FLEXIBLE 0 TO 10V DIMMING SIGNAL INTERFACE CONTROLLER

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.

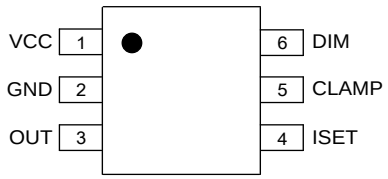
The AL8116 has a wide input voltage range from 10V to 56V. The DIM pin of the AL8116 can output an adjustable accurate bias current that make it suit for both active and passive 0 to 10V dimmers, meanwhile potentiometers. The AL8116 output duty cycle accuracy is typically ±2.5% and the minimum output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

Pin Assignments

(Top View)



SOT26 (Type CJ)

Features

- Wide VCC Operating Range 10V to 56V
- Low Operation Current (Typical 600μA)
- Precision Dimmer Type with
  - Voltage Potential: 0/1V to 10V
  - PWM Dimming: 0.2k to 10kHz
  - Potentiometer: 0 to 100kΩ
- Adjustable Bias Current Source of DIM Pin
- Accurate Output Duty Cycle Tolerance ±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 or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Applications

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

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.

Typical Applications Circuit

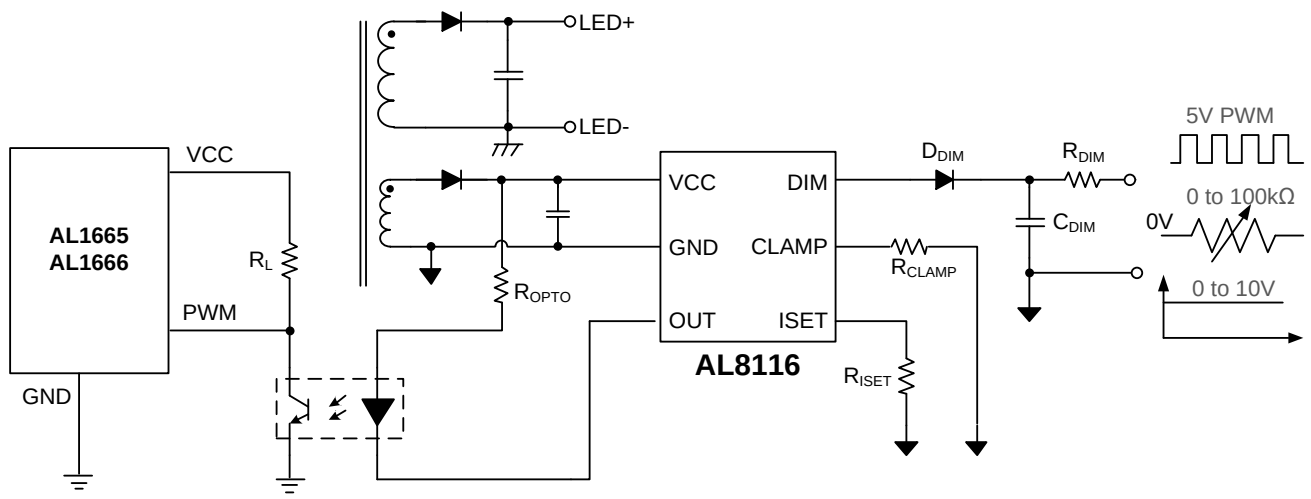


Figure 1. AL8116 Typical Application Circuit

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 (R_{ISET}) connected between this pin and GND.
5	CLAMP	This pin is used to set minimum output clamped duty cycle by a resistor (R_{CLAMP}) 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

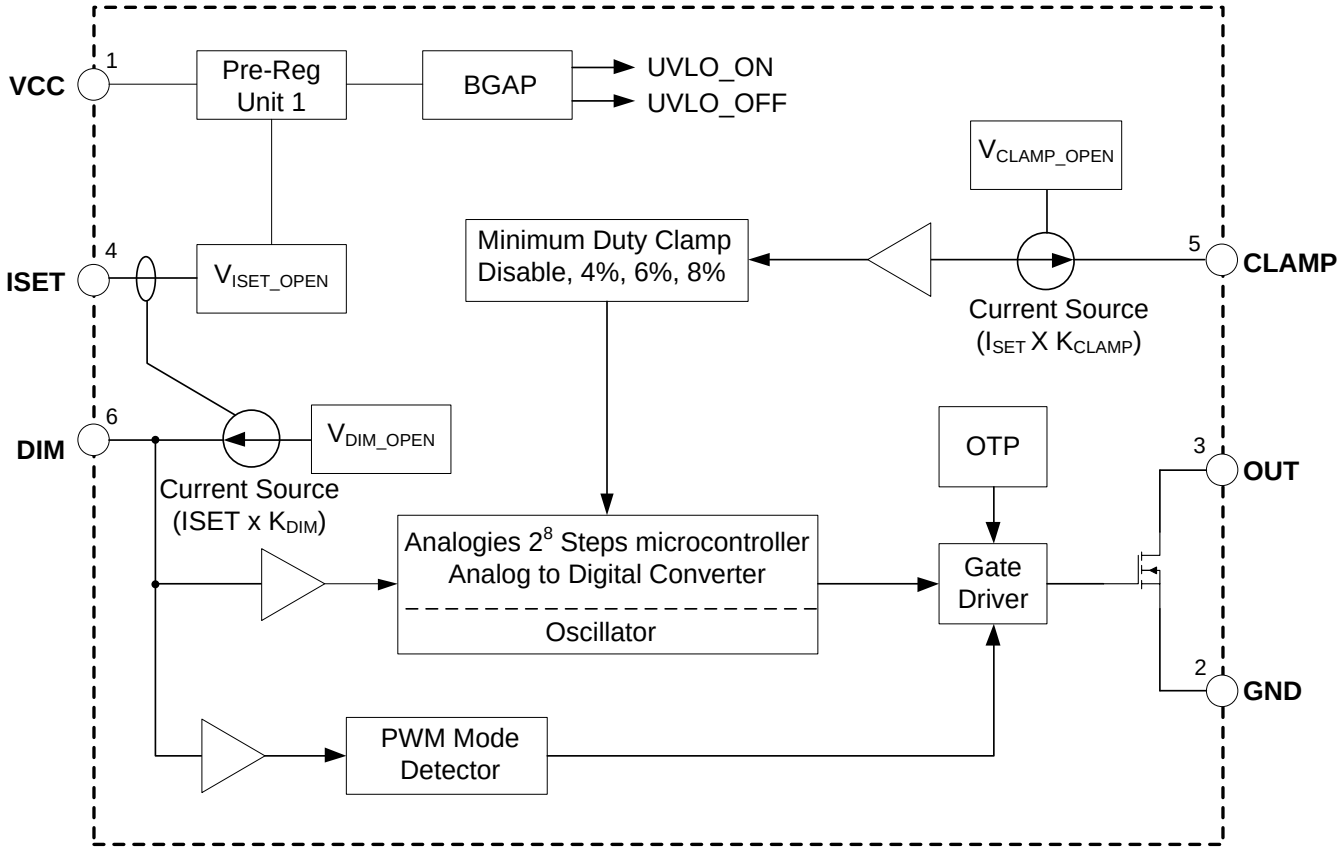


Figure 2. AL8116 Functional Block Diagram

Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.) (Note 4)

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

Thermal Information (Note 5)

Package	θ_{JC} Thermal Resistance Junction-to-Case	θ_{JA} Thermal Resistance Junction-to-Ambient	P_D T_A = +85°C
SOT26 (Type CJ)	60°C/W	240°C/W	200mW

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.) (Note 6)

Symbol	Parameter	Min	Max	Unit
V_{CC}	Supply VCC Voltage	10	56	V
V_{OUT}	Input Voltage on OUT Pin	—	56	V
T_J	Operating Junction Temperature	-40	+125	°C
R_{ISET}	Resistor of ISET Pin	33	330	kΩ
I_{DIM_SOURCE}	Source Current of DIM Pin	—	300	μA
V_{DIM}	Input Voltage of DIM Pin	0	13	V
f_{DIM}	Input PWM Frequency of DIM Pin	0.5	5	kHz
C_{DIM}	Capacitor of DIM Pin (C_{DIM}) (Note 7)	330	1000	pF
R_{DIM}	Resistance of DIM Pin (R_{DIM}) (Note 7)	1	6.5	kΩ
—	PWM Signal Input Rising and Falling Time Rate	3	—	V/μs
$V_{DIM\_PWM\_H}$	High Voltage Level PWM Signal Input on DIM Pin	3.2	13	V
$V_{DIM\_PWM\_L}$	Low Voltage Level PWM Signal Input on DIM Pin	—	1.2	V
I_{OUT_SINK}	Sink Current of OUT Pin	—	20	mA
T_A	Ambient Temperature	-40	+105	°C

Notes:
4. 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.
5. Test condition: device mounted on 1" × 1" FR-4 substrate PCB, 2oz copper, with minimum recommended pad layout.
6. 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.
7. Test condition is R_{ISET} = 100kΩ. (This mean is I_{DIM} = 100μA).

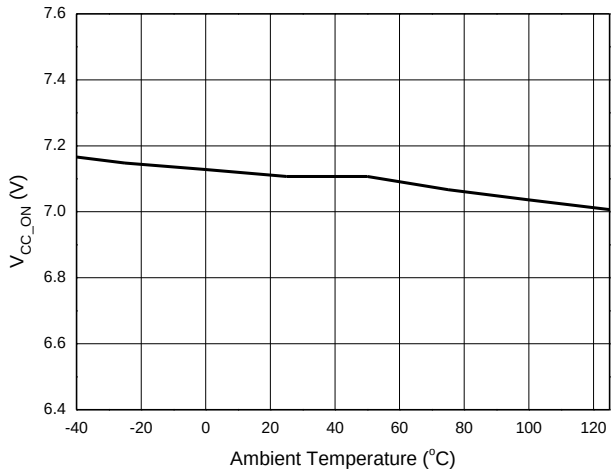
Electrical Characteristics (V_{CC} = 32V @ T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Supply Voltage (VCC Pin)						
V_{CC_ON}	UVLO(ON)	V_{CC} Startup Threshold	6.0	7.0	8.0	V
V_{CC_OFF}	UVLO(OFF)	V_{CC} Minimum Operating Voltage	5.2	6.0	6.8	V
I_{VCC}	Operating Current	R_{ISET} = 100kΩ, DIM Pin and CLAMP Pin are Floating.	—	600	850	μA
ISET Pin						
V_{ISET_OPEN}	Open Voltage	ISET Pin is Floating.	2.45	2.5	2.55	V
K_{DIM}	Current Ratio of I_{DIM} to I_{SET} (Calculate I_{DIM} / I_{SET})	—	—	4	—	—
K_{CLAMP}	Current Ratio of I_{CLAMP} to I_{SET} (Calculate I_{CLAMP} / I_{SET})	—	—	0.4	—	—
DIM Pin (Dimming Function)						
V_{DIM_OPEN}	Open Voltage	R_{ISET} = 100kΩ, DIM Pin is Floating.	12.2	13	13.8	V
$V_{DIM\_MAX\_ON}$	Maximum Voltage on Level	Output Duty = 100%	10.07	10.27	10.47	V
$V_{DIM\_Zero\_ON}$	Zero Duty On OUT Pin	Output Duty ≦ 1%	—	1.5	—	V
I_{DIM_100}	Bias Current	R_{ISET} = 100kΩ	97.5	100.5	103.5	μA
$V_{DIM\_PWM\_H}$	High Level of PWM Input Signal	(Note 8)	3.2	—	—	V
$V_{DIM\_PWM\_L}$	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_{DIM_OFF}	Cut-Off Level Voltage	Output Duty = 0%	1.23	1.3	1.37	V
$V_{DIM\_OFF\_HYS}$	Cut-Off Recovery Hysteresis Voltage	Output Duty ≥ 0%	—	0.1	—	V
CLAMP Pin (Clamping Minimum Dimming)						
V_{CLAMP_OPEN}	Open Voltage	R_{ISET} = 100kΩ, CLAMP Pin is Floating.	4.7	5.0	5.3	V
$D_{OUT\_0\%}$	Minimum Duty Cycle Clamp When R_{ISET} = 100kΩ	R_{CLAMP} ≧ 1MΩ or Open V_{CLAMP} ≧ 4.2V and V_{DIM} = 1.65V	1	2	4	%
$D_{OUT\_4\%}$		R_{CLAMP} = 300kΩ V_{CLAMP} = 2.6V to 3.6V and V_{DIM} = 1.5V	2	4	6	%
$D_{OUT\_6\%}$		R_{CLAMP} = 150kΩ V_{CLAMP} = 1V to 2V and V_{DIM} = 1.5V	4	6	8	%
$D_{OUT\_8\%}$		R_{CLAMP} = 0Ω V_{CLAMP} ≦ 0.5V and V_{DIM} = 1.5V	6	8	10	%
Open Drain Output Set (OUT Pin)						
V_{OUT_LOW}	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_{OUT}	Output Frequency	—	1.0	1.5	2.0	kHz
Internal OTP (Over Temperature Protection)						
OTP	OTP Trip Level	(Note 8)	—	+135	—	°C
ΔOTP	OTP Hysteresis	(Note 8)	—	+20	—	°C

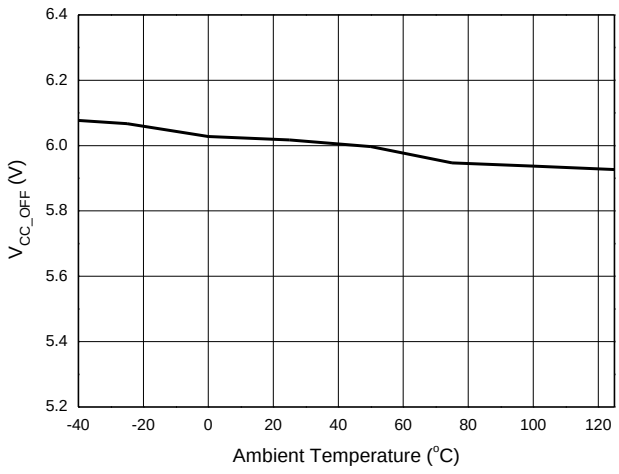
Note: 8. These parameters, although guaranteed by design, are not 100% tested in production.

Performance Characteristics

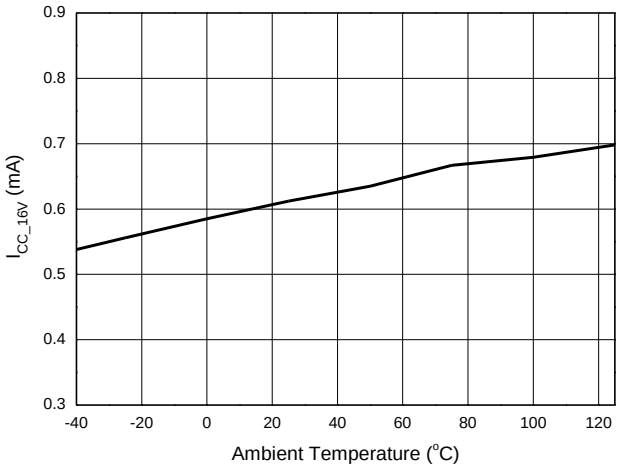
V_{CC_ON} vs. Ambient Temperature



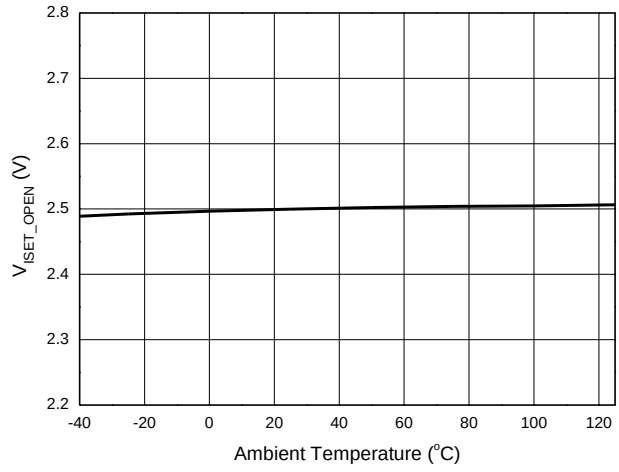
V_{CC_OFF} vs. Ambient Temperature



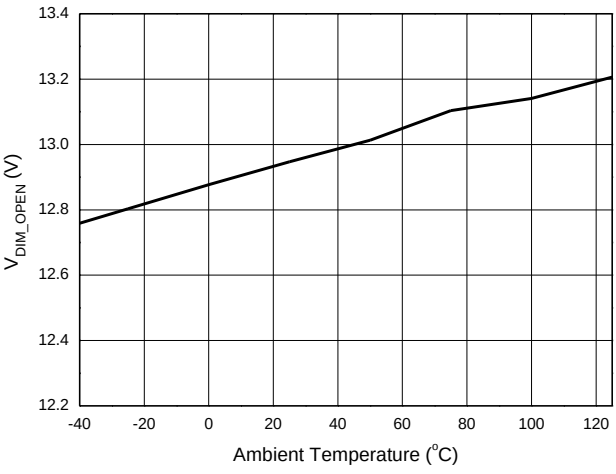
I_{CC_16V} Current vs. Ambient Temperature



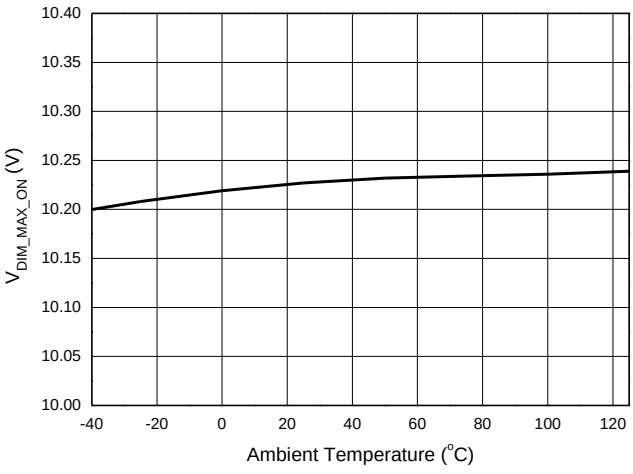
V_{ISET_OPEN} vs. Ambient Temperature



V_{DIM_OPEN} vs. Ambient Temperature

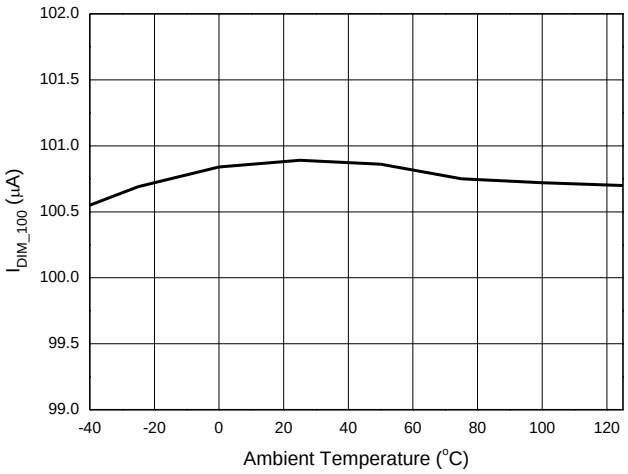


$V_{DIM\_MAX\_ON}$ vs. Ambient Temperature

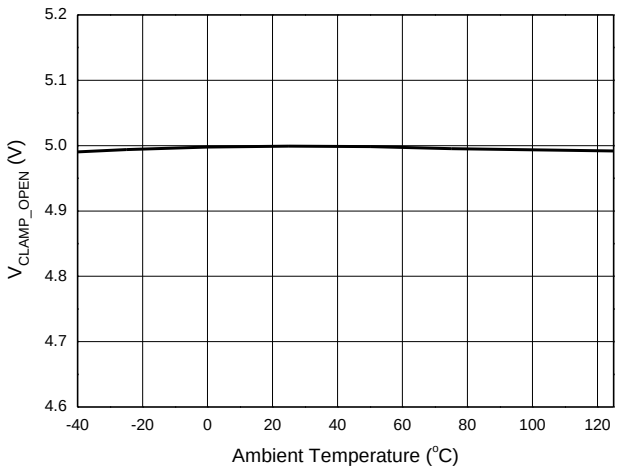


Performance Characteristics (continued)

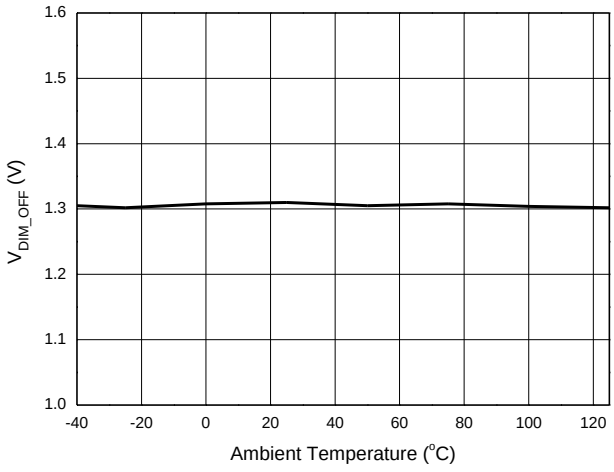
I_{DIM_100} vs. Ambient Temperature



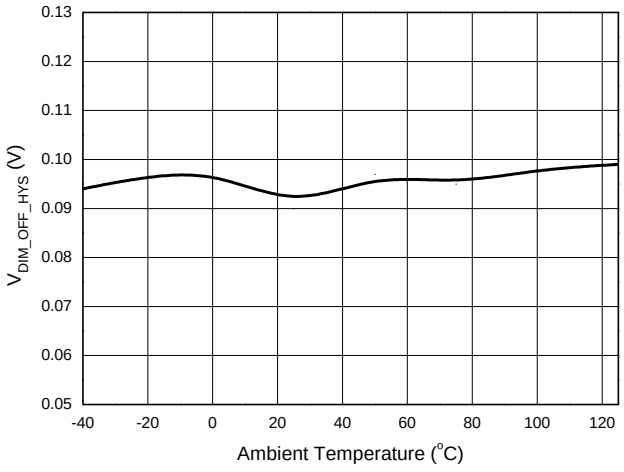
V_{CLAMP_OPEN} vs. Ambient Temperature



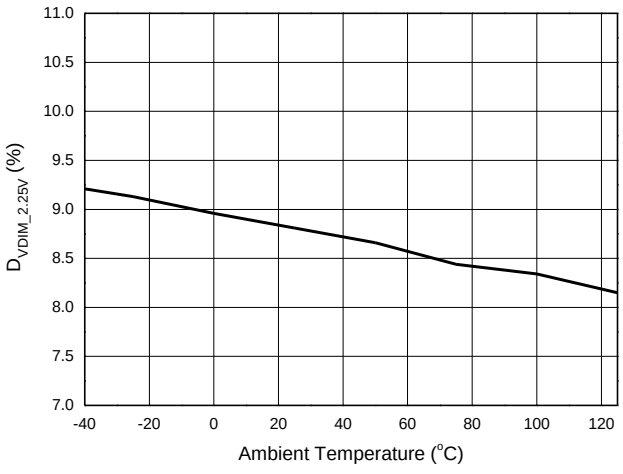
V_{DIM_OFF} vs. Ambient Temperature



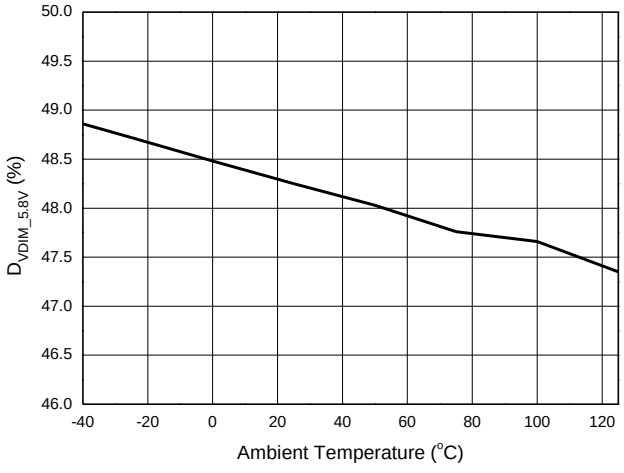
$V_{DIM\_OFF\_HYS}$ vs. Ambient Temperature



$D_{VDIM\_2.25V}$ vs. Ambient Temperature

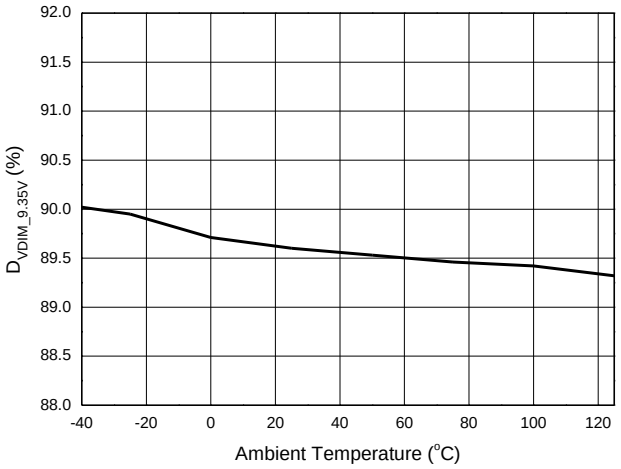


$D_{VDIM\_5.8V}$ vs. Ambient Temperature

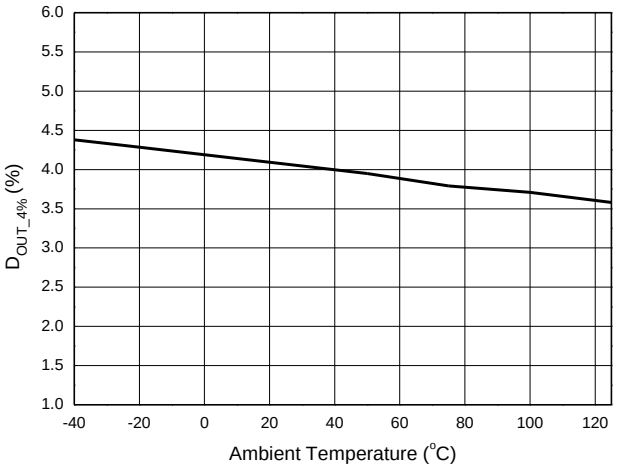


Performance Characteristics (continued)

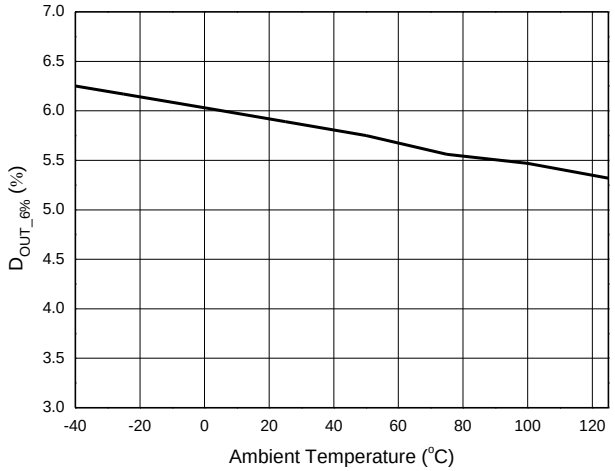
$D_{VDIM\_9.35V}$ vs. Ambient Temperature



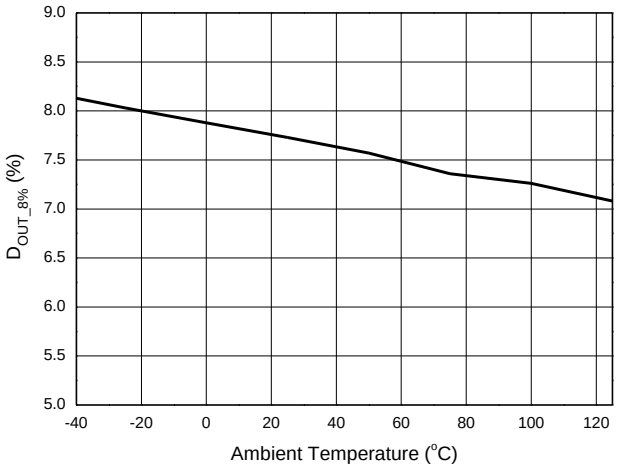
$D_{OUT\_4\%}$ vs. Ambient Temperature



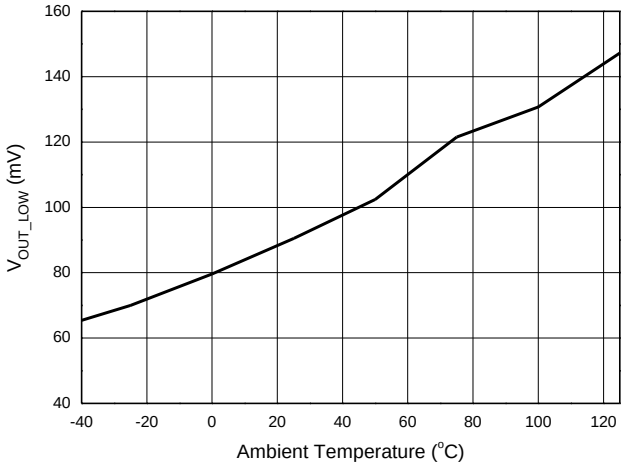
$D_{OUT\_6\%}$ vs. Ambient Temperature



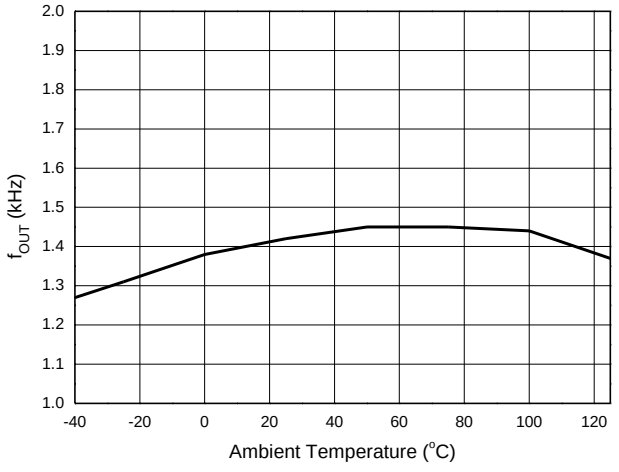
$D_{OUT\_8\%}$ vs. Ambient Temperature



V_{OUT_LOW} Voltage vs. Ambient Temperature



f_{OUT} 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_{CC_ON} (7V) and V_{CC_OFF} (6V) respectively. When the voltage of VCC pin is above V_{CC_OFF} (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_{ISET}), which is connected between ISET pin and GND. For the typical application, the output bias current of DIM pin is 100μA when R_{ISET} is 100kΩ. The relationship between resistor and output bias current is:

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

Where, K_{DIM} is a coefficient of current ratio of I_{DIM} to I_{SET}. The resistance range of R_{ISET} 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_{CLAMP}) 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_{CLAMP} 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_{CLAMP} is a coefficient of current ratio of I_{CLAMP} per I_{ISET}.

Table 1. Minimum Output Duty Cycles Clamping Selection

V_{CLAMP} (V)	Suggestion R_{CLAMP} (Ω) When R_{ISET} = 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_{CLAMP} < 4.2V; When the DIM Pin voltage (V_{DIM}) decreases from 10.2V to V_{DIM_OFF} = 1.3V, the output duty cycle decreases from 100% to the minimum output clamping duty, which is set in Table 1. When the V_{DIM} signal increases from V_{DIM_ON} = 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_{DIM_OFF} and V_{DIM_ON} voltage. The dimming curve is shown in Figure 3a.

When V_{CLAMP} ≥ 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)

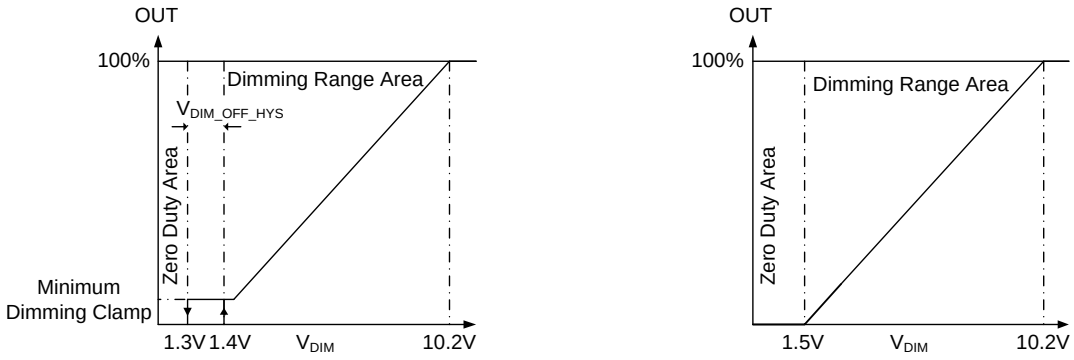


Figure 3. AL8116 Dimming Curve

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/μs through 1.2V to 3.2V and continues for 8 cycles. If PWM rising slew rate of DIM pin is larger than 3 V/μs, 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.

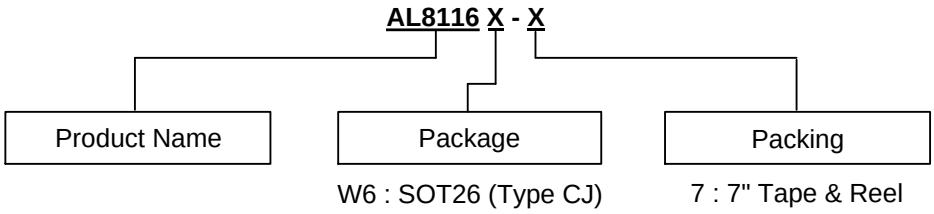
Opto-Coupler Selection Guide

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.

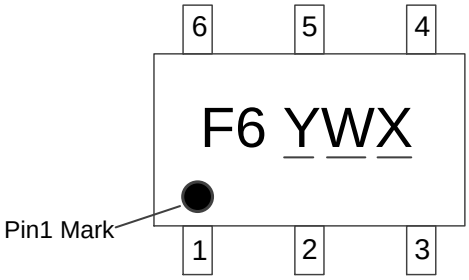
Ordering Information (Note 9)



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

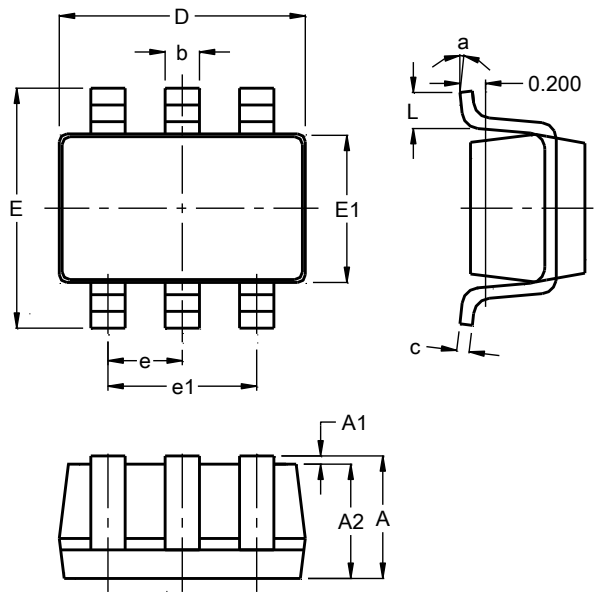


F6: Identification Code
Y: Year 0 to 9
W: Week A to Z: 1 to 26 Week
Week a to z: 27 to 52 Week
z Represents 52 and 53 Week
X: Assembly Site Code

Package Outline Dimensions

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

SOT26 (Type CJ)

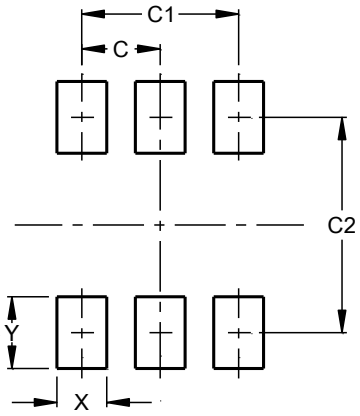


SOT26 (Type CJ)			
Dim	**Min**	**Max**	**Typ**
A	1.050	1.250	--
A1	0.00	0.10	--
A2	1.050	1.150	--
b	0.300	0.500	--
c	0.100	0.200	--
D	2.820	3.020	--
E	2.650	2.950	--
E1	1.500	1.700	--
e	0.950BSC		
e1	1.800	2.000	--
L	0.300	0.600	--
a	0°	8°	--
All Dimensions in mm			

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(e3)
- Weight: 0.016 grams (Approximate)

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