MT7815B

PWM/Analog dimmable Non-isolated Constant Current LED Driver

DESCRIPTION

MT7815B is a high precision LED constant current controller operating at critical conduction mode (CRM) with zero current switched-on and peak current switched-off. It's mainly targeted for non-isolated buck LED power systems and PWM/Analog dimmable application.

Critical conduction mode ensures that the MT7815B turns on the internal switch when the inductor current reaches zero, reducing the switch-on switching losses, and achieving more than 93% efficiency.

With critical conduction mode, and the input compensation, MT7815B outputs high accuracy LED current, and further achieves excellent line regulation and load regulation.

MT7815B has wide working voltage range, which is suitable for full-range AC input or 12V ~ 500V DC input voltage. MT7815B provides various protection features to improve the system reliability, including over current protection (OCP), short circuit protection (SCP), adjustable over voltage protection (OVP) and over temperature regulation (OTR), etc.

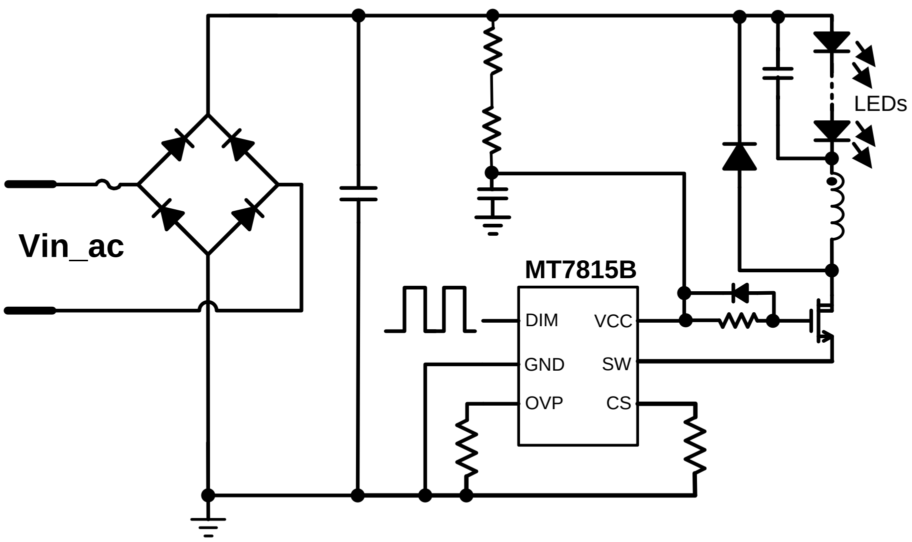
FEATURES

- Critical Conduction Mode, insensitive to the inductance
- PWM/ Analog dimming function
- High efficiency (up to 93%)
- Highly accurate constant LED current
- Cycle-by-cycle current limiting
- LED short circuit protection
- Adjustable LED over voltage protection
- Leading edge blanking technique
- Under-voltage lockout (UVLO) protection
- Over temperature regulation (OTR)
- Available in SOT23-6 package

APPLICATIONS

- LED tube, signal lamp, landscape lamp
- LED stage light, etc
- Intelligent LED lighting application

Typical Application Circuit



ABSOLUTE MAXIMUM RATINGS

VCC maximum sink current	5mA
SW (internal switch input pin input voltage)	-0.3V~ 40V
OVP (over voltage protection pin input voltage)	-0.3V ~ 6V
DIM (PWM/Analog dimming pin input voltage)	-0.3V ~ 6V
CS (current sense pin input voltage)	-0.3V ~ 6V
P_{DMAX} (maximum power dissipation)	0.5W
Storage Temperature range	-55°C ~ 150°C
Junction Temperature (Tj)	150°C

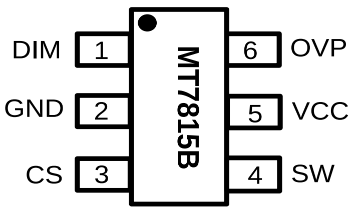
RECOMMENDEDE OPERATING CONDITIONS

Operating Ambient Temperature Range	-40°C ~ 105°C
Output Current	<700mA

Thermal resistance

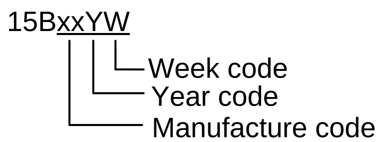
Junction to ambient ($R_{\theta JA}$)	170°C/W

PIN CONFIGURATIONS



(SOT23-6)

Chip Mark



PIN DESCRIPTION

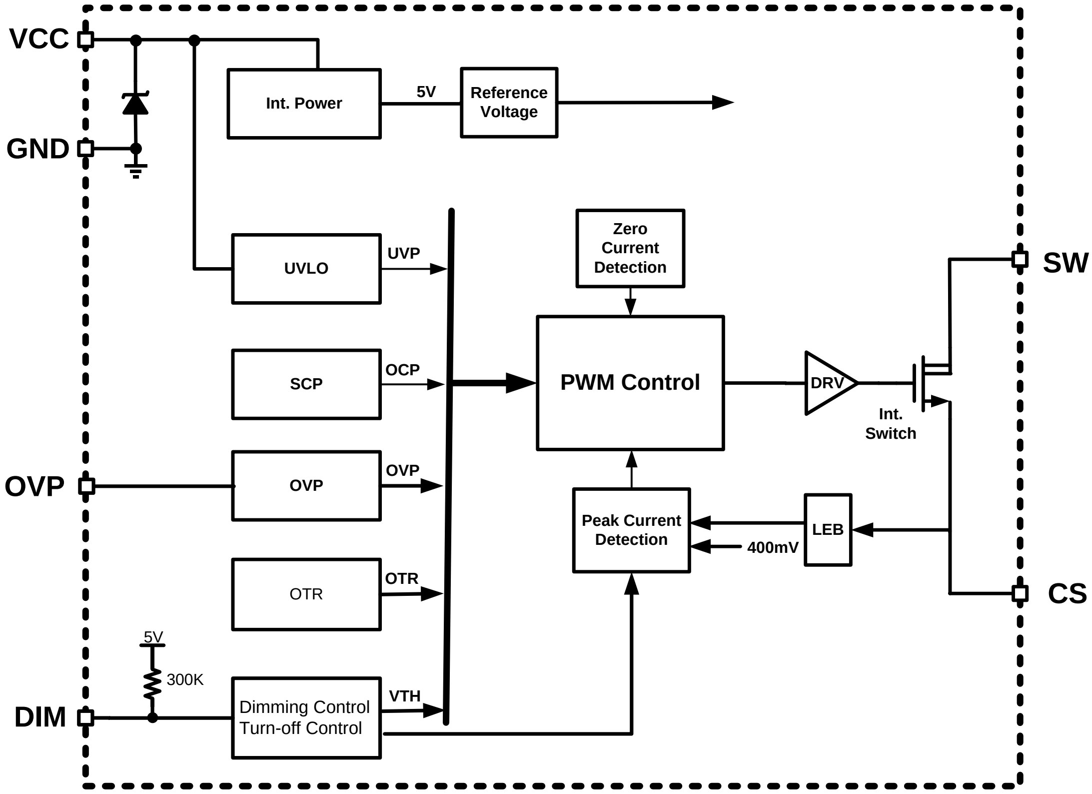
Name	Pin No.	Description
DIM	1	Chip enable/ PWM dimming /analog dimming Internal has a 300K pull_up resistor, this pin can be floating
GND	2	Ground
CS	3	Current sense input, connect a sense resistor to ground
SW	4	Internal switch input
VCC	5	Power supply pin, internal clamped at 14V
OVP	6	Adjustable over voltage protection pin

ELECTRICAL CHARACTERISTICS

(Test condition: VCC=13V, TA=25°C unless otherwise stated.)

Symbol	Parameter		Min	Typ	Max	Unit
Start-up and supply voltage (VCC Pin)						
I_{START}	Start up current	$V_{CC}< V_{CC\_UV}$		220	260	μA
V_{CC_UV}	Under Voltage Lockout (UVLO)	V_{CC} Pin ramp down		6.5		V
V_{START}	Start-up voltage	V_{CC} Pin ramp up		11.5		V
$V_{CC\text{-}CLAMP}$	V_{CC} Clamp voltage	I_{DD}<5mA		14		V
Supply current						
I_{op}	Operating current			0.35		mA
Current sense (CS Pin)						
$V_{CS\text{-}TH}$	Threshold voltage for peak current limit		390	400	410	mV
LEB1	Leading edge blanking time for current sense			500		ns
DIM dimming (DIM Pin)						
$V_{DIM\_floating}$	DIM pin floating			5		V
R_{DIM_Pullup}	DIM pin floating			300K		Ω
V_{DIM_EN}	Chip enable threshold (Enable: $V_{DIM}> V_{DIM\_EN}$)		0.5		0.7	V
V_{DIM_ON}	The turn on threshold for PWM dimming			2.5		V
V_{DIM_ANALOG}	Analog dimming range		0.7		1.6	V
Over Temperature Regulation						
OTR	Thermal regulation temperature			155		℃
Driver Circuit						
T_{OFF_MIN}	Minimum OFF time	DIM pin floating		2.5		us
T_{OFF_MAX}	Maximum OFF time			400		us
T_{ON_MAX}	Maximum ON time			40		us
Internal switch (SW Pin)						
R_{DSON}	Static drain-source on-resistance	V_{GS}=13V/I_D=0.5A		0.7		Ω
BV_{DSS}	Breakdown voltage	V_{GS}=0V/I_D=250uA	40			V
I_{DSS}	Leakage current	V_{GS}=0V/V_{DS}=40V			10	uA

BLOCK DIAGRAM



APPLICATION INFORMATION

MT7815B is a constant current driver, designed for non-isolated buck applications with PWM/ /analog dimming function.

MT7815B works under critical conduction mode, switches on the internal switch at inductor current is zero. This way improves efficiency and reduces the switch-on switching loss. With very few peripheral components, the MT7815B achieves excellent constant current control.

Start up

During start-up, VCC is charged through the start-up resister. As VCC reaches 11.5V, the control logic starts to work, and internal switch starts toggling. When the VCC rises up to 14V, it will be clamped. MT7815B shuts down as VCC falls below 6.5V.

CRM and Output Current Setup

The internal switch current is cycle-by–cycle detected by monitoring the CS pin voltage. When the voltage on CS pin reaches 400mV (internal reference voltage), the internal switch is turned off. When the inductor current drops to zero, the system turns on the internal switch again.

The peak inductor current is given by:

$$I_{LPK} = \frac{400}{R_{CS}}(mA) \qquad (1)$$

Where, R_{CS} is the current sense resistor in ohm. The CS comparator also includes a 500ns leading edge blanking time to block the transient noise as the power switch just turned on.

The current at LED can be calculated as:

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$$I_{LED} = \frac{I_{LPK}}{2} = \frac{400\text{mV}}{2 \times Rcs}(mA) \quad (2)$$

Where, I_{LPK} is the peak current through the inductor. Shown in the above equation, the output current is determined by the R_{CS} and the 400mV reference voltage, insensitive to the inductance.

Switching Frequency

MT7815B operates at critical conduction mode. When the inductor current is zero, the system turns on the internal switch, the inductor current rises up from the ground. The on time of the internal switch is calculated by the equation:

$$T_{ON} = \frac{L \times I_{LPK}}{V_{IN} - V_{LED}} \quad (3)$$

Where, L is the inductance of the inductor;
I_{LPK} is the peak current through the inductor;
V_{IN} is the DC voltage of the rectified input voltage;
V_{LED} is the forward voltage drop of the LED.
The internal switch is switched off, while the voltage on the CS pin increases to 400mV. The inductor current will discharge the LED through the free-wheeling diode. The internal switch won't be turned on until the current in the inductor drops to zero. The off time of the internal switch is calculated by the equation:

$$T_{OFF} = \frac{L \times I_{LPK}}{V_{LED}} \quad (4)$$

Operating frequency of the system is:

$$\text{F} = \frac{1}{T_{ON} + T_{OFF}} = \frac{V_{LED} \times (1 - \frac{V_{LED}}{V_{IN}})}{L \times I_{LPK}} \quad (5)$$

From the above equation, it's showing that MT7815B operating frequency is determined by the input voltage V_{IN}, the LED forward voltage drop V_{LED} and the inductance L. The higher input voltage V_{IN} makes the operating frequency to be higher. The appropriate inductance should be determined at minimum input voltage condition to meet the requirement:

1) For both EMI and efficiency consideration, set the operating frequency between 30kHz ~80kHz.
2) It's recommended to set the minimum operating frequency to be higher than 40kHz at lowest input voltage condition to achieve better PWM dimming effect.

MT7815B sets the maximum off-time T_{OFF_MAX}=400us, the minimum off-time T_{OFF_MIN}=2.5us. Shown in T_{OFF} equation, if the inductance is too large, T_{OFF} maybe longer than T_{OFF_MAX}, the system will turn on the switch before the inductor current falls to zero, the system will operate in continuous conduction mode and the output current will be higher than the designed value. On the contrary, if inductance is too small, the T_{OFF} may be shorter than T_{OFF_MIN}, the system enters OVP protection status. So it's important to choose a proper inductance.

Analog Dimming Application

The DIM pin can be driven by an external DC voltage to adjust the average output current by adjusting the internal reference voltage.
Analog dimming range is about 0.7V to 1.6V. The dimming curve is shown in Fig.2.
The average output current can be calculated as:

$$I_{LED} = 0.5 \times \frac{(400 - 400 \times (1.6V - V_{DIM}))mV}{R_{CS}} \quad (6)$$

Where, $0.7V \le V_{DIM} \le 1.6V$

As V_{DIM} in the range of 1.7V to 5V ($1.7V \le V_{DIM} \le 5V$), the output current I_{LED} keeps as the maximum value.
There are two methods for analog dimming:

1) Input analog level directly. The DC voltage can be adjusted by a potentiometer to generate a variable analog signal on DIM pin.
2) Using PWM signal to generate analog signal by connecting a Low-Pass RC filter to DIM pin. Refer to Fig.1.

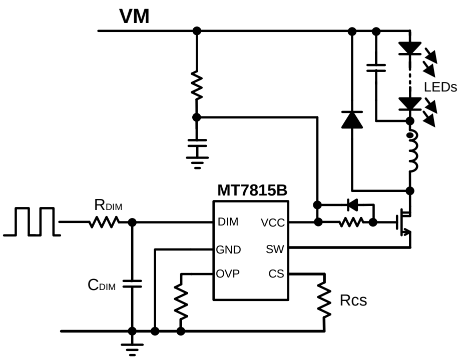


Fig.1 Analog dimming setup

The analog signal value after RC-filtered:

$$V_{DIM} = D_{PWM} \times V_{AM} \quad (7)$$

Where, V_{AM} is the amplitude of the PWM signal. By adjusting the duty cycle of the PWM signal (D_{PWM}), analog dimming is achieved.

It is recommended to set the R_{DIM} to be less than 10K, to adjust the C_{DIM} to achieve PWM filtering. The ratio between the dimming frequency of PWM signal and the cutoff frequency of the $R_{DIM} \times C_{DIM}$ should be greater than 300. Refer to Fig.1.

$$\frac{F_{PWM}}{\left(\frac{1}{2\pi \times R_{DIM} \times C_{DIM}}\right)} > 300 \quad (8)$$

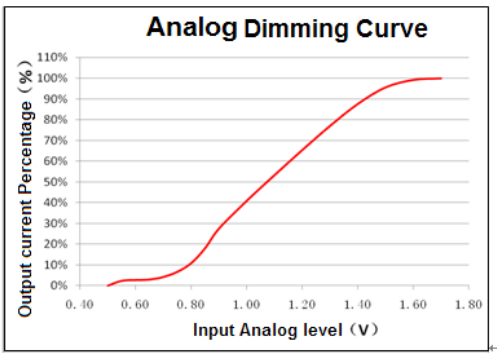


Fig.2 Analog dimming curve

PWM Dimming

The output current can be adjusted by the DIM pin which connects a PWM signal. By adjusting the duty cycle of the PWM signal (D_{PWM}) to adjust the output current to be lower than the setting value, which is set by resistor Rcs.

Amplitude of the PWM signal must be higher than 2.5V, and the frequency should keep in 100Hz ~ 3kHz range. The PWM dimming frequency can be increased by increasing the system operating frequency accordingly.

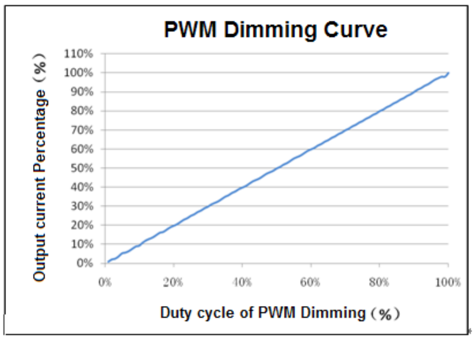


Fig.3 PWM dimming curve (Dimming frequency is 1kHz)

Shut Down Mode

If the voltage of the DIM pin is lower than 0.5V, the system will shut down. The quiescent current of the system will keep as low as 220uA.

LED Over Voltage Protection Setup

The OVP function is enabled by DIM pin:
When $V_{DIM} \geq 2.5V$, OVP function is enabled;
When $V_{DIM} < 2.5V$, OVP function is disabled.

The OVP threshold of MT7815B is adjustable through the resistor R_{SET} (Refer to Fig.4.).

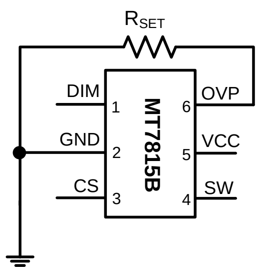


Fig.4 OVP setup

The OVP threshold can be calculated as:

$$V_{OVP} = \frac{2.75 \times L \times R_{SET}}{R_{CS}} \text{ (V)} \qquad (9)$$

Where, L is in Henry; Rcs is in ohm; R_{SET} is in ohm

Consideration for OVP Setup：

1) Considering the accuracy of the inductor, the calculated value of OVP threshold by Equation above may not exactly match the real value. It is highly recommended to set the OVP threshold to be 1.3 times of the maximum LED voltage. Otherwise it may false trigger the OVP protection during normal operation, resulting in flickering.
2) The OVP pin can be floated. If this pin is left floating, the OVP function will be not available.
3) If the voltage of the inductor is relatively small, the system will enter MAXON status. Thus, the real I_{LPK} will be lower than the calculated value, and the demagnetization time will be reduced, when the demagnetization time decreased to lower than the OVP setting value, the system will trigger OVP protection. This can be avoided through increasing the input capacitor or increasing the OVP threshold.

LED Short-circuit Protection

When the LED is shorted, the system enters MAXOFF status, and the power dissipation is reduced to be the lowest. Once the short-circuit condition is removed, MT7815B automatically resumes to normal working status.

Over-current Protection

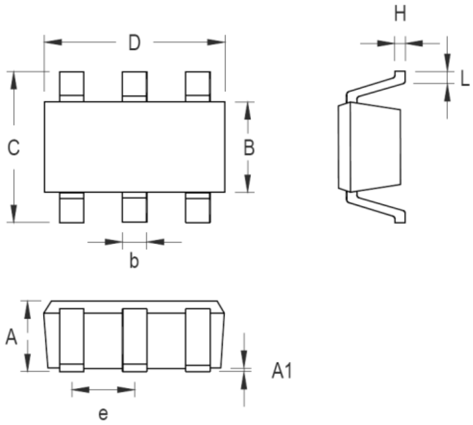
MT7815B immediately turns off the internal switch once the voltage at CS pin reaches 400mV. This cycle- by- cycle current limitation scheme prevents the relevant components, such as external power MOSFET, transformer, etc. suffers from damage.

Thermal Regulation

The MT7815B integrates thermal regulation function to monitor the IC junction temperature. When the system is over heated, the output current is gradually reduced and so as the output power and thermal dissipation. This way the system temperature is adjusted in the reliable range. The thermal regulation temperature is 155℃.

PACKAGE INFORMATION

SOT23-6 PACKAGE OUTLINE AND DIMENSIONS



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A	0.889	1.295	0.035	0.051
A1	0.000	0.152	0.000	0.006
B	1.397	1.803	0.055	0.071
b	0.250	0.559	0.010	0.022
C	2.591	2.997	0.102	0.118
D	2.692	3.099	0.106	0.122
e	0.838	1.041	0.033	0.041
H	0.080	0.254	0.003	0.010
L	0.300	0.610	0.012	0.024

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