

High Integrated Dimmable LED Controller with Spread Spectrum Frequency Modulation for Automotive Headlight

DESCRIPTION

TS19501CB10 is a single channel LED driver of low-side-current sense. This device can operate in DCM, BCM and CCM mode with full protection and diagnostics. This device is dedicated for and ideally suited to automotive headlight. This controller supports typical topologies such as boost, buck-boost and SEPIC.

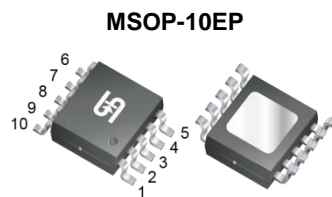
Output current regulation is based on average current mode control supervised by a control loop. The fault flag is connected to pullup resistor from V_{DC} for highlight the information of fault, fault status flag is latched by the timer when output is low.

APPLICATION

- Automotive LED Lighting: High and low Beam, Daytime Running Light, Turn indicator, Position Light, Fog Light
- General Lighting Applications
- High Brightness LED Applications

FEATURES

- Operating Ambient Temperature Range -40°C to 125°C
- Drives LEDs in Boost, Buck-Boost and SEPIC Topology
- Operation in DCM, BCM, CCM mode
- Input Voltage $4.5\text{V} \sim 38\text{V}$ (42V Abs. Max.)
- Adjustable Switching Frequency $70\text{k} \sim 700\text{kHz}$
- Low-Side Current Sense
- Internal Voltage Reference $150\text{mV} \pm 3.3\%$
- Both PWM Dimming and Analog Dimming
- Over Voltage Protection (OVP)
- Over Current Protection (OCP)
- Over Temperature Protection (OTP)
- Under Voltage Lockout (UVLO)
- Jitter function for effective spread spectrum to reduce EMI
- Fault Status flag
- Internal Soft Start
- Compliant to RoHS Directive 2011/65/EU and in accordance to WEEE 2002/96/EC.
- Halogen-Free according to IEC 61249-2-21

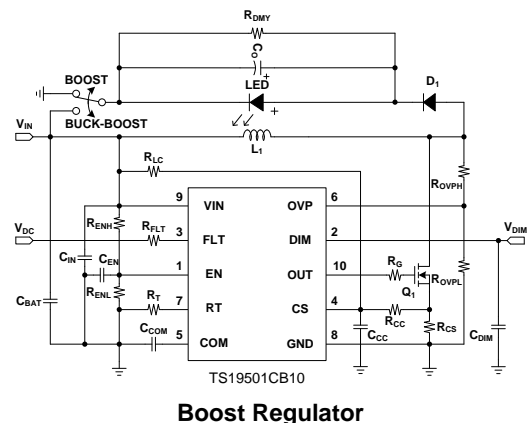
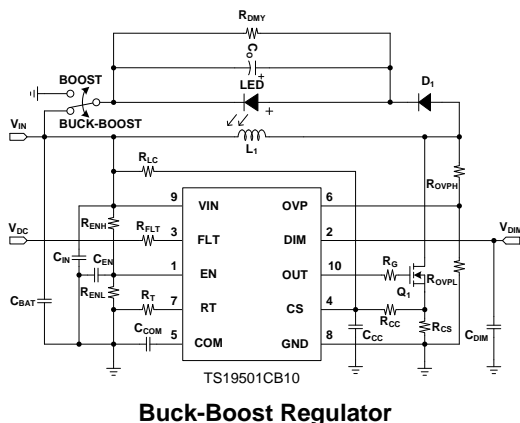


Pin Definition:

- | | |
|--------|---------|
| 1. EN | 10. OUT |
| 2. DIM | 9. VIN |
| 3. FLT | 8. GND |
| 4. CS | 7. RT |
| 5. COM | 6. OVP |

Notes: MSL 1 (Moisture Sensitivity Level) per J-STD-020

TYPICAL APPLICATION CIRCUIT



ABSOLUTE MAXIMUM RATINGS ($T_A = 25^\circ\text{C}$ unless otherwise specified) ^(Note 1)			
PARAMETER	SYMBOL	LIMIT	UNIT
Battery power input Pin	V_{IN}	-0.3 to 42	V
FLT output to GND	V_{FLT}	-0.3 to 42	V
OUT voltage to GND	V_{OUT}	-0.3 to 20	V
EN voltage to GND	V_{EN}	-0.3 to 5.5	V
DIM voltage to GND	V_{DIM}	-0.3 to 5.5	V
CS voltage to GND	V_{CS}	-0.3 to 5.5	V
COM voltage to GND	V_{COM}	-0.3 to 5.5	V
OVP voltage to GND	V_{OVP}	-0.3 to 5.5	V
RT voltage to GND	V_{RT}	-0.3 to 5.5	V
Junction Temperature Range	T_J	-40 to +150	$^\circ\text{C}$
Storage Temperature Range	T_{STG}	-65 to +150	$^\circ\text{C}$
Lead Temperature (Soldering 10 sec)	T_{LEAD}	260	$^\circ\text{C}$
Power Dissipation @ $T_A=25^\circ\text{C}$	P_D	1.1	W
ESD Rating (Human Body Model)	HBM	± 2	kV
ESD Rating (Charged Device Model)	CDM	± 1	kV

THERMAL PERFORMANCE ^(Note 2)			
PARAMETER	SYMBOL	TYP	UNIT
Thermal Resistance Junction to Ambient	$R_{\theta JA}$	113	$^\circ\text{C/W}$
Thermal Resistance Junction to Case	$R_{\theta JC}$	38	$^\circ\text{C/W}$

RECOMMENDED OPERATING CONDITION ($T_A = 25^\circ\text{C}$ unless otherwise specified) ^(Note 3)			
PARAMETER	SYMBOL	LIMIT	UNIT
Battery power input Pin	V_{IN}	8 to 38	V
FLT output to GND	V_{FLT}	0 to 38	V
OUT voltage to GND	V_{OUT}	0 to 18	V
EN voltage to GND	V_{EN}	0 to 5	V
DIM voltage to GND	V_{DIM}	0 to 5	V
CS voltage to GND	V_{CS}	0 to 0.8	V
COM voltage to GND	V_{COM}	1.2 to 3.6	V
OVP voltage to GND	V_{OVP}	1.6 to 3.1	V
RT voltage to GND	V_{RT}	1.2	V
Storage Temperature Range	T_{STG}	-55 to +150	$^\circ\text{C}$
Operating Junction Temperature Range	T_J	-40 to +150	$^\circ\text{C}$
Operating Ambient Temperature Range	T_{OPA}	-40 to +125	$^\circ\text{C}$

ELECTRICAL SPECIFICATIONS ($V_{IN}=14V$, $T_A=25^{\circ}C$ unless otherwise specified)						
PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Supply Voltage						
V_{IN} Turn-on Threshold	V_{IN_ON}		3.9	4.5	5	V
V_{IN} Hysteresis	V_{HYS}		--	0.1	--	V
EN Turn-on Threshold	V_{EN_ON}		1.05	--	1.35	V
EN Hysteresis Current	I_{HYS_EN}		10	20	30	μA
Quiescent Current	I_Q		--	150	240	μA
Operating Supply Current	I_{IN}	$R_{RT}=50k\Omega$	0.3	--	4	mA
GM Amplifier						
Internal Reference Voltage	V_{REF}		145	150	155	mV
Transconductance	G_m	$I_{COM_SINK}/0.4$	80	100	120	$\mu A/V$
Sink Current	I_{COM_SINK}	$V_{CS}=400mV$	32	40	48	μA
Source Current	I_{COM_SOUR}	$V_{CS}=0V$	12	15	18	μA
Oscillator						
Oscillator Frequency	F_{OSC}	$R_{RT}=50k\Omega$	185	200	215	kHz
Jitter Frequency	F_{JT}	Design Guarantee	--	± 8.5	--	%
Soft Start Time	T_{SS}		--	1024	--	Clock Cycles
Fault Blank Time	T_{FB}		--	2048	--	
Hiccup Time	T_{HUP}		--	32768	--	
Driver						
Dropout Voltage	V_{OH}	$V_{IN}=12V$, $C_O=1nF$, $I_O=10mA$	--	550	--	mV
	V_{OL}	$V_{IN}=12V$, $C_O=1nF$, $I_O=-10mA$	--	50	--	mV
Output Rising Time	T_R	$C_O=1nF$	--	50	--	ns
Output Falling Time	T_F	$C_O=1nF$	--	50	--	ns
Output Clamp Voltage	V_{O_CLAMP}	$C_O=1nF$	--	12.5	18	V
Protection						
Output Voltage Protection Short Circuit Protection	V_{OVP}		3.0	3.25	3.5	V
	V_{SCP}		1.4	--	1.6	V
Current Limit Voltage	V_{CSL}		--	800	900	mV
Leading Edge Blanking Time	LEB_t	$C_O=1nF$	--	320	--	ns
MOS Current Protection	V_{MCP}	$C_O=1nF$	--	1.2	1.35	V
FLT Dropout Voltage	V_{FLT}	$I_{FLT}=10mA$	--	200	--	mV
Maximum Duty	V_{DUTY}	$C_O=1nF$	--	85	--	%

ELECTRICAL SPECIFICATIONS ($T_A = 25^\circ\text{C}$ unless otherwise specified)						
PARAMETER	SYMBOL	CONDITION	MIN	TYP	MAX	UNIT
Dimming						
PWM Dimming High Threshold Voltage	V_{OH_DIM}		2.5	--	--	V
Linear Dimming Threshold Voltage of 100% Current Regulation	V_{MAX_DIMA}		--	1.6	--	V
Source Current of DIM	I_{DIM}		7.5	10	12.5	μA
Thermal Section (Note 4, 5)						
Thermal Shutdown	TSD		--	165	--	$^\circ\text{C}$
Temperature Hysteresis	T_{HYS}		--	30	--	$^\circ\text{C}$

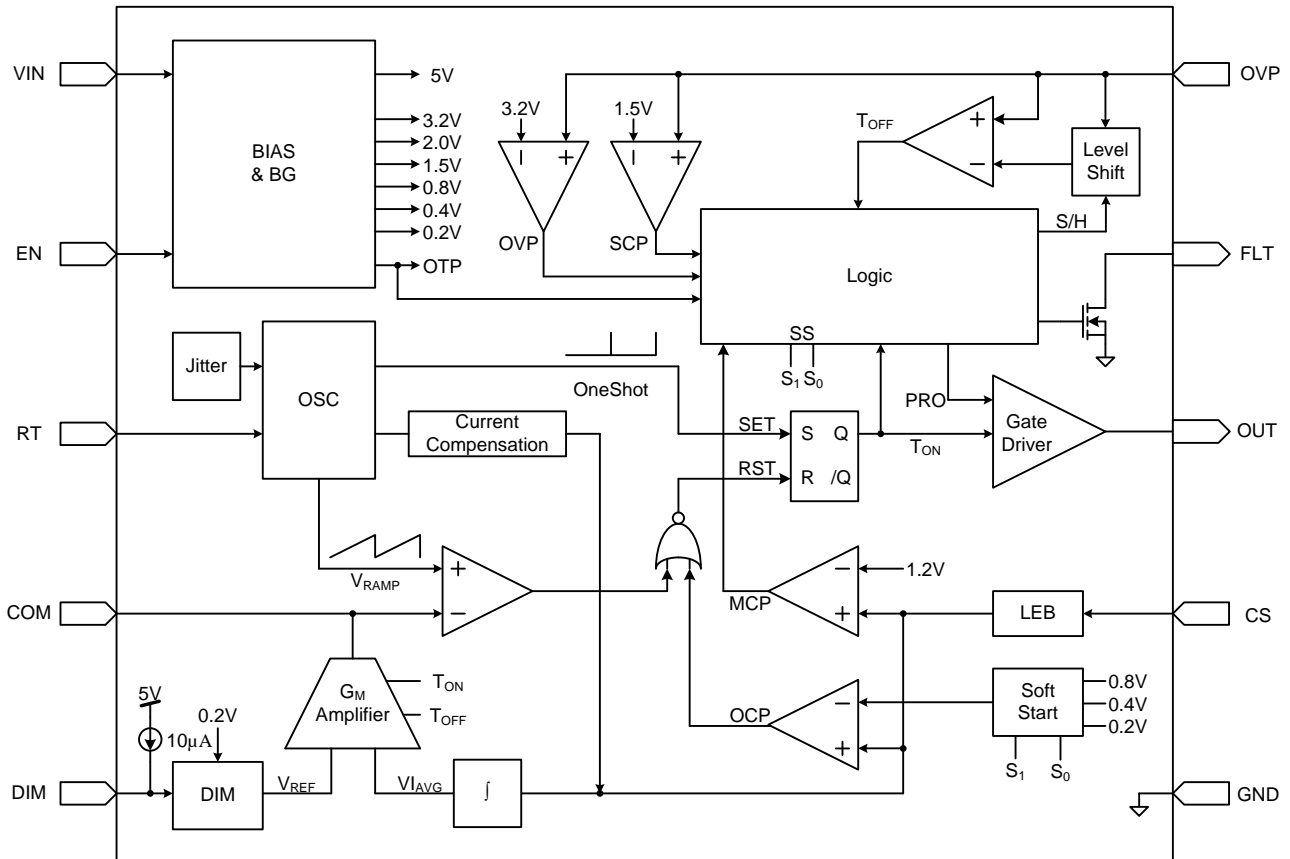
Note:

1. Stresses listed as the above "Absolute Maximum Ratings" may cause permanent damage to the device. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.
2. Test boards conditions:
 - (a) 5.6mm × 4mm, 2 layers, thickness: 1mm.
 - (b) 1-oz copper traces located on the top of the PCB.
 - (c) 1-oz copper ground plane, bottom layer.
 - (d) 5-thermal vias (0.3mm) located under the device package.
3. The device is not guaranteed to function outside its operating conditions.
4. Guaranteed by design.
5. Auto Recovery type.

ORDERING INFORMATION

ORDERING CODE	PACKAGE	PACKING
TS19501CB10 RBG	MSOP-10EP	5,000pcs / 13"Reel

FUNCTION BLOCK



PIN DESCRIPTION

PIN NO.	NAME	FUNCTION
1	EN	Enable and shut down pin
2	DIM	PWM/Linear dimming voltage input
3	FLT	Open drain output pin for fault status flag.
4	CS	Input current sense pin.
5	COM	Compensation output pin of error amplifier.
6	OVP	Over voltage sensing pin
7	RT	Connect external resistor to GND to set frequency.
8	GND	Ground return for all internal circuitry.
9	VIN	Battery power input pin for all internal circuitry.
10	OUT	Power MOS output pin.

TYPICAL PERFORMANCE CURVES

$V_{IN}=12V$, $I_{LED}=600mA$, $V_O=24V$ (8 LEDs) unless otherwise specified.

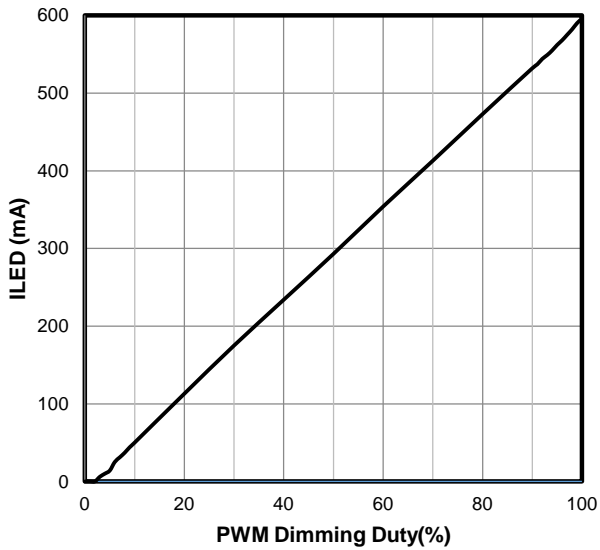


Figure 1. ILED vs. PWM Dimming Duty

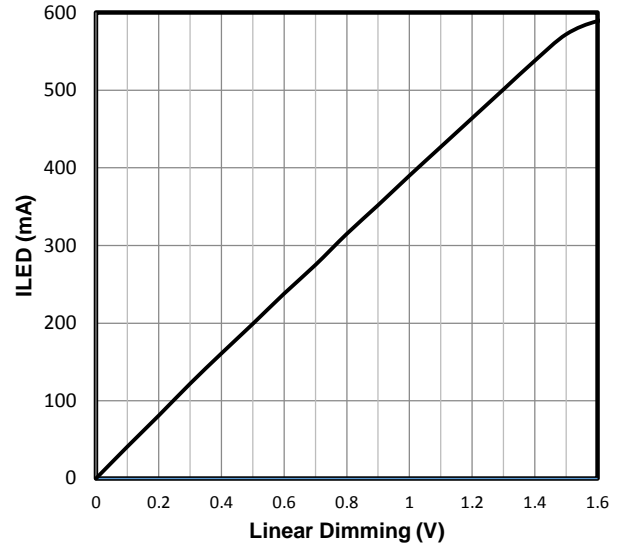


Figure 2. ILED vs. Linear Dimming

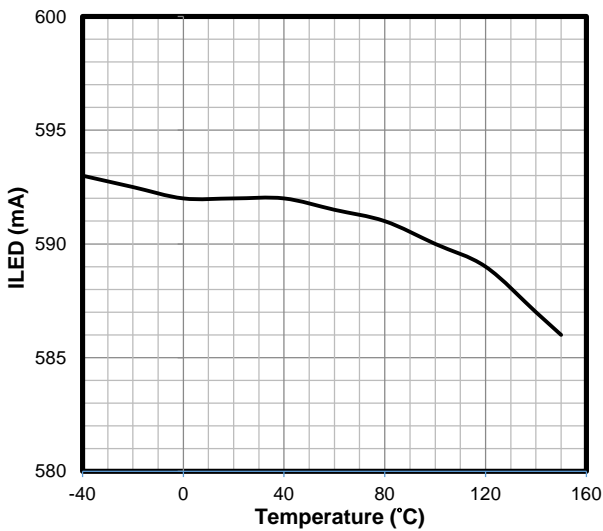


Figure 3. ILED vs. Temperature

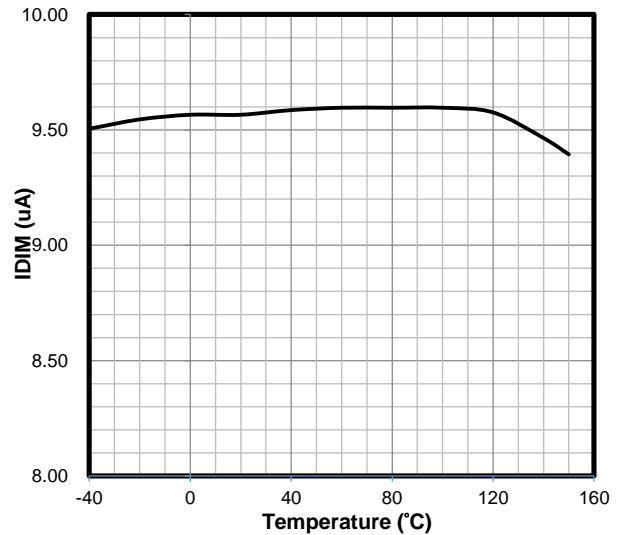


Figure 4. IDIM vs. Temperature

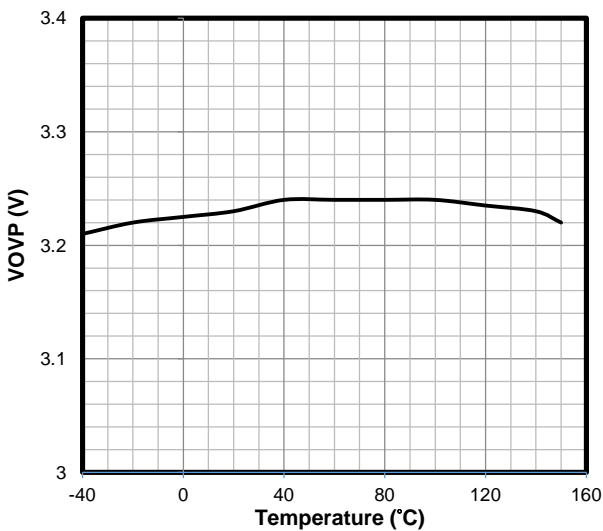


Figure 5. OVP vs. Temperature

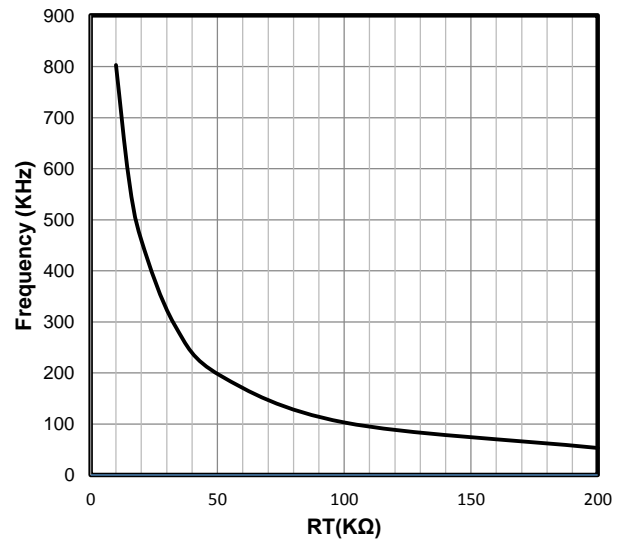
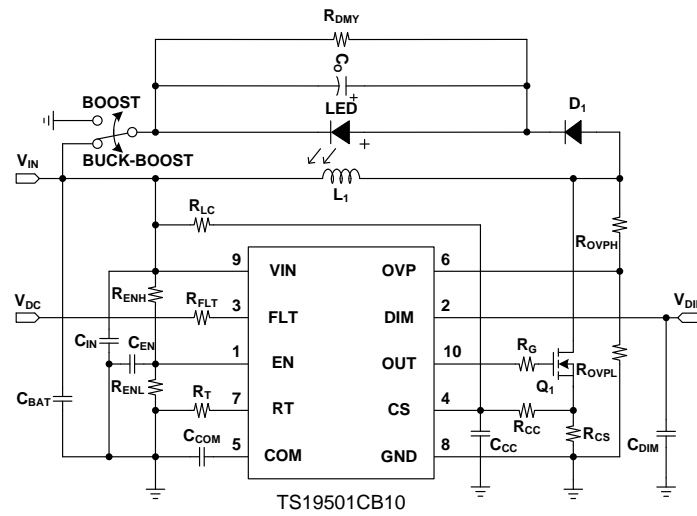
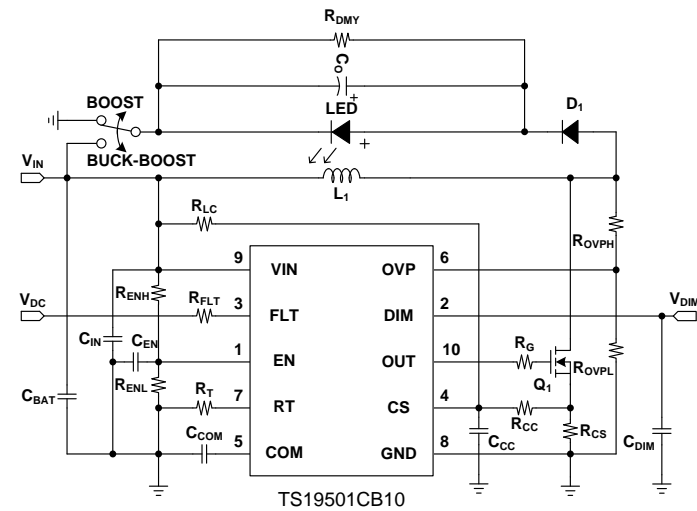


Figure 6. Frequency vs. RT

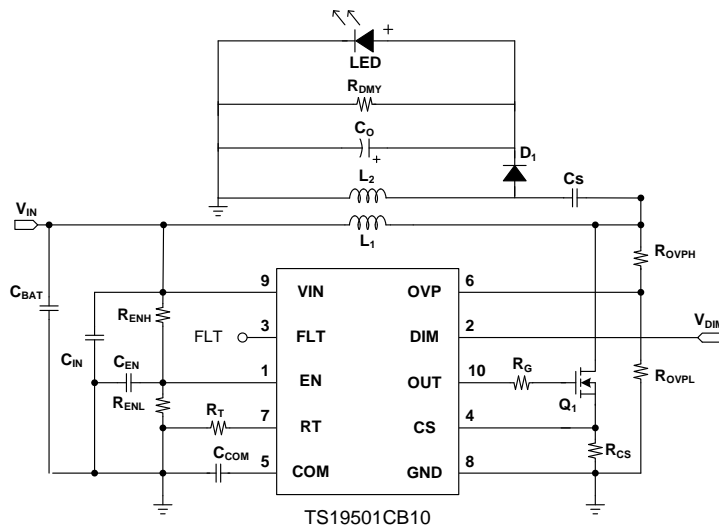
TYPICAL APPLICATION CIRCUITS



Buck-Boost Regulator



Boost Regulator



SEPIC

APPLICATION INFORMATION

The TS19501CB10 uses an external current sense resistor (R_{CS}) between the MOSFET source and the GND to convert the input power. The MOSFET ON current signal and V_{REF} are input to the GM amplifier. The special GM amplifier follow the design formula to combine the T_{ON} and T_{OFF} information which are force to be equal potential through system negative feedback.

The average LED current can be expressed as below.

$$I_{LED_avg} = \frac{V_{REF}}{R_{CS}}$$

Where:

- I_{LED_avg} is the average LED current
- V_{REF} is the internal reference voltage (150mV)
- R_{CS} is the sensing resistor connected between the MOSFET source and the GND

Pin Definitions

EN Pin

The EN pin can sense V_{IN} information by voltage divider resister. The hysteresis current (I_{EN}) is 20 μ A when the divider voltage over V_{EN_ON} .

DIM Pin

A PWM and linear dimming function is applied in TS19501CB10. The linear dimming range is an analog voltage from 0V to 1.6V. PWM dimming function is the same pin of linear dimming. The current regulation is decided by duty cycle of external PWM signal. Built-in 10 μ A source current is for NTC resistance application.

FLT Pin

Open drain output for fault status flag.

CS Pin

MOSFET current signal sensing and current limit setting function.

$$I_{CS(LIMIT)} = \frac{0.8}{R_{CS}}$$

Where:

- $I_{CS(LIMIT)}$ is the input current limit
- R_{CS} is the sensing resistor connected between the MOSFET source and GND

COM Pin

This is the output of the G_m amplifier. Connect with a suitable RC network to ground.

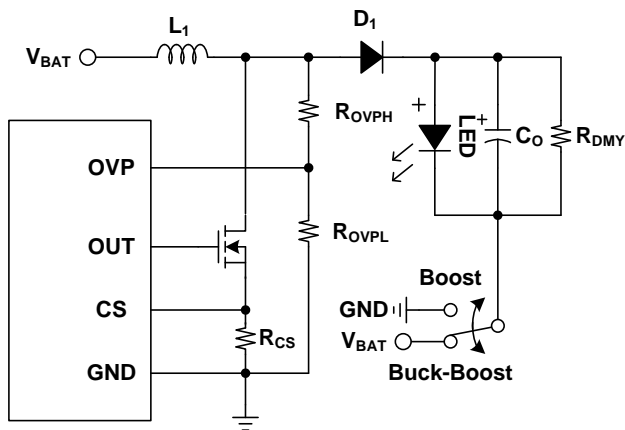
APPLICATION INFORMATION

Pin Definitions (Continue)

OVP Pin

The Output voltage is reflected by inductor voltage. The OVP pin can sense output information to depart from start-up voltage (V_{SCP}) and protect voltage (V_{OVP}).

When the OVP sense voltage under V_{SCP} a period of time (8 clock cycles), The short circuit protection (SCP) will work. When the OVP sense voltage over V_{OVP} a period of time (8 clock cycles), the over voltage protection (OVP) will work. it will attempt to recover after every 32768 clock cycles.



For Boost

$$V_{O_OVP} = 3.2 \times \frac{R_{OVPH} + R_{OVPL}}{R_{OVPL}}$$

$$V_{O_SCP} = 1.5 \times \frac{R_{OVPH} + R_{OVPL}}{R_{OVPL}}$$

For Buck-Boost and SEPIC

$$V_{O_OVP} = \left(3.2 \times \frac{R_{OVPH} + R_{OVPL}}{R_{OVPL}} \right) - V_{BAT}$$

$$V_{O_SCP} = \left(1.5 \times \frac{R_{OVPH} + R_{OVPL}}{R_{OVPL}} \right) - V_{BAT}$$

Where:

- V_{OVP} is the output-over-voltage protection point (3.2V)
- V_{SCP} is the output-short-circuit protection point (1.5V)

RT Pin

This pin is to program the operation frequency by connecting a resistor to ground.

Reference formula as below:

$$F_s = \frac{1}{1 \times 10^{-10} \times R_T}$$

GND Pin

GND is the reference node of internal circuit.

VIN Pin

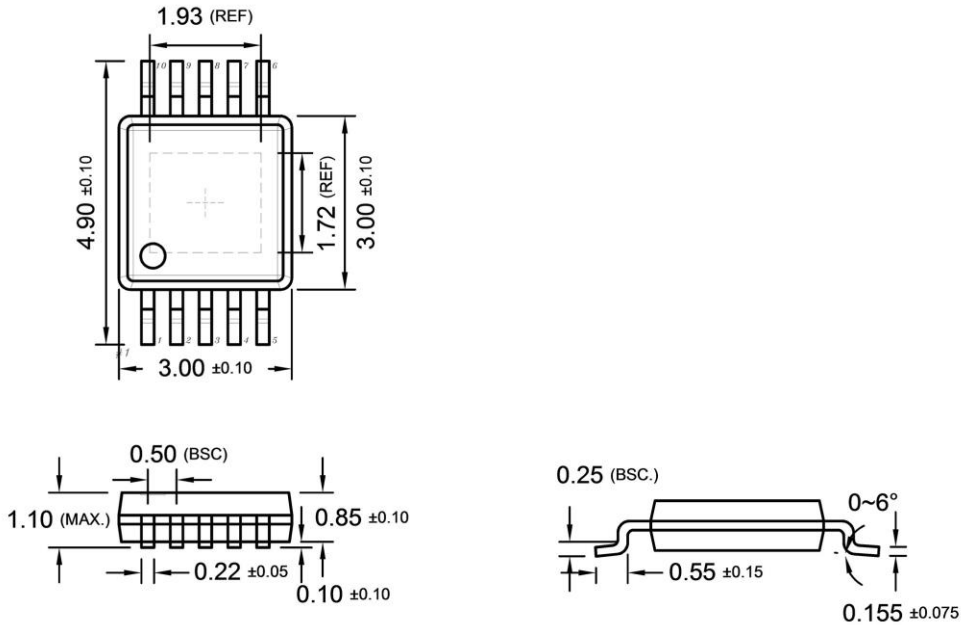
Power supply input for the controller during normal operation. The controller will start up when V_{IN} reaches 4.2V (typical) and will shut-down when V_{IN} voltage is below 4.0V (typical) when V_{EN} over 1.2V. A decoupling capacitor should be connected between the V_{IN} and GND pin as close as possible.

OUT Pin

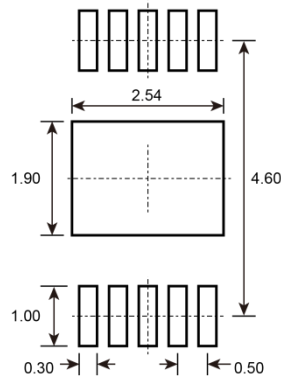
Gate drive for external MOSFET switch and built-in gate clamp function.

PACKAGE OUTLINE DIMENSIONS (Unit: Millimeters)

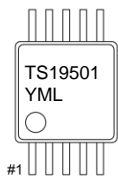
MSOP-10EP



SUGGESTED PAD LAYOUT (Unit: Millimeters)



MARKING DIAGRAM



Y = Year Code
M = Month Code for Halogen Free Product
O =Jan P =Feb Q =Mar R =Apr
S =May T =Jun U =Jul V =Aug
W =Sep X =Oct Y =Nov Z =Dec
L = Lot Code (1~9, A~Z)

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