

## Description

The AL8116 is a flexible dimming signal interface controller that can convert the three different inputs of dimmer type including 0 to 10V DC linear dimming, 0 to 100% duty cycle PWM (pulse width modulation) signal and a simple resistive potentiometer to an output PWM signal. It is easy to provide an isolation dimming control via an opto-coupler to the primary side LED driver.

The AL8116 has a wide input voltage range from 10V to 56V. The DIM pin of the AL8116 can output an adjustable accurate bias current that make it suit for both active and passive 0 to 10V dimmers, meanwhile potentiometers. The AL8116 output duty cycle accuracy is typically  $\pm 2.5\%$  and the minimum output duty cycle can be set through the CLAMP pin resistor.

The AL8116 has an internal auto-recoverable over-temperature-protection.

The AL8116 is available in SOT26 (Type CJ) package to minimize PCB space as well as external component count.

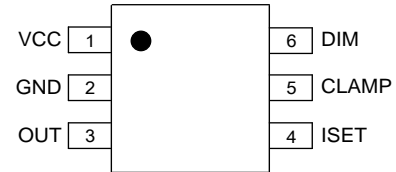
## Features

- Wide VCC Operating Range 10V to 56V
- Low Operation Current (Typical 600 $\mu$ A)
- Precision Dimmer Type with
  - Voltage Potential: 0/1V to 10V
  - PWM Dimming: 0.2k to 10kHz
  - Potentiometer: 0 to 100k $\Omega$
- Adjustable Bias Current Source of DIM Pin
- Accurate Output Duty Cycle Tolerance  $\pm 2.5\%$
- Adjustable Minimum Output PWM Duty Clamping: 8%, 6%, 4%, and 2%
- Built-In Over Temperature Protection for Chip
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please [contact us](mailto:contact@diodes.com) or your local Diodes representative. <https://www.diodes.com/quality/product-definitions/>**

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
  2. See <https://www.diodes.com/quality/lead-free/> for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
  3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

## Pin Assignments

(Top View)



**SOT26 (Type CJ)**

## Applications

- 0 to 10V Dimming Luminaires
- Dimmable LED Power Supply
- Dimming Control Devices
- Commercial LED Lighting
- Smart LED Lighting

**Typical Applications Circuit**

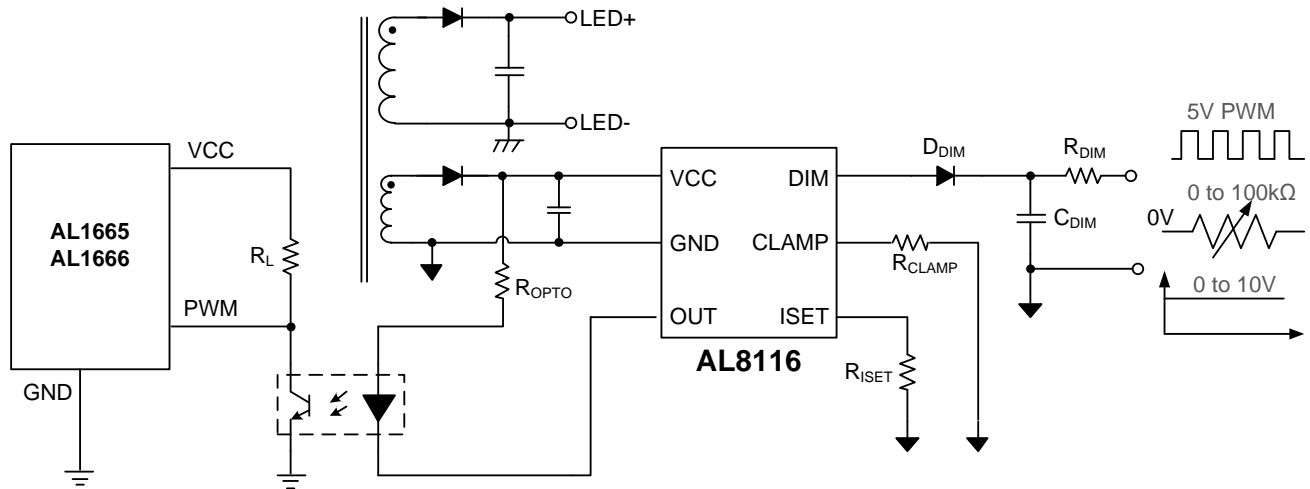
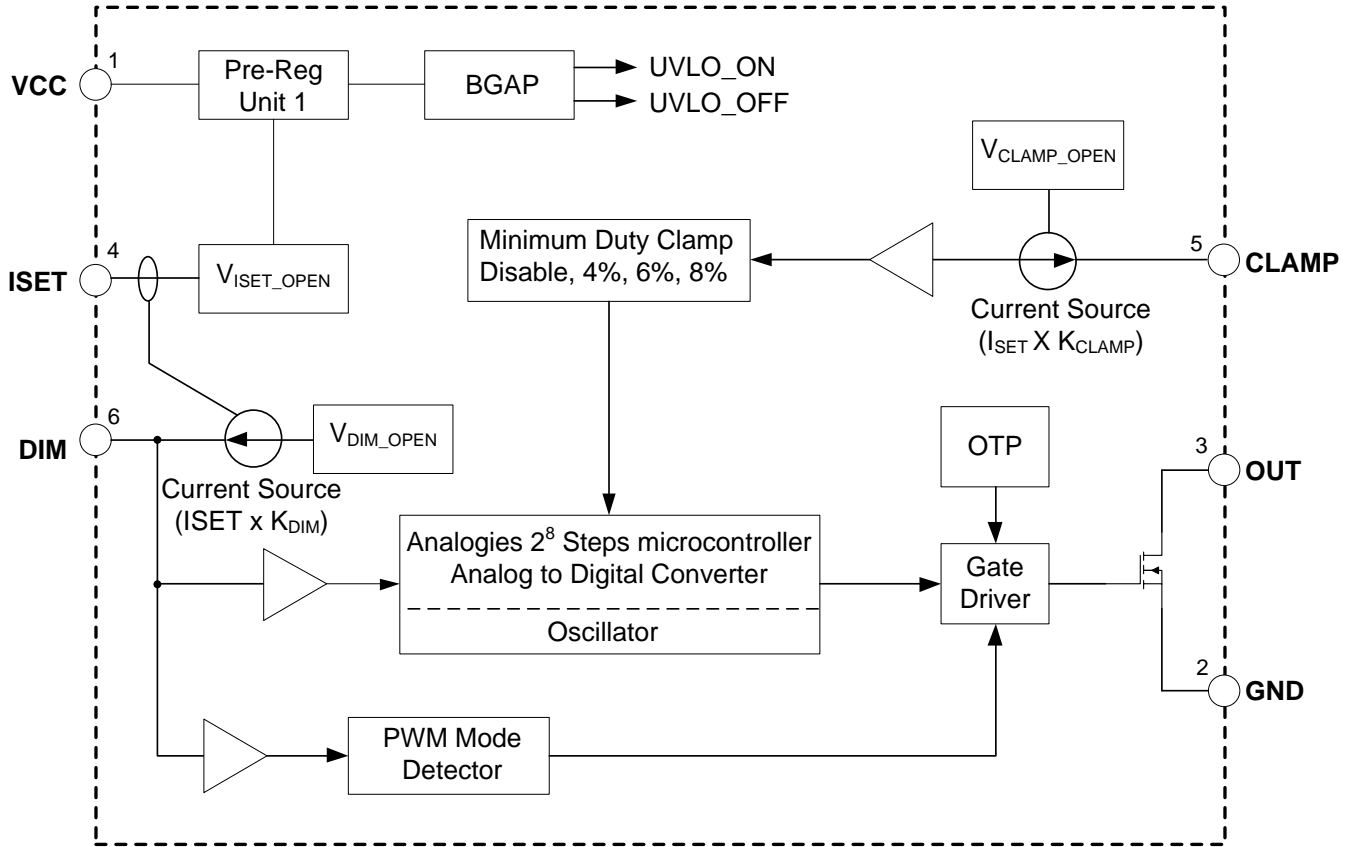


Figure 1. AL8116 Typical Application Circuit

**Pin Descriptions**

Pin Number	Pin Name	Function
1	VCC	Supply voltage pin.
2	GND	Ground or Power return pin.
3	OUT	This pin is dimming output. It's an open-drain configuration. Connect this pin to power supply by a resistor.
4	ISET	This pin is used to set bias current of DIM pin by a resistor (RISET) connected between this pin and GND.
5	CLAMP	This pin is used to set minimum output clamped duty cycle by a resistor (RCLAMP) connected between this pin and GND.
6	DIM	Dimming signal input; - Voltage Potential: 0/1V to 10V - PWM Dimming: 0.2k to 10kHz and amplitude is upper 3.2V - Potentiometer: 0 to 100kΩ

**Functional Block Diagram**



**Figure 2. AL8116 Functional Block Diagram**

### Absolute Maximum Ratings (@T<sub>A</sub> = +25°C, unless otherwise specified.) (Note 4)

Symbol	Parameter	Rating	Unit
V <sub>CC</sub>	Voltage at VCC Pin	-0.3 to +60	V
V <sub>OUT</sub>	Voltage at OUT Pin	-0.3 to +60	V
I <sub>OUT</sub>	OUT Sink Current	30	mA
V <sub>DIM</sub>	Voltage at DIM Pin	-0.3 to +20	V
V <sub>ISET</sub> , V <sub>CLAMP</sub>	Voltages at ISET, CLAMP Pins	-0.3 to +6	V
T <sub>LEAD</sub>	Lead Temperature (Soldering, 10s)	+260	°C
T <sub>J</sub>	Operating Junction Temperature	-40 to +150	°C
T <sub>ST</sub>	Storage Temperature	-65 to +150	°C
—	ESD (Human Body Model)	2.5	kV
—	ESD (Charged-Device Model)	1000	V

### Thermal Information (Note 5)

Package	$\theta_{JC}$ Thermal Resistance Junction-to-Case	$\theta_{JA}$ Thermal Resistance Junction-to-Ambient	P <sub>D</sub> T <sub>A</sub> = +85°C
SOT26 (Type CJ)	60°C/W	240°C/W	200mW

### Recommended Operating Conditions (@T<sub>A</sub> = +25°C, unless otherwise specified.) (Note 6)

Symbol	Parameter	Min	Max	Unit
V <sub>CC</sub>	Supply VCC Voltage	10	56	V
V <sub>OUT</sub>	Input Voltage on OUT Pin	—	56	V
T <sub>J</sub>	Operating Junction Temperature	-40	+125	°C
R <sub>ISET</sub>	Resistor of ISET Pin	33	330	kΩ
I <sub>DIM_SOURCE</sub>	Source Current of DIM Pin	—	300	μA
V <sub>DIM</sub>	Input Voltage of DIM Pin	0	13	V
f <sub>DIM</sub>	Input PWM Frequency of DIM Pin	0.5	5	kHz
C <sub>DIM</sub>	Capacitor of DIM Pin (C <sub>DIM</sub> ) (Note 7)	330	1000	pF
R <sub>DIM</sub>	Resistance of DIM Pin (R <sub>DIM</sub> ) (Note 7)	1	6.5	kΩ
—	PWM Signal Input Rising and Falling Time Rate	3	—	V/μs
V <sub>DIM_PWM_H</sub>	High Voltage Level PWM Signal Input on DIM Pin	3.2	13	V
V <sub>DIM_PWM_L</sub>	Low Voltage Level PWM Signal Input on DIM Pin	—	1.2	V
I <sub>OUT_SINK</sub>	Sink Current of OUT Pin	—	20	mA
T <sub>A</sub>	Ambient Temperature	-40	+105	°C

- Notes:
- Stresses greater than those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability. All voltages unless otherwise stated and measured with respect to GND.
  - Test condition: device mounted on 1" × 1" FR-4 substrate PCB, 2oz copper, with minimum recommended pad layout.
  - It's essential to connect VCC pin with a SMD ceramic capacitor (0.1μF to 0.47μF) to filter out the undesired switching noise for stable operation. This capacitor should be placed as close to IC as possible.
  - Test condition is R<sub>ISET</sub> = 100kΩ. (This mean is I<sub>DIM</sub> = 100μA).

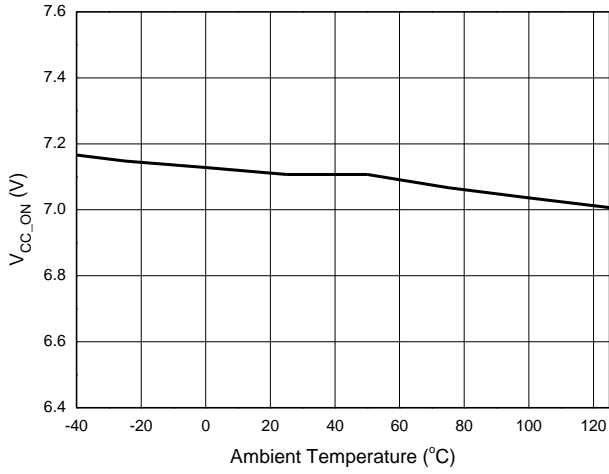
**Electrical Characteristics** ( $V_{CC} = 32V @ T_A = +25^\circ C$ , unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>Supply Voltage (VCC Pin)</b>						
V <sub>CC_ON</sub>	UVLO(ON)	V <sub>CC</sub> Startup Threshold	6.0	7.0	8.0	V
V <sub>CC_OFF</sub>	UVLO(OFF)	V <sub>CC</sub> Minimum Operating Voltage	5.2	6.0	6.8	V
I <sub>VCC</sub>	Operating Current	R <sub>ISET</sub> = 100kΩ, DIM Pin and CLAMP Pin are Floating.	—	600	850	μA
<b>ISET Pin</b>						
V <sub>ISET_OPEN</sub>	Open Voltage	ISET Pin is Floating.	2.45	2.5	2.55	V
K <sub>DIM</sub>	Current Ratio of I <sub>DIM</sub> to I <sub>SET</sub> (Calculate I <sub>DIM</sub> / I <sub>SET</sub> )	—	—	4	—	—
K <sub>CLAMP</sub>	Current Ratio of I <sub>CLAMP</sub> to I <sub>SET</sub> (Calculate I <sub>CLAMP</sub> / I <sub>SET</sub> )	—	—	0.4	—	—
<b>DIM Pin (Dimming Function)</b>						
V <sub>DIM_OPEN</sub>	Open Voltage	R <sub>ISET</sub> = 100kΩ, DIM Pin is Floating.	12.2	13	13.8	V
V <sub>DIM_MAX_ON</sub>	Maximum Voltage on Level	Output Duty = 100%	10.07	10.27	10.47	V
V <sub>DIM_Zero_ON</sub>	Zero Duty On OUT Pin	Output Duty ≤ 1%	—	1.5	—	V
I <sub>DIM_100</sub>	Bias Current	R <sub>ISET</sub> = 100kΩ	97.5	100.5	103.5	μA
V <sub>DIM_PWM_H</sub>	High Level of PWM Input Signal	(Note 8)	3.2	—	—	V
V <sub>DIM_PWM_L</sub>	Low Level of PWM Input Signal	(Note 8)	—	—	1.2	V
—	PWM Dimming Mode Setting	Trigger Rising Rate and Continuous 8 Times. (Note 8)	3	—	—	V/μs
V <sub>DIM_OFF</sub>	Cut-Off Level Voltage	Output Duty = 0%	1.23	1.3	1.37	V
V <sub>DIM_OFF_HYS</sub>	Cut-Off Recovery Hysteresis Voltage	Output Duty ≥ 0%	—	0.1	—	V
<b>CLAMP Pin (Clamping Minimum Dimming)</b>						
V <sub>CLAMP_OPEN</sub>	Open Voltage	R <sub>ISET</sub> = 100kΩ, CLAMP Pin is Floating.	4.7	5.0	5.3	V
D <sub>OUT_0%</sub>	Minimum Duty Cycle Clamp When R <sub>ISET</sub> = 100kΩ	R <sub>CLAMP</sub> ≥ 1MΩ or Open V <sub>CLAMP</sub> ≥ 4.2V and V <sub>DIM</sub> = 1.65V	1	2	4	%
D <sub>OUT_4%</sub>		R <sub>CLAMP</sub> = 300kΩ V <sub>CLAMP</sub> = 2.6V to 3.6V and V <sub>DIM</sub> = 1.5V	2	4	6	%
D <sub>OUT_6%</sub>		R <sub>CLAMP</sub> = 150kΩ V <sub>CLAMP</sub> = 1V to 2V and V <sub>DIM</sub> = 1.5V	4	6	8	%
D <sub>OUT_8%</sub>		R <sub>CLAMP</sub> = 0Ω V <sub>CLAMP</sub> ≤ 0.5V and V <sub>DIM</sub> = 1.5V	6	8	10	%
<b>Open Drain Output Set (OUT Pin)</b>						
V <sub>OUT_LOW</sub>	Output Low Level	@2mA Sink Current	—	—	200	mV
D. A	Dimming Accuracy of Duty (Chip to Chip)	During DIM Voltage is from 2V to 9V. (Note 8)	-2.5	—	+2.5	%
f <sub>OUT</sub>	Output Frequency	—	1.0	1.5	2.0	kHz
<b>Internal OTP (Over Temperature Protection)</b>						
OTP	OTP Trip Level	(Note 8)	—	+135	—	°C
ΔOTP	OTP Hysteresis	(Note 8)	—	+20	—	°C

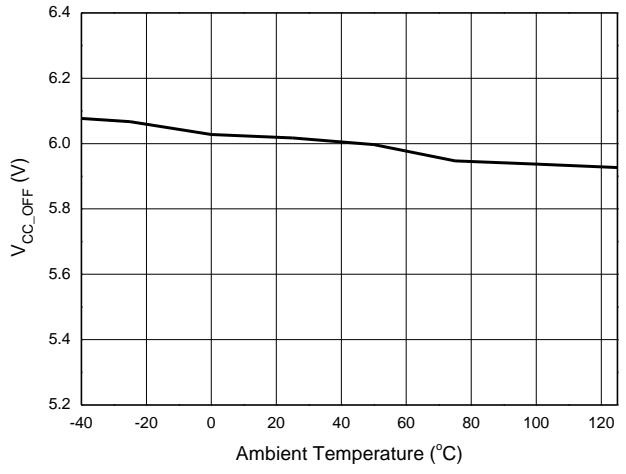
Note: 8. These parameters, although guaranteed by design, are not 100% tested in production.

**Performance Characteristics**

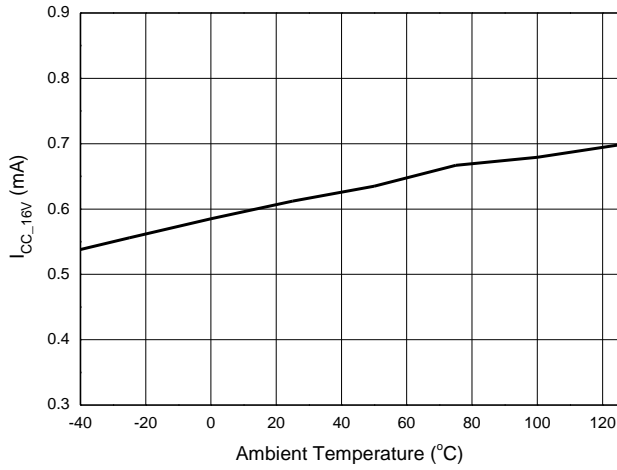
**V<sub>CC\_ON</sub> vs. Ambient Temperature**



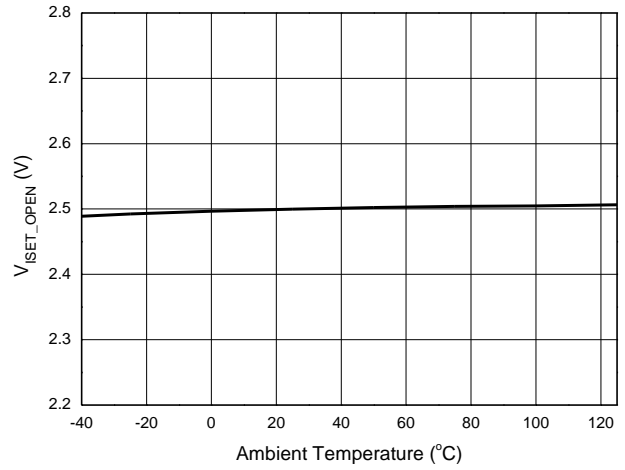
**V<sub>CC\_OFF</sub> vs. Ambient Temperature**



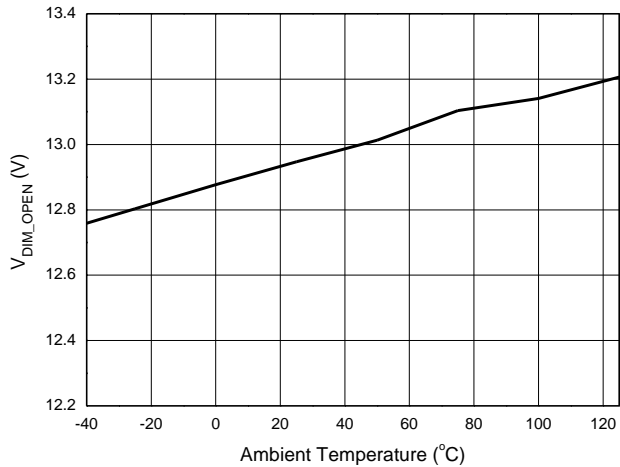
**I<sub>CC\_16V</sub> Current vs. Ambient Temperature**



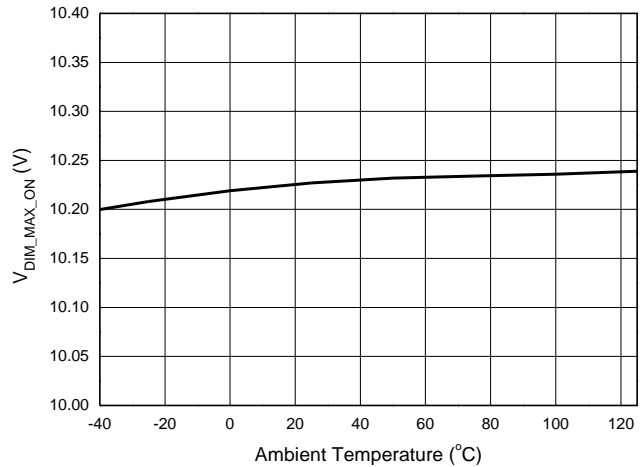
**V<sub>ISET\_OPEN</sub> vs. Ambient Temperature**



**V<sub>DIM\_OPEN</sub> vs. Ambient Temperature**

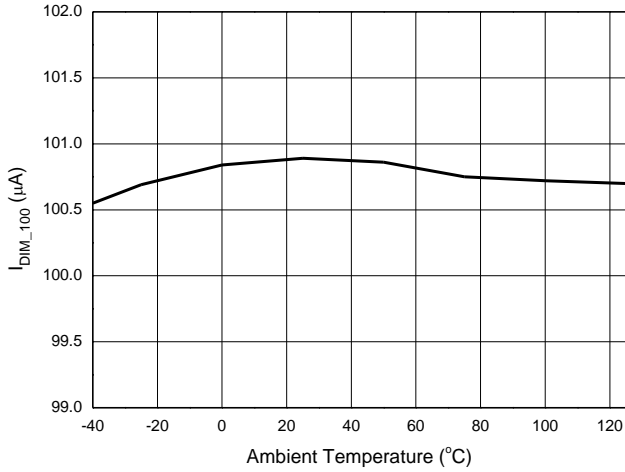


**V<sub>DIM\_MAX\_ON</sub> vs. Ambient Temperature**

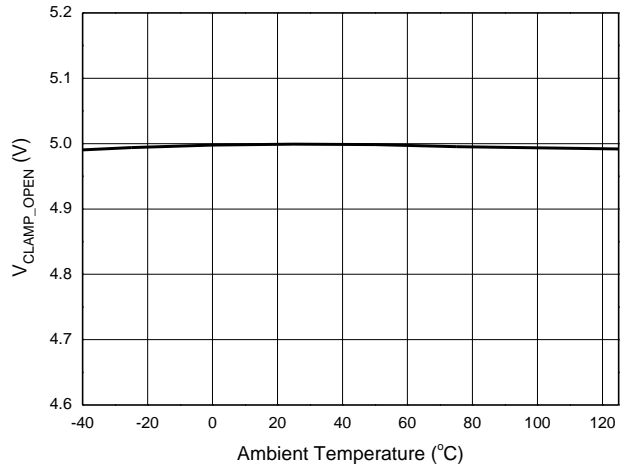


**Performance Characteristics** (continued)

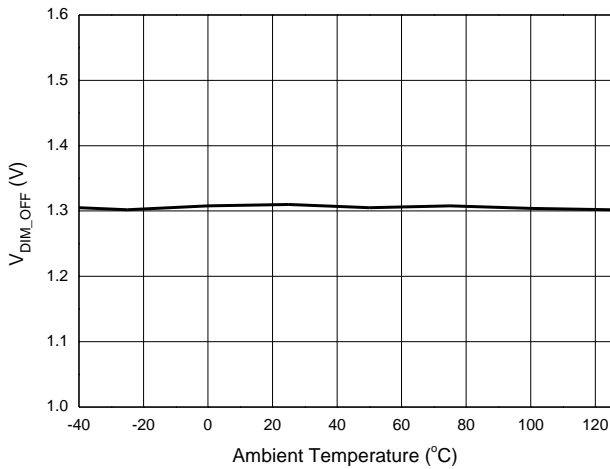
**I<sub>DIM\_100</sub> vs. Ambient Temperature**



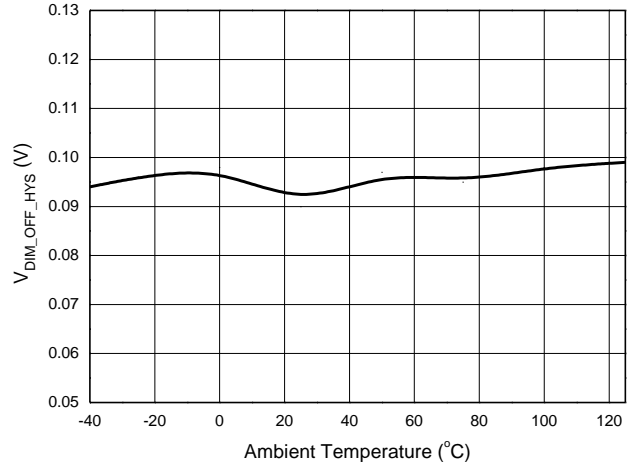
**V<sub>CLAMP\_OPEN</sub> vs. Ambient Temperature**



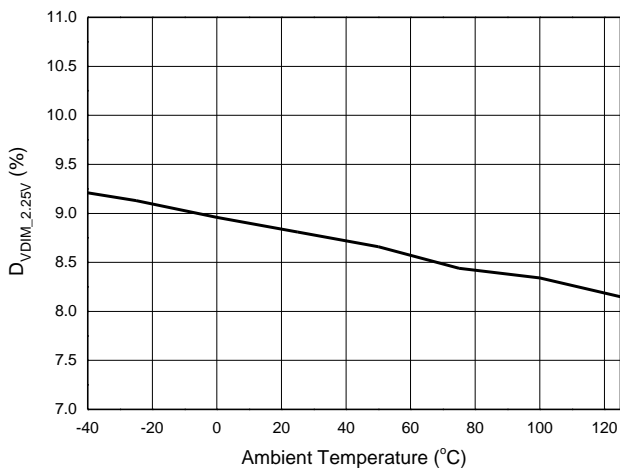
**V<sub>DIM\_OFF</sub> vs. Ambient Temperature**



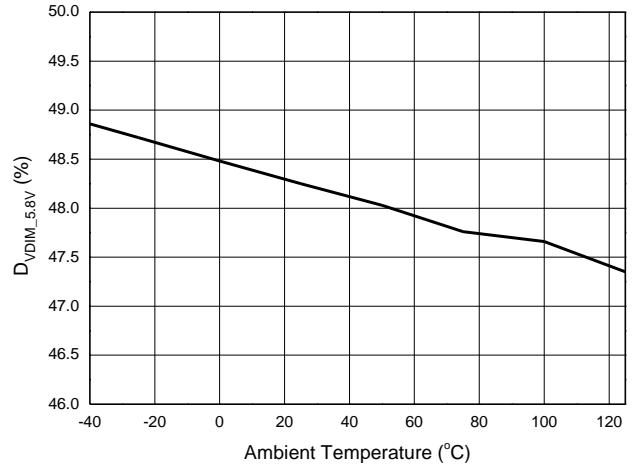
**V<sub>DIM\_OFF\_HYS</sub> vs. Ambient Temperature**



**D<sub>VDIM\_2.25V</sub> vs. Ambient Temperature**

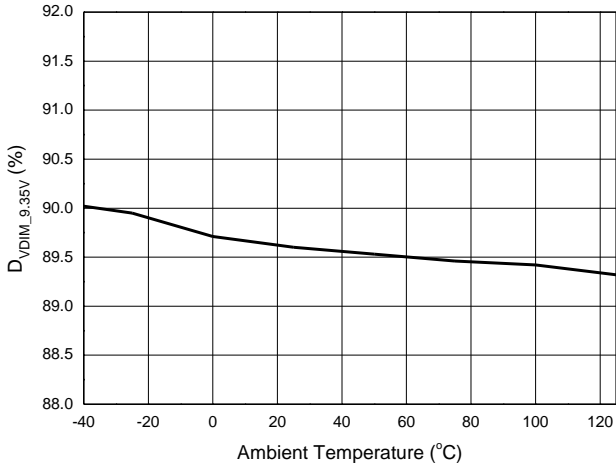


**D<sub>VDIM\_5.8V</sub> vs. Ambient Temperature**

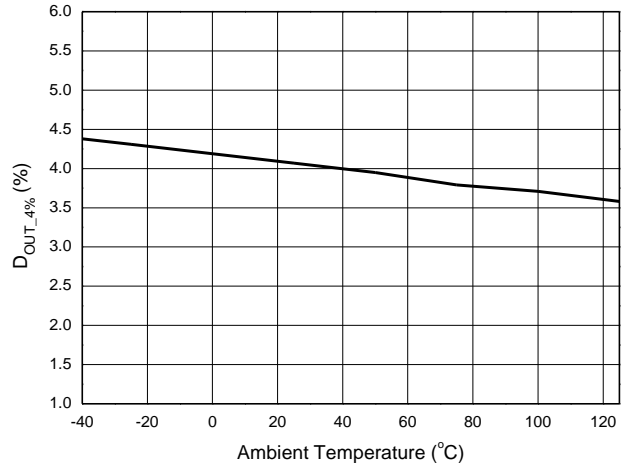


**Performance Characteristics** (continued)

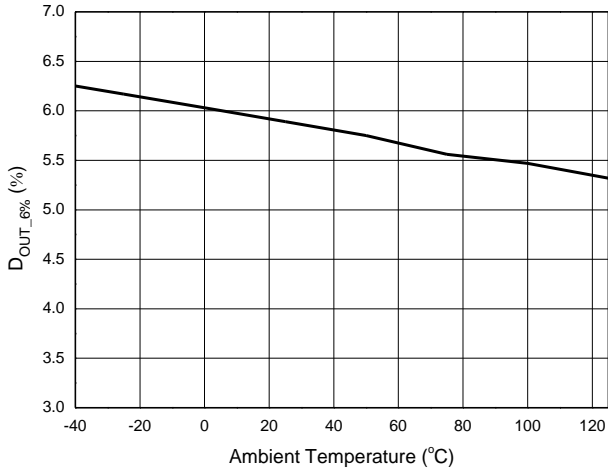
**D<sub>VDIM\_9.35V</sub> vs. Ambient Temperature**



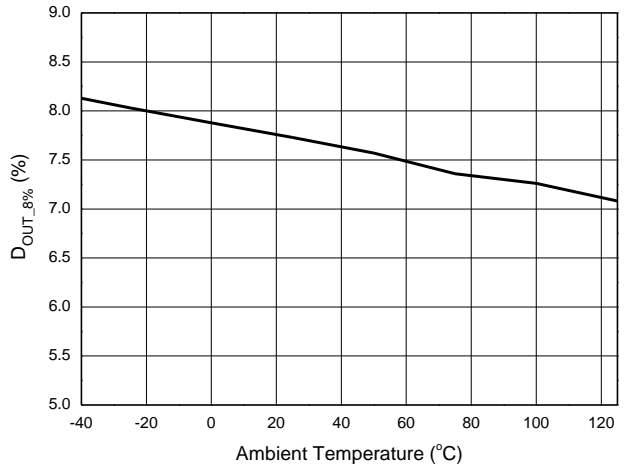
**D<sub>OUT\_4%</sub> vs. Ambient Temperature**



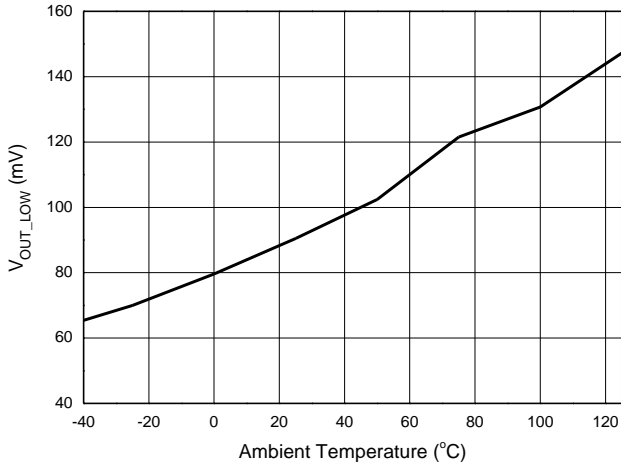
**D<sub>OUT\_6%</sub> vs. Ambient Temperature**



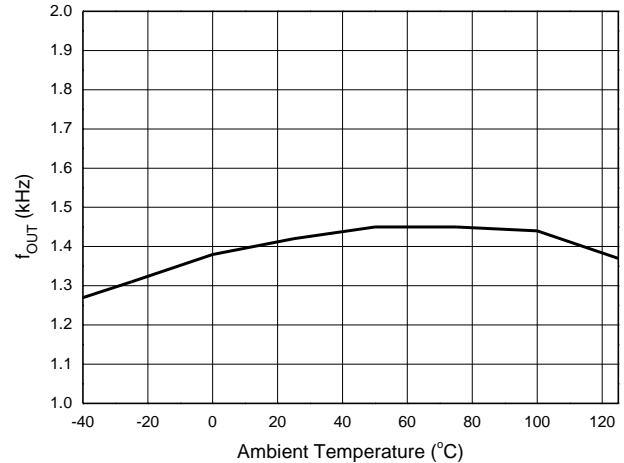
**D<sub>OUT\_8%</sub> vs. Ambient Temperature**



**V<sub>OUT\_LOW</sub> Voltage vs. Ambient Temperature**



**f<sub>OUT</sub> vs. Ambient Temperature**





## Functional Description and Application Information

### Operating Overview

The AL8116 is an excellent 3-in-1 dimming signal interface controller for LED commercial lighting applications. It integrates many functions to reduce the external components' count and the PCB board size.

The AL8116 can convert the three different inputs of dimmer type including 0 to 10V DC linear dimming, 0 to 100% duty cycle PWM (pulse width modulation) signal and a simple resistive potentiometer to an output PWM signal. The output of AL8116 is an open-drain configuration that can pull down any source directly to control power supply dimming. The DIM pin of AL8116 provides an adjustable bias current, thus it can be compatible with both active and passive 0 to 10V dimmers, meanwhile potentiometers. It also can be used in an isolation dimming control via an opto-coupler with combination use of Diodes Incorporated's primary side dimmable LED drivers AL1665 and AL1666.

### Startup and Under Voltage Lockout (UVLO)

A UVLO comparator is embedded to detect the voltage on the VCC pin to ensure the supply voltage enough to power on the AL8116. The turn-on and turn-off threshold voltages are fixed at V<sub>CC\_ON</sub> (7V) and V<sub>CC\_OFF</sub> (6V) respectively. When the voltage of VCC pin is above V<sub>CC\_OFF</sub> (6V), the AL8116 will generate PWM output based on the input DC voltage, PWM signal or potentiometer.

### Bias Current of DIM Pin

The ISET pin of AL8116 is used to set the bias current of DIM pin by a resistor (R<sub>ISET</sub>), which is connected between ISET pin and GND. For the typical application, the output bias current of DIM pin is 100µA when R<sub>ISET</sub> is 100kΩ. The relationship between resistor and output bias current is:

$$I_{DIM} = \frac{2.5V}{R_{ISET}} \times K_{DIM}$$

Where, K<sub>DIM</sub> is a coefficient of current ratio of I<sub>DIM</sub> to I<sub>SET</sub>. The resistance range of R<sub>ISET</sub> is recommended from 33kΩ to 330kΩ and the range of bias current is 30µA to 300µA correspondingly.

### Minimum Output Duty Cycle

When the input of DIM pin is DC potential, the CLAMP pin of AL8116 can set minimum output duty cycle by a resistor (R<sub>CLAMP</sub>) on CLAMP pin which is connected to GND. There are four modes for users to select. Please refer to the below Table 1. The relationship between the R<sub>CLAMP</sub> resistor and the voltage on CLAMP pin is below formula.

$$V_{CLAMP} = I_{CLAMP} \times R_{CLAMP} = \frac{2.5V}{R_{ISET}} \times K_{CLAMP} \times R_{CLAMP}$$

Where, K<sub>CLAMP</sub> is a coefficient of current ratio of I<sub>CLAMP</sub> per I<sub>SET</sub>.

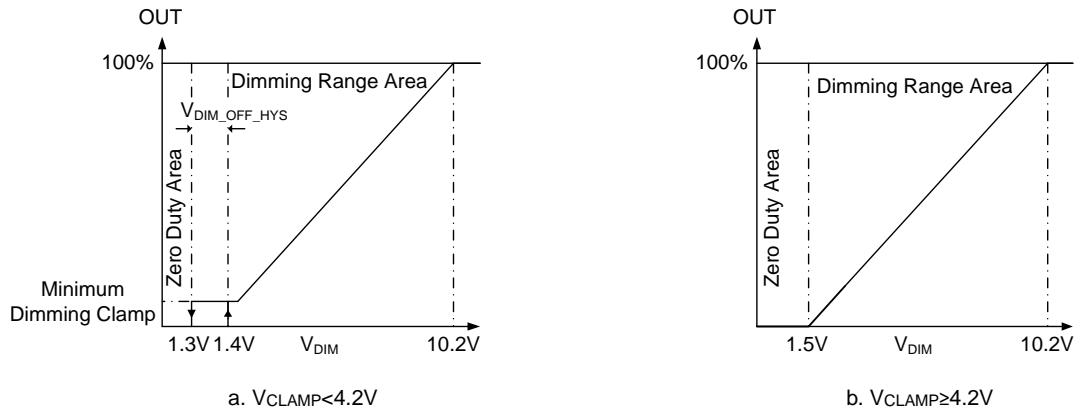
Table 1. Minimum Output Duty Cycles Clamping Selection

V <sub>CLAMP</sub> (V)	Suggestion R <sub>CLAMP</sub> (Ω) When R <sub>ISET</sub> = 100kΩ	Minimum Output Duty Clamping
<0.5	0 (Short)	8%
1 to 2	150k	6%
2.6 to 3.6	300k	4%
>4.2	>510k (Open)	No Clamping

The minimum output duty cycle is clamped when V<sub>CLAMP</sub> < 4.2V; When the DIM Pin voltage (V<sub>DIM</sub>) decreases from 10.2V to V<sub>DIM\_OFF</sub> = 1.3V, the output duty cycle decreases from 100% to the minimum output clamping duty, which is set in Table 1. When the V<sub>DIM</sub> signal increases from V<sub>DIM\_ON</sub> = 1.4V to 10.2V, the output duty cycle increases from the minimum output clamping duty to 100% accordingly. There's 100mV hysteresis for V<sub>DIM\_OFF</sub> and V<sub>DIM\_ON</sub> voltage. The dimming curve is shown in Figure 3a.

When V<sub>CLAMP</sub> ≥ 4.2V, the minimum output duty cycle will not be clamped and it can reach 0%. Thus, the output duty cycle can be adjusted from 0% to 100%, shown in Figure 3b.

**Functional Description and Application Information** (continued)



**Figure 3. AL8116 Dimming Curve**

**Dimming Performance**

**1) 0 to 10V Potential Dimming**

When the input signal of DIM pin is a DC voltage, the AL8116 will transfer the DC potential to a PWM signal output at OUT pin. The frequency of output PWM on OUT pin is around 1.5kHz. Typical dimming curve is shown in Figure 3.

**2) PWM Dimming**

When the input signal of DIM pin is a PWM signal, the AL8116 will output a PWM signal at the OUT pin. The output frequency and duty of OUT pin follows the input PWM signal. The high level of input PWM signal on DIM pin must be higher or equal to 3.2V and the low level must be less than 1.2V. And the recommended PWM frequency range is from 500Hz to 5kHz. The AL8116 will switch to PWM dimming mode when the PWM rising slew rate of DIM pin signal is faster than 3V/ $\mu$ s through 1.2V to 3.2V and continues for 8 cycles. If PWM rising slew rate of DIM pin is larger than 3 V/ $\mu$ s, the AL8116 will reset internal cycles counter. Once entering PWM dimming mode, the AL8116 will continuously work at this mode until a new VCC UVLO cycle begins.

**3) Potentiometer Dimming**

When DIM pin is connected with a potentiometer to GND, the bias current source of DIM pin will flow through this potentiometer and generate a DC voltage on DIM pin, the AL8116 will transfer the resistance of potentiometer to a PWM signal output at OUT pin. The frequency of PWM signal on OUT pin is around 1.5kHz.

**Internal Over Temperature Protection**

When internal over temperature protection threshold is triggered (+135°C typ), the OUT pin of the AL8116 is then open drain. This protection will be auto-recovery after internal temperature goes down to a normal operating temperature.

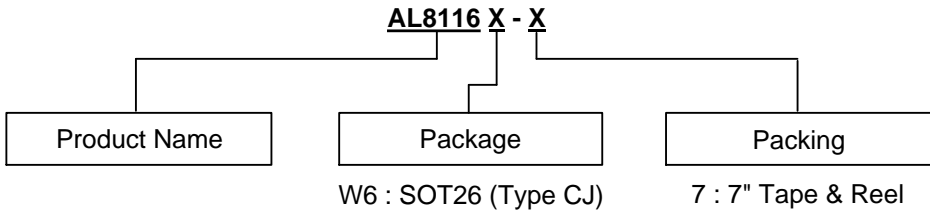
**Opto-Coupler Selection Guide**

In the majority of applications, the dimming signal needs to be isolated from the rest of the application circuitry. An opto-coupler is often used to implement functional and reinforced isolation. Opto-couplers are excellent choices since they are very cost-effective and able to comply with virtually all safety standards.

The most common and cost-effective opto-couplers are four-pin devices consisting of a LED and a photosensitive BJT, only collector and emitter of the photosensitive BJT are connected to the pins of the device. This character limits the device performance, especially switching times. Six-pin devices with the base of the BJT connected to a pin are seen less often. With use of these six-pin devices, the bandwidth of the transmission can be improved if necessary. Finally, there are high-speed digital couplers available, they are designed for very high data rates and offer a buffered output with a nearly perfect PWM signal. While offering superior performance, high speed couplers are considerably more expensive than simple LED-BJT couplers.

There are two parameters of an opto-coupler that are most important to use with the AL8116: the current transfer ratio CTR and the switching times  $t_r$  and  $t_f$ .

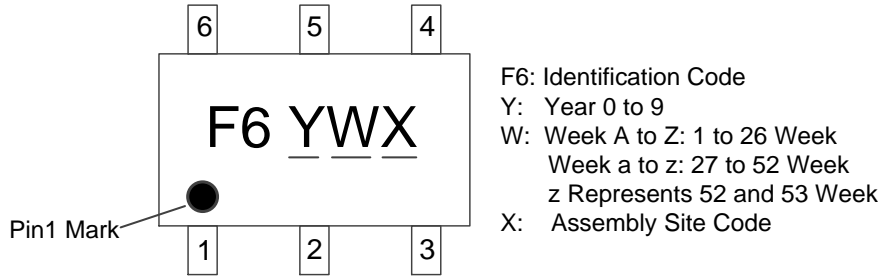
**Ordering Information** (Note 9)



Part Number	Package Code	Package	7" Tape and Reel	
			Quantity	Part Number Suffix
AL8116W6-7	W6	SOT26 (Type CJ)	3000/Tape & Reel	-7

Note: 9. For packaging details, go to our website at <https://www.diodes.com/design/support/packaging/diodes-packaging/>.

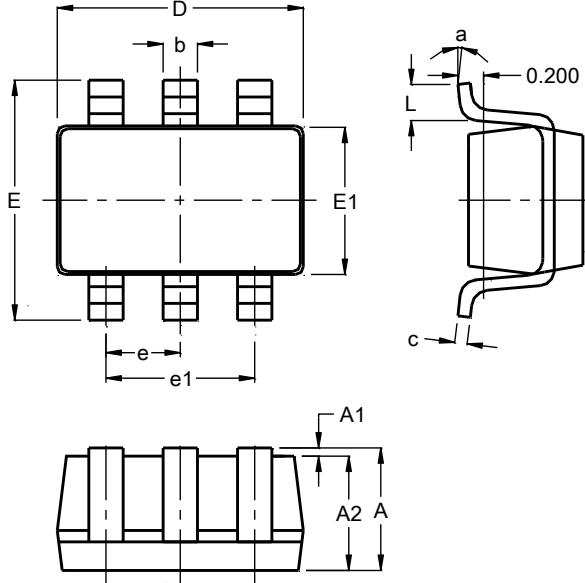
**Marking Information**



## Package Outline Dimensions

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

SOT26 (Type CJ)

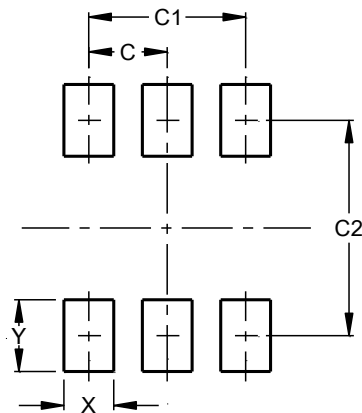


SOT26 (Type CJ)			
Dim	Min	Max	Typ
A	1.050	1.250	--
A1	0.00	0.10	--
A2	1.050	1.150	--
b	0.300	0.500	--
c	0.100	0.200	--
D	2.820	3.020	--
E	2.650	2.950	--
E1	1.500	1.700	--
e	0.950BSC		
e1	1.800	2.000	--
L	0.300	0.600	--
a	0°	8°	--
All Dimensions in mm			

## Suggested Pad Layout

Please see <http://www.diodes.com/package-outlines.html> for the latest version.

SOT26 (Type CJ)



Dimensions	Value (in mm)
C	0.95
C1	1.90
C2	2.40
X	0.60
Y	1.00

## Mechanical Data

- Moisture Sensitivity: Level 3 per JESD22-A113
- Terminals: Finish - Matte Tin Plated Leads, Solderable per M2003 JESD22-B102<sup>(3)</sup>
- Weight: 0.016 grams (Approximate)

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