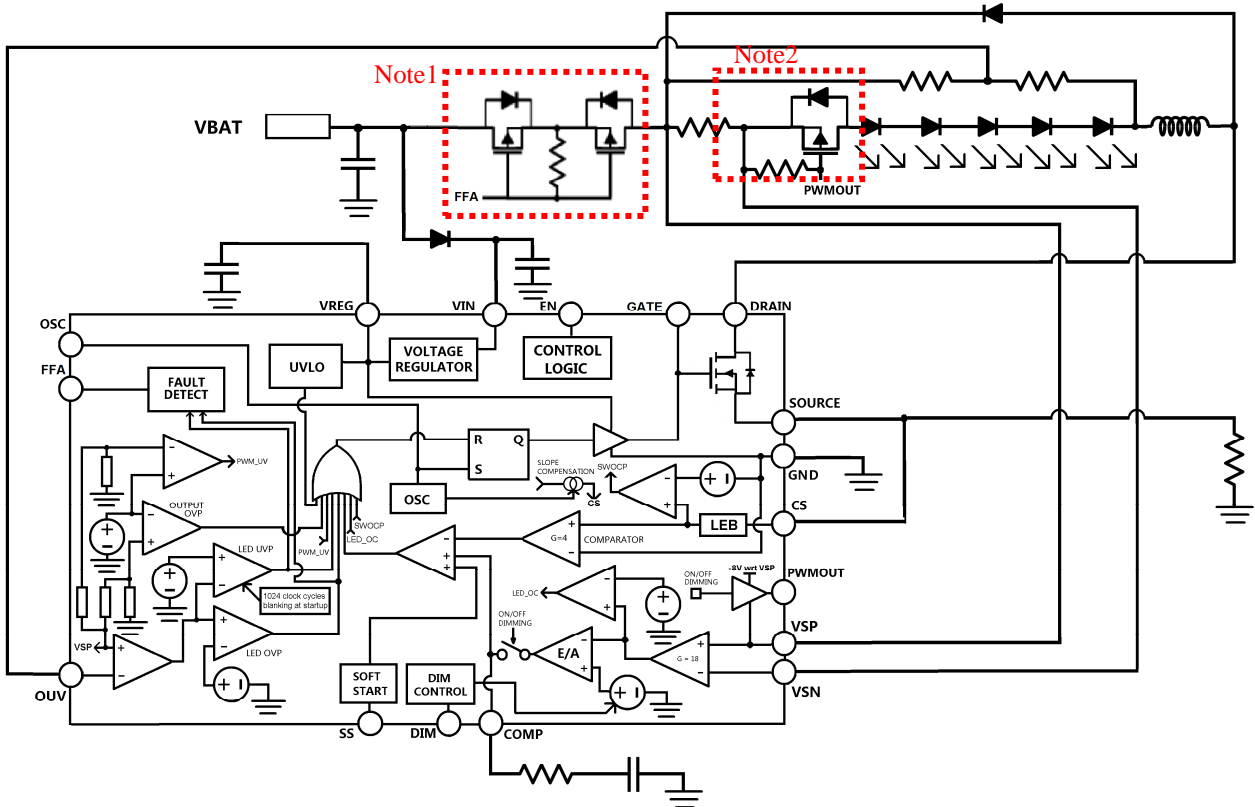
The T8382GN can be configured as Boost, Buck, Buck-Boost and SEPIC. The application circuits are shown below:



Boost Converter which is for  $V_{BAT} < V_{LED}$

**Note:** *VLED must be less than MOSFET rating.*

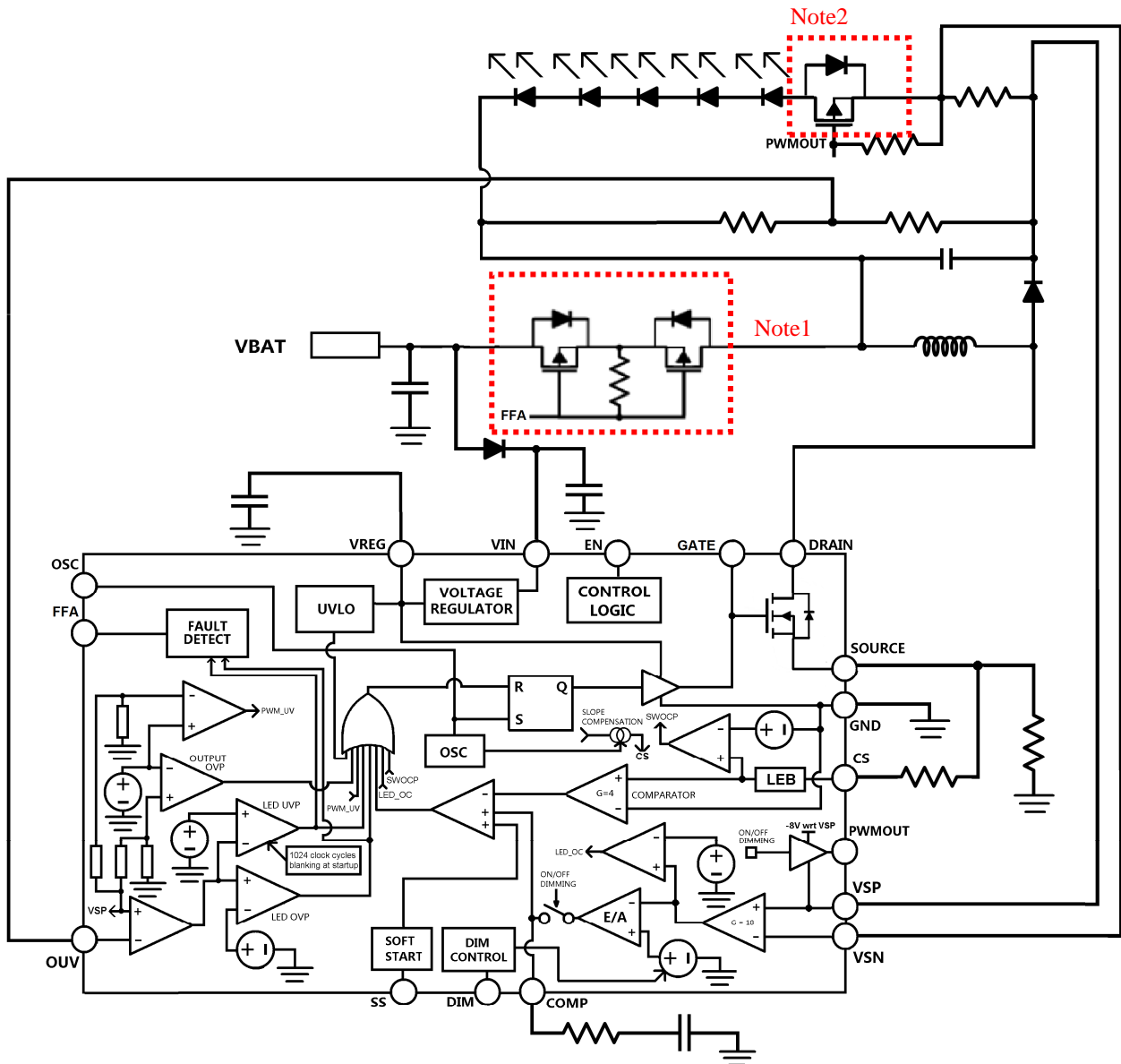
- Note1 : option for safety protection
- Note2 : option for high precision PWM dimming



Buck Converter which is for  $V_{BAT} > V_{LED}$

**Note:  $V_{BAT}$  must be less than MOSFET rating.**

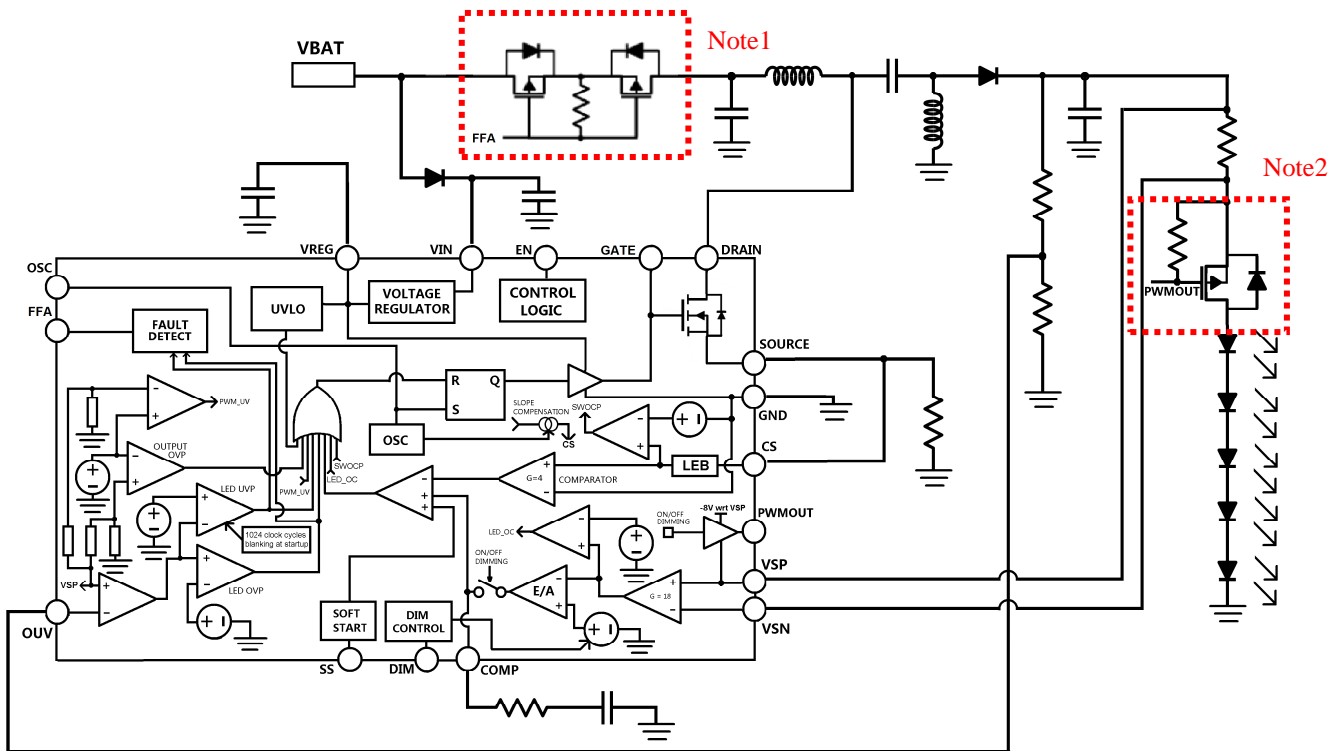
- Note 1 : option for safety protection
- Note 2 : option for high precision PWM dimming



Buck-Boost which is for  $V_{BAT} < V_{LED}$  or  $V_{BAT} > V_{LED}$ .

**Note:**  $V_{BAT} + V_{LED}$  must be less than MOSFET rating.

- Note1 : option for safety protection
- Note2 : option for high precision PWM dimming



SEPIC which is for  $V_{BAT} < V_{LED}$  or  $V_{BAT} > V_{LED}$ .

**Note:**  $V_{BAT} + V_{LED}$  must be less than MOSFET rating.

Note1 : option for safety protection

Note2 : option for high precision PWM dimming

