

1.2A Buck Converter for High Brightness LED Driver With LED Thermal Shutdown

■ FEATURES

- 7V to 36V Input Voltage Range
- Up to 1.2A Output Current
- Adjustable Constant Output Current
- Up to 96% Efficiency
- User-Defined LED Thermal Control
- Supports External PWM Dimming and Analog Dimming
- LED Thermal Overload Protection
- Wide Range PWM Dimming Control (100:1)
- 40KHz Maximum Dimming Frequency
- Integrated Power MOSFET
- Internal Soft-Start Function
- Built-in OCP, SCP and OTP
- Available in SOT23-5, SOT23-6 and SOP-8 Exposed Pad Package

■ APPLICATIONS

- High Brightness LED Lighting
- Indicators and Signage Lighting
- Automotive Lighting
- LED Back up Lighting
- Constant Current Source

■ DESCRIPTION

The AIC2516 buck constant-current high brightness LED driver, with an internal switch, provides a cost effective solution for driving single or multiple LEDs in series up to a total of 1.2A output current. Applications cover indicators and signage lighting, automotive lighting, LED lighting (such as MR16 and other LED illumination application) with input voltages ranging from 7V to 36V. Depending upon supply voltage and external components, it can provide up to 25W of output power. Various dimming method available on demand, includes DC dimming and PWM dimming for design flexibility to add customer specific features. An on-chip LED protection circuit also allows output current to be reduced above a predetermined threshold temperature using hysteretic control and an external thermistor at the TH pin.

The operation of AIC2516 is based on a hysteretic PFM control scheme resulting in the operation frequency varies with different load and input voltage. A hysteretic PFM control scheme ensures excellent input-supply rejection and fast response during load transients and PWM dimming. It is allowing for small PCB size, competitive cost/ performance, high power conversion efficiency and maximum LED brightness/reliability.

The AIC2516 operates over -40°C to +85°C automotive temperature range and is available in SOT23-5, SOT23-6 and SOP-8 exposed pad package.

■ TYPICAL APPLICATION CIRCUIT

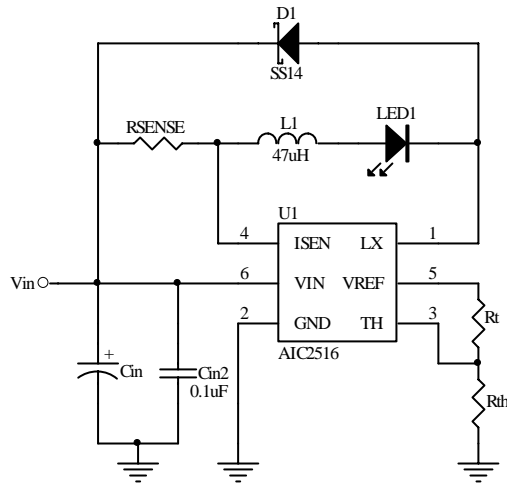
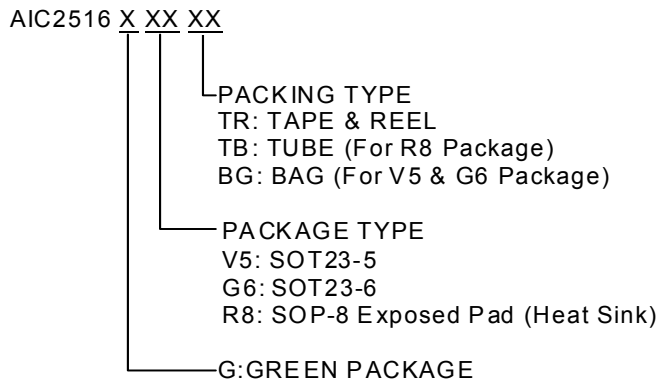
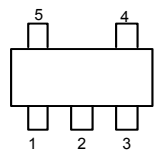
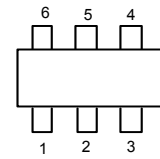
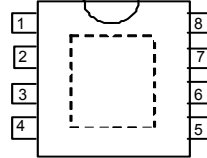


Fig. 1 AIC2516 Typical Application Circuit

ORDERING INFORMATION



PACKAGE TYPE	PIN CONFIGURATION
V5 (SOT23-5)	SOT23-5 FRONT VIEW 1: LX 2: GND 3: DIM 4: ISEN 5: VIN 
G6 (SOT23-6)	SOT23-6 FRONT VIEW 1: LX 2: GND 3: TH 4: ISEN 5: VREF 6: VIN 
R8 (SOP-8)	SOP-8 Exposed Pad (Heat Sink) 1: PGND 2: VIN 3: ISEN 4: DIM 5: TH 6: VREF 7: GND 8: LX 

Example: AIC2516GV5TR
 → With GV5 type pin configuration in SOT23-5 Green Package & Taping & Reel Packing Type

AIC2516GR8TR
 → With GR8 type pin configuration in SOP-8 Green Package & Taping & Reel Packing Type

■ ABSOLUTE MAXIMUM RATINGS

Supply Voltage (VIN).....		40V
ISEN Voltage.....		'VIN+0.3V' to 'VIN-5V'
DIM Pin Input Voltage.....		-0.3V to 5V
Operating Temperature Range.....		-40°C ~ 85°C
Storage Temperature Range.....		-65°C ~ 150°C
Junction Temperature.....		150°C
Lead Temperature (Soldering 10sec.).....		260°C
Thermal Resistance Junction to Case	SOT23-5.....	115°C /W
	SOT23-6.....	115°C /W
	SOP-8 Exposed Pad*.....	15°C/W
Thermal Resistance Junction to Ambient	SOT23-5.....	250°C /W
	SOT23-6.....	250°C /W
(Assume no ambient airflow, no heatsink)	SOP-8 Exposed Pad*.....	60°C/W

Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

*The package is placed on a two layers PCB with 2 ounces copper and 2 square inch, connected by 8 vias.

ELECTRICAL CHARACTERISTICS
($V_{IN}=12V$, $L=47\mu H$, 1*LED, LED Current=330mA, $T_A=25^\circ C$, unless otherwise specified) (Note1)

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
V_{IN} Operating Voltage	V_{IN} Pin Voltage	V_{IN}	7		36	V
Quiescent Current with Output Switching	DIM pin floating, $f=250KHz$	I_{Qon}		0.5	1	mA
Quiescent Current with Output Off	$V_{DIM} < 0.2V$	I_{Qoff}		35	45	μA
Mean Current sense threshold voltage	Measured on ISEN pin with respect to V_{IN} . $L=47\mu H$, $I_{OUT}=330mA$	V_{sen}	95	100	105	mV
Sense threshold hysteresis				± 15		%
Output Current Range	$V_{IN} = 12V$	I_{OUT}	150		1200	mA
Efficiency	$V_{IN} = 12V$, $V_{OUT} = 7.2V$ $I_{OUT} = 330mA$, $L=47\mu H$			93		%
Switch ON resistance	N-MOSFET ($PVDD2 = 5V$)	$R_{DS(ON)}$		0.5		Ω
Switch Leakage Current				1	5	μA
Operating Frequency	DIM floating, $L=47\mu H$, $I_{OUT} = 330mA$	f_{SW}		600		KHz
Minimum switch On-Time		T_{ONmin}		180		nS
Minimum switch Off-Time		T_{Offmin}		280		nS
VREF Output Voltage		V_{REF}	2.46	2.5	2.54	V
VREF Output Current		I_{REF}			250	μA
Recommended duty cycle range of output switch at f_{SW_MAX}		D_{SW}	30		70	%
UNDER VOLTAGE LOCK OUT						
Under Voltage Threshold	V_{IN} rising			6		V
	V_{IN} falling			5.5		V
DIM Input						
Maximum DIM Frequency		f_{DIM}			40	KHz
DIM Input Level	Logic High	V_{DIM_H}	1.3			V
	Analog DIM	V_{DIM_DC}	0.4		1.25	V
	Logic Low	V_{DIM_L}			0.2	V
DIM Low Shutdown Delay				16		ms
DIM Pull Up Current				3.7		μA

■ ELECTRICAL CHARACTERISTICS (Continued)

PARAMETER	TEST CONDITIONS	SYMBOL	MIN.	TYP.	MAX.	UNIT
Thermal Protection						
Thermal Shutdown Threshold				150		°C
Thermal shutdown Hysteresis				30		°C
LED Thermal Protection Parameters						
LED Thermal Shutdown Threshold	Rt=15.4KΩ, Rth=1.36KΩ, Turn off LED	V _{TH_L}	0.196	0.202	0.208	V
LED Thermal Shutdown Recovery Threshold	Rt=15.4KΩ, Rth=2.589KΩ, Turn on LED	V _{TH_H}		0.36		V

Note1: Specifications are production tested at T_A=25°C. Specifications over the -40°C to 85°C operating temperature range are assured by design, characterization and correlation with Statistical Quality Controls (SQC).

■ TYPICAL PERFORMANCE CHARACTERISTICS

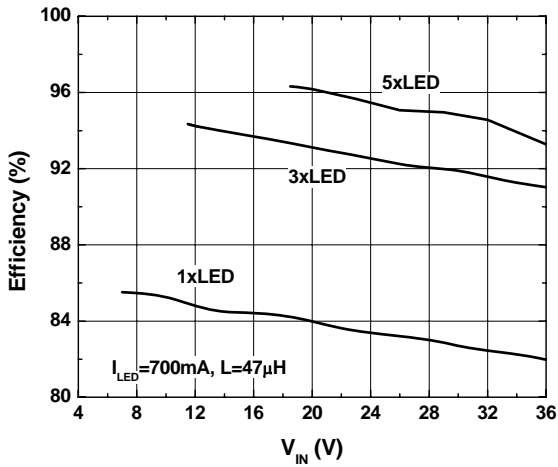


Fig. 2 Efficiency vs. Input Voltage

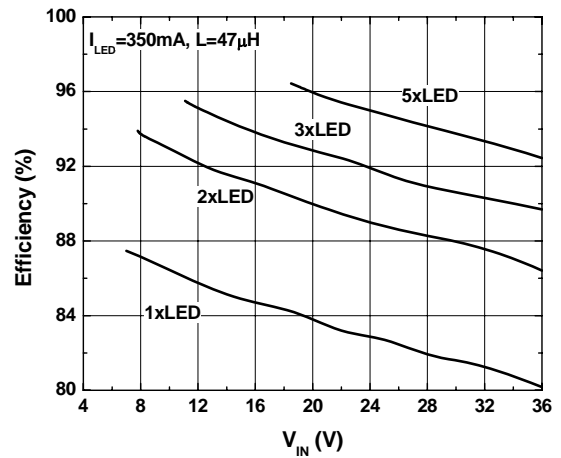


Fig. 3 Efficiency vs. Input Voltage

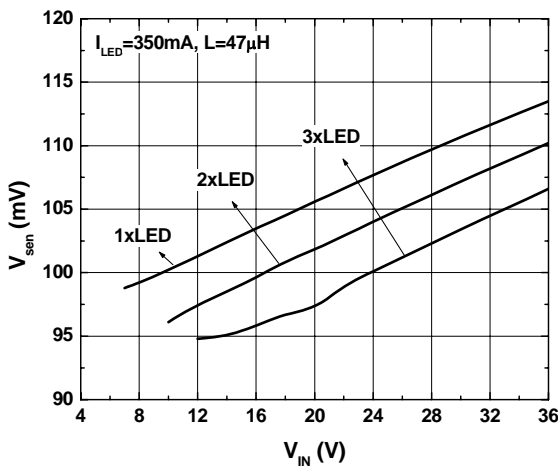


Fig. 4 V_{SENSE} vs. Input Voltage

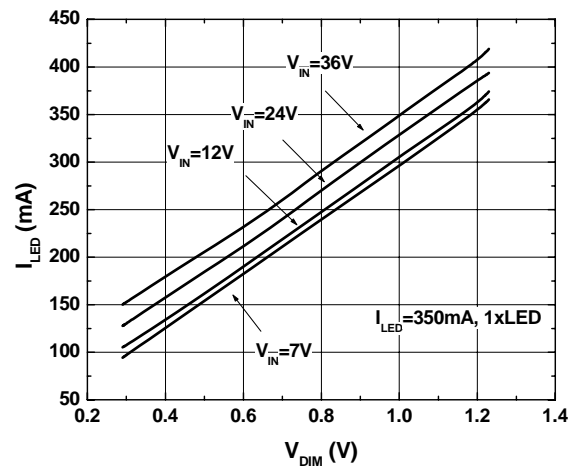


Fig. 5 LED Current vs. DIM pin Voltage

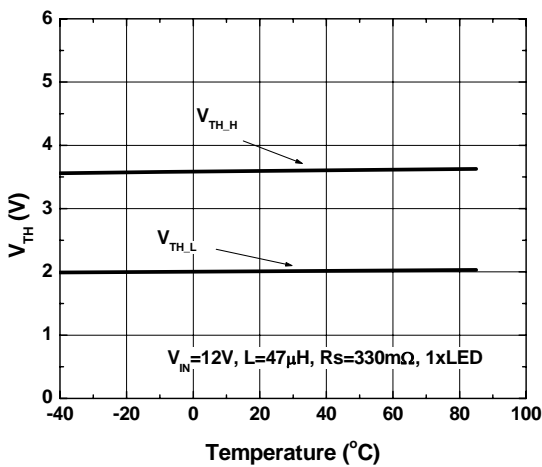


Fig. 6 Thermal Shutdown Threshold vs. Temperature

■ TYPICAL PERFORMANCE CHARACTERISTICS (Continued)

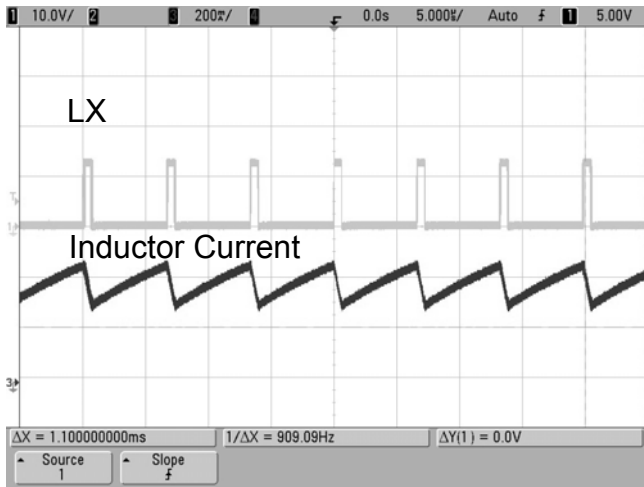


Fig. 7 Switch Waveform at $V_{IN}=12V$, $I_{LED}=350mA$, 3xLED

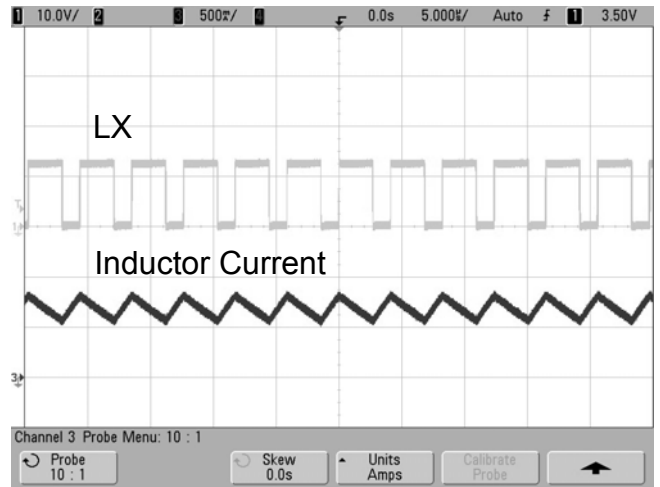


Fig. 8 Switch Waveform at $V_{IN}=12V$, $I_{LED}=700mA$, 1xLED

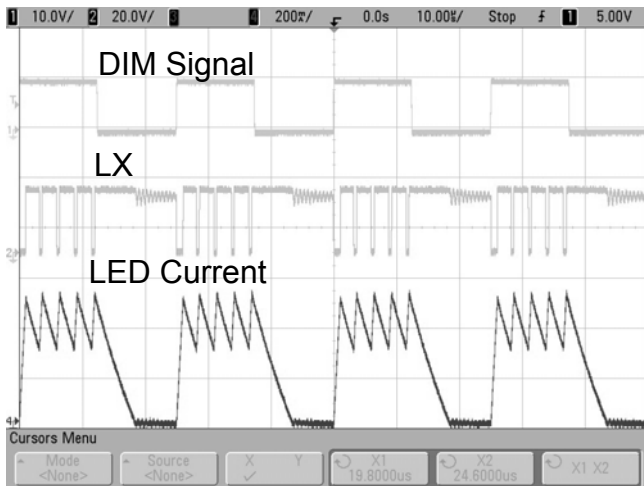


Fig. 9 PWM Dimming at $V_{IN}=24V$, Duty=50%, $f_{PWM}=40kHz$

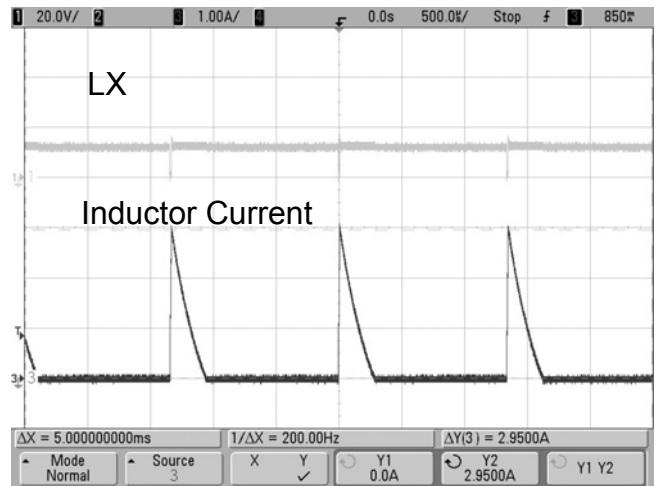
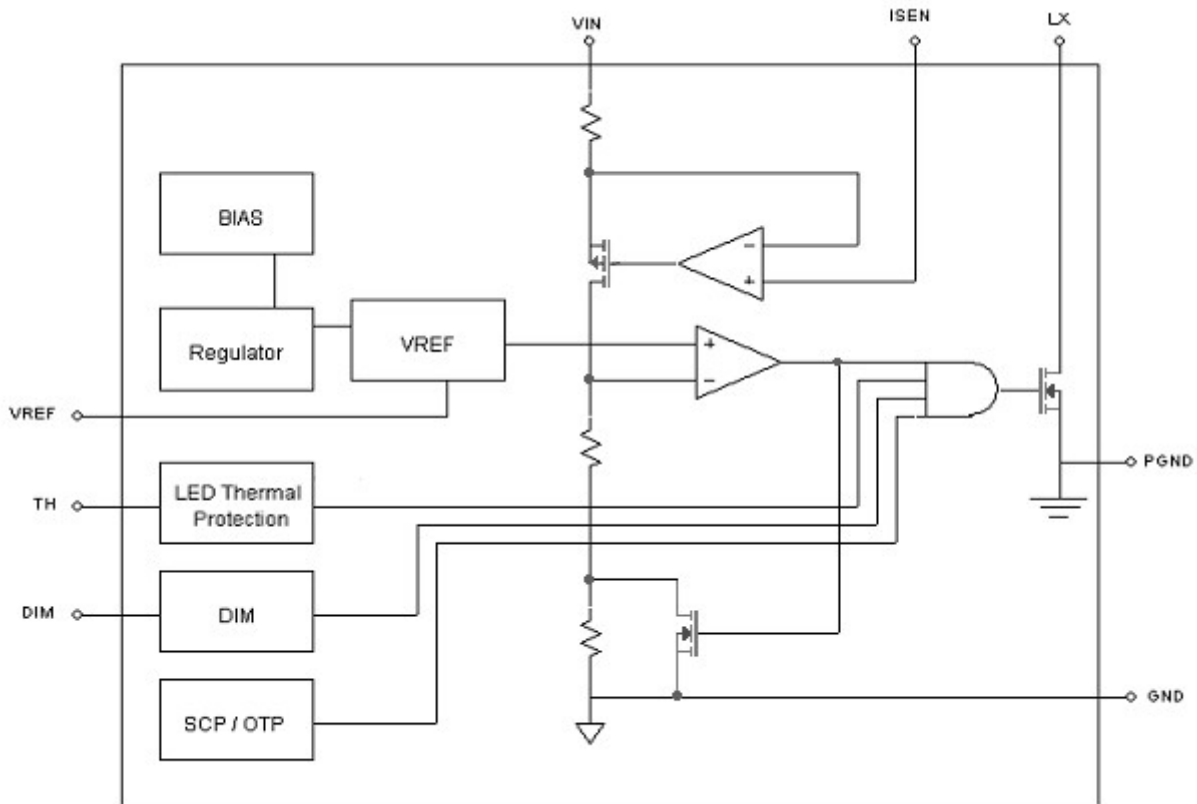


Fig. 10 Short Circuit at $V_{IN}=12V$

■ BLOCK DIAGRAM

■ PIN DESCRIPTION

LX	Power Switching Connection. Connect LX pin to inductor and output rectifier.
DIM (5 Pin and 8 Pin)	Dimming and Shutdown pin. For automatic startup, leave DIM pin unconnected.
GND	Ground pin for IC. All voltage levels are measured with respect to this pin.
ISEN	Current setting pin. Connect resistor R_{SENSE} from this pin to VIN pin to define nominal average output current.
VIN	Power supply input pin. A suitable input bypass capacitor must be present at this pin to minimize voltage transients and to supply the switching currents needed by the converter.
TH (6 Pin and 8 Pin)	Temperature sense input for LED thermal protection. Connect LED thermal sense resistors to this pin to turnoff output current above a preset temperature threshold.
PGND (8 Pin)	Power ground pin.
VREF (6 Pin and 8 Pin)	Reference Voltage for Thermal protection.

■ APPLICATION INFORMATION

OPERATING FREQUENCY

$$f_s = \frac{1}{T_{on} + T_{off}}$$

Where f_s is operating frequency, T_{on} is LX on time, and T_{off} is LX off time.

The LX on time can be calculated by the below equation:

$$T_{on} = \frac{L\Delta I_L}{V_{IN} - V_{LED} - I_{LED}(R_S + R_L + R_{LX(ON)})}$$

$$T_{on(min)} > 250ns$$

The LX off time can be calculated by the below equation:

$$T_{off} = \frac{L\Delta I_L}{V_{LED} + V_D + I_{LED}(R_S + R_L)}$$

$$T_{off(min)} > 350ns$$

Where V_{IN} is the Input Voltage,

V_{LED} is the total LED forward voltage,

I_{LED} is the LED average current,

R_S is the current sense resistance,

R_L is the inductor resistance,

$R_{LX(ON)}$ is the switch on resistance (0.5Ω typ.),

L is the inductance,

ΔI_L is the inductor peak-peak current (internally set to $I_{avg} \times 0.3$), and

V_D is the diode forward voltage at the LED average Current. The recommend operating frequency is not more than 1MHz.

LED THERMAL PROTECTION

The AIC2516 provides the LED thermal protection circuit to prevent LED over temperature. The AIC2516 will continuously monitor the LED temperature by measuring the voltage on the TH pin. A negative temperature coefficient (NTC) thermistor R_{th} and a fixed resistor R_t between VREF pin and ground typical develop this voltage, as shown in figure 11.

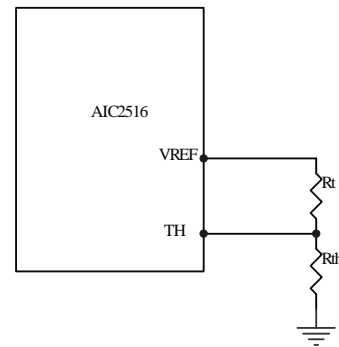


Fig. 11

By setting $R_t = 15.4K\Omega$ and using a 103KT1608 thermistor, the voltage on the TH pin will reduce to 0.2V when the LED temperature reaches 87.5°C and the LED will be turned off. When LED temperature reduces to 65°C, the voltage on the TH pin will rise to 0.36V and the LED will be turned on. The LED protection temperature can be set by using a different thermistor of R_{th} or a different component value of R_t . If the LED thermal protection function isn't required, the TH pin should be connected to VREF pin to disable this function.

SETTING OUTPUT CURRENT

The output current of AIC2516 can be set by the external sense resistor R_{SENSE} . The relationship between I_{OUT} and R_{SENSE} is

$$R_{SENSE} = V_{SENSE} / I_{OUT} = 0.1V / I_{OUT}$$

Where R_{SENSE} is the component value of the external sense resistor and V_{SENSE} is the voltage on the external sense resistor.

PWM DIMMING CONTROL

A wider dimming range can be achieved by applying a PWM control signal to the DIM pin to turn the device on and off, giving an average output current proportional to the duty cycle of the PWM signal. The allowed maximum PWM dimming frequency is about 40 KHz.

ANALOG DIMMING CONTROL

The LEDs brightness can also be controlled by applying a variable DC voltage signal to the DIM pin. With this way, the LEDs operate with full 100% brightness while V_{DIM} is equal or larger than 1.25V. When analog dimming is required, the DC voltage range of V_{DIM} should be between 0.4V to 1.25V. If dimming control is not required, one could just leave DIM pin floating to turn on LEDs.

LED OPEN CIRCUIT PROTECTION

When any LED connected to AIC2516 is open-circuit, output current of AIC2516 will be turned off.

LED SHORT CIRCUIT PROTECTION

When any LED connected to AIC2516 is short-circuit, output current of AIC2516 will not change.

UVLO PROTECTION

When input voltage of AIC2516 is below 5.5V, output current of AIC2516 will be turned off. When input voltage of AIC2516 resumes to 6V, output current of AIC2516 will be turned on again.

SHUTDOWN CONTROL

Digital logic of DIM pin provides an electrical ON/OFF control of AIC2516. Connecting this pin to ground or to any less than 0.2V with more than 20ms will completely turn off AIC2516. In this state, the quiescent current is less than 35 μ A and the internal reference, error amplifier, comparators, and biasing circuitry turn off.

DIODE SELECTION

Schottky diodes, with their low forward voltage drop and fast reverse recovery, are the ideal choices for AIC2516 applications. The forward voltage drop of a Schottky diode represents the conduction losses in the diode, while the diode capacitance (CT or CD) represents the switching losses. For diode selection,

both forward voltage drop and diode capacitance need to be considered. Schottky diodes with higher current ratings usually have lower forward voltage drop and larger diode capacitance, which can cause significant switching losses. A Schottky diode with 2A current rating is sufficient for most AIC2516 applications.

INPUT CAPACITOR SELECTION

The small size of ceramic capacitors makes them ideal for AIC2516 applications. When selecting an input capacitor, a low ESR capacitor is required to keep the noise at the IC to a minimum. It may be necessary in some designs to add a small valued ceramic type capacitor in parallel with the input capacitor to prevent any ring.

INDUCTOR SELECTION

Recommended the inductor values for the AIC2516 are in the range 22 μ H to 68 μ H. Although small size and high efficiency are major concerns, the inductor should have low core losses and low DCR (copper wire resistance).

Layout Consideration

In order to ensure a proper operation of AIC2516, the following points should be managed comprehensively.

1. The input capacitor and VIN pin should be placed as close as possible to each other to reduce the input voltage ripple and noise.
2. The output loop, which is consisted of the inductor, the internal power switch, the Schottky diode, the output capacitor and the LEDs, should be kept as small as possible.
3. The routes with large current should be kept short and wide.
4. Logically the large current on the converter should flow at the same direction.
5. In order to prevent the effect from noise, the IC's GND pin should be placed close to the ground of

the input bypass capacitor.

6. The ISEN pin and VIN pin should be connected to the sense resistor directly and the route should be away from the noise sources.
7. The VREF pin and TH pin should be connected to the LED thermal sense resistors directly and the route should be away from the noise sources.

APPLICATION CIRCUIT

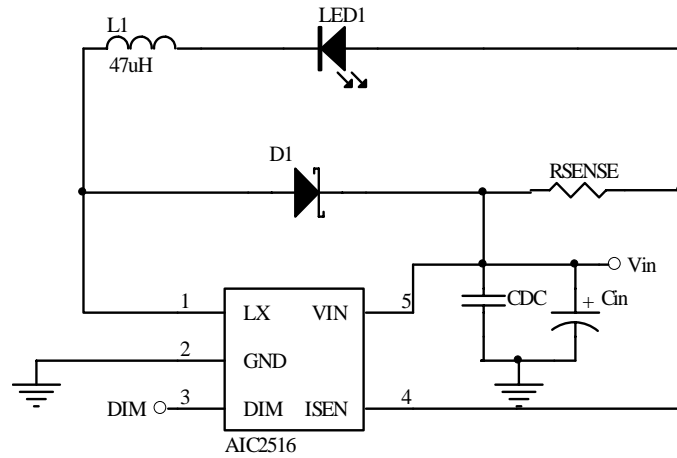


Fig.12 AIC2516 with Dimming Control Application Circuit

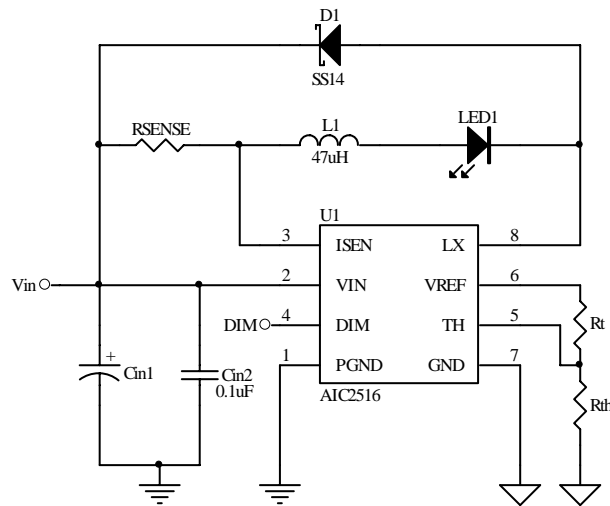
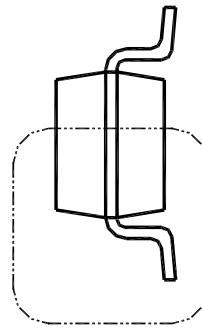
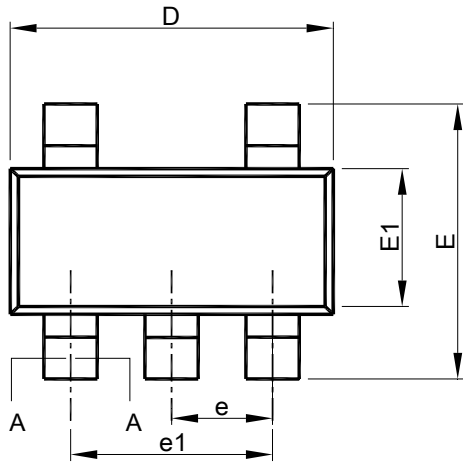


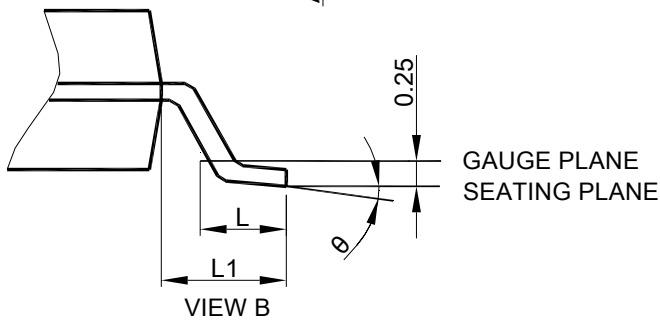
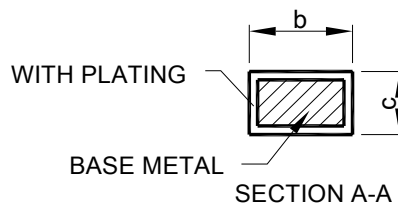
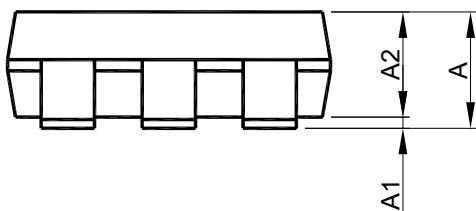
Fig.13 AIC2516 with Dimming Control and LED Thermal Protection Application Circuit

■ PHYSICAL DIMENSIONS (unit: mm)

● SOT23-5



SEE VIEW B



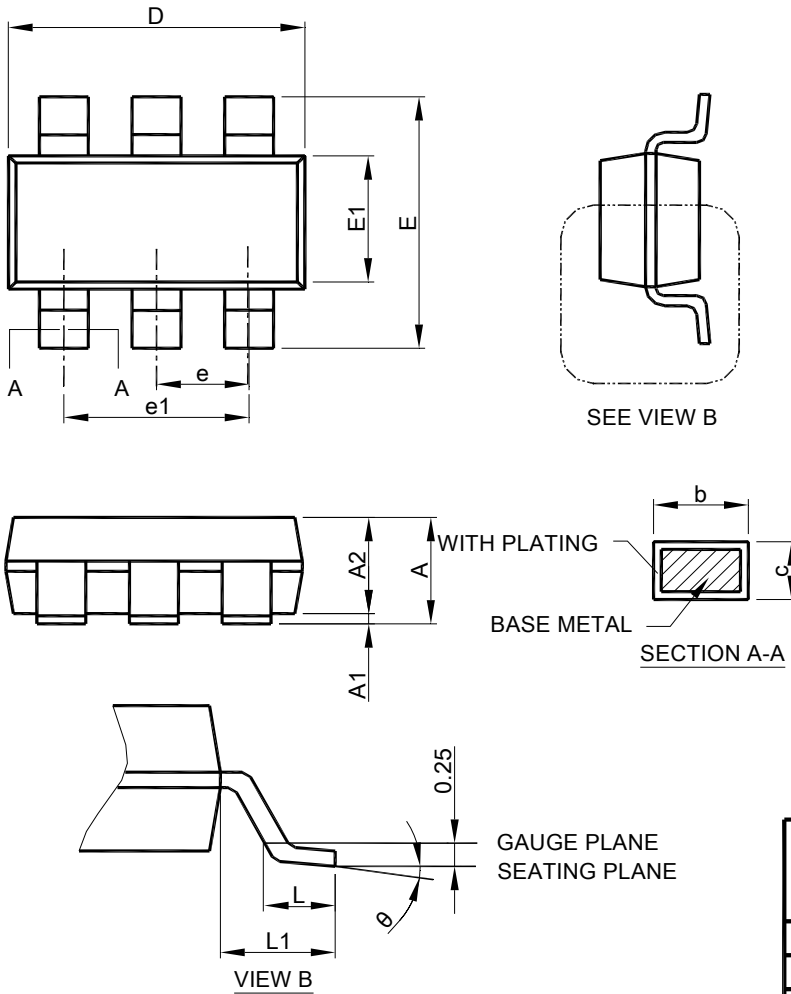
SYMBOL	SOT-23-5	
	MILLIMETERS	
	MIN.	MAX.
A	0.95	1.45
A1	0.05	0.15
A2	0.90	1.30
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.60 REF	
q	0°	8°

Note : 1. Refer to JEDEC MO-178AA.

2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.
3. Dimension "E1" does not include inter-lead flash or protrusions.
4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

■ PHYSICAL DIMENSIONS (Continued) (unit: mm)

● SOT23-6



Note : 1. Refer to JEDEC MO-178AB.

2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.

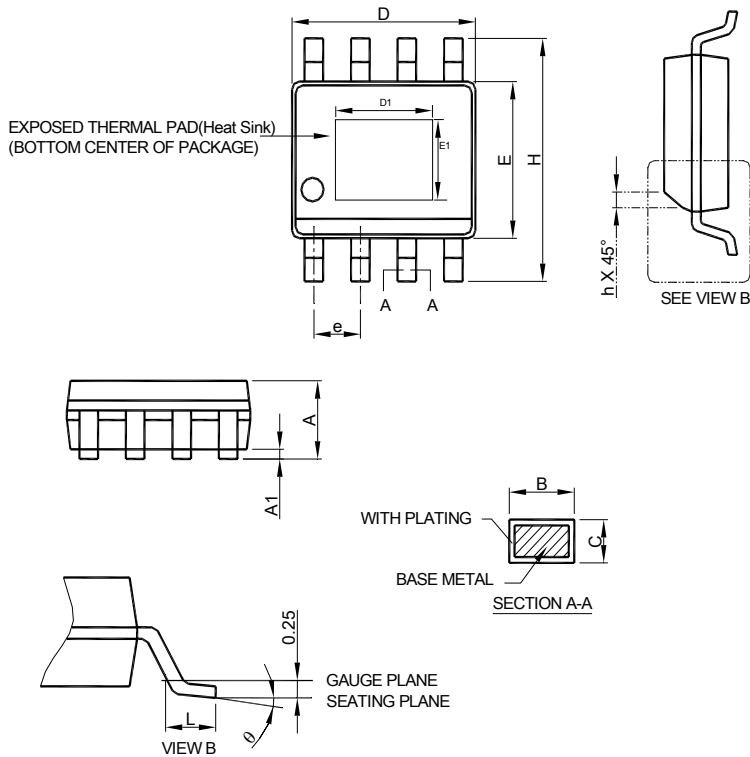
3. Dimension "E1" does not include inter-lead flash or protrusions.

4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

SYMBOL	SOT-23-6	
	MILLIMETERS	
	MIN.	MAX.
A	0.95	1.45
A1	0.05	0.15
A2	0.90	1.30
b	0.30	0.50
c	0.08	0.22
D	2.80	3.00
E	2.60	3.00
E1	1.50	1.70
e	0.95 BSC	
e1	1.90 BSC	
L	0.30	0.60
L1	0.42 REF	
θ	0°	8°

■ PHYSICAL DIMENSIONS (Continued) (unit: mm)

● SOP-8 Exposed Pad (Heat Sink)



- Note :
1. Refer to JEDEC MS-012E.
 2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side .
 3. Dimension "E" does not include inter-lead flash or protrusions.
 4. Controlling dimension is millimeter, converted inch dimensions are not necessarily exact.

SYMBOL	SOP-8 Exposed Pad(Heat Sink)	
	MILLIMETERS	
	MIN.	MAX.
A	1.35	1.75
A1	0.00	0.15
B	0.31	0.51
C	0.17	0.25
D	4.80	5.00
E	3.80	4.00
e	1.27 BSC	
H	5.80	6.20
h	0.25	0.50
L	0.40	1.27
q	0°	8°
D1	1.5	3.5
E1	1.0	2.55

Note:

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