

Description

The AP3609 is an eight-channel constant current sink with current match used for LED driver. It uses an external resistor to set the current for eight LED strings with an accuracy of $\pm 1.5\%$. The full scale LED current can be adjusted from 10mA to 100mA for each channel. The LED light can be adjusted by PWM dimming function.

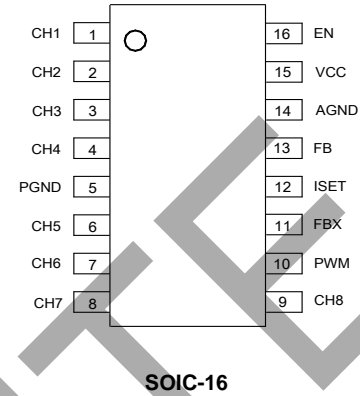
The device can keep working when LED opens without damage. It features under voltage lockout protection and over temperature protection.

The AP3609 has two interface terminals (FB and FBX). They enable the device to be connected in parallel.

The AP3609 is available in SOIC-16 package.

Pin Assignments

(Top View)



Features

- Input Voltage Range: 4.2V to 5.5V
- Typical Output Current: 480mA (60mA/1V per Channel)
- Maximum Output Current: 800mA (100mA/1.5V per Channel)
- Current Match Accuracy: $\pm 1.5\%$
- PWM Dimming Control
- Open LED Self-check and Protection
- Under Voltage Lockout Protection
- Over Temperature Protection
- Enable Parallel Application

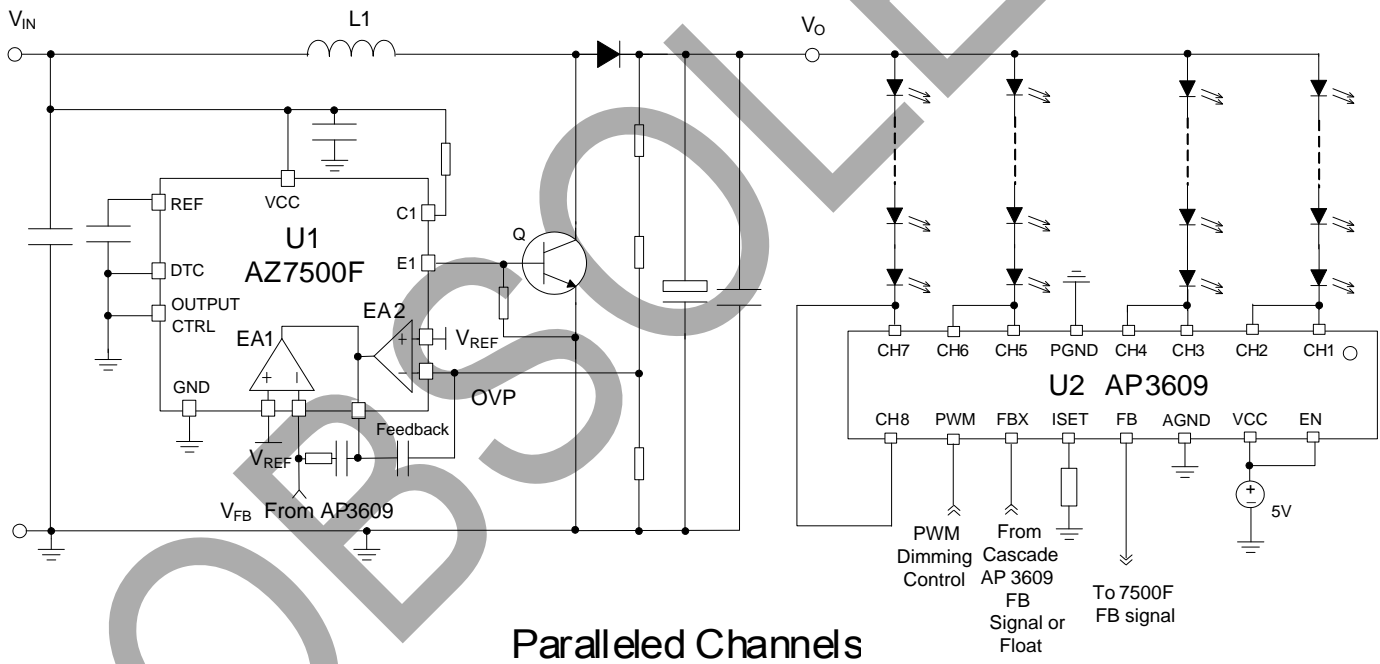
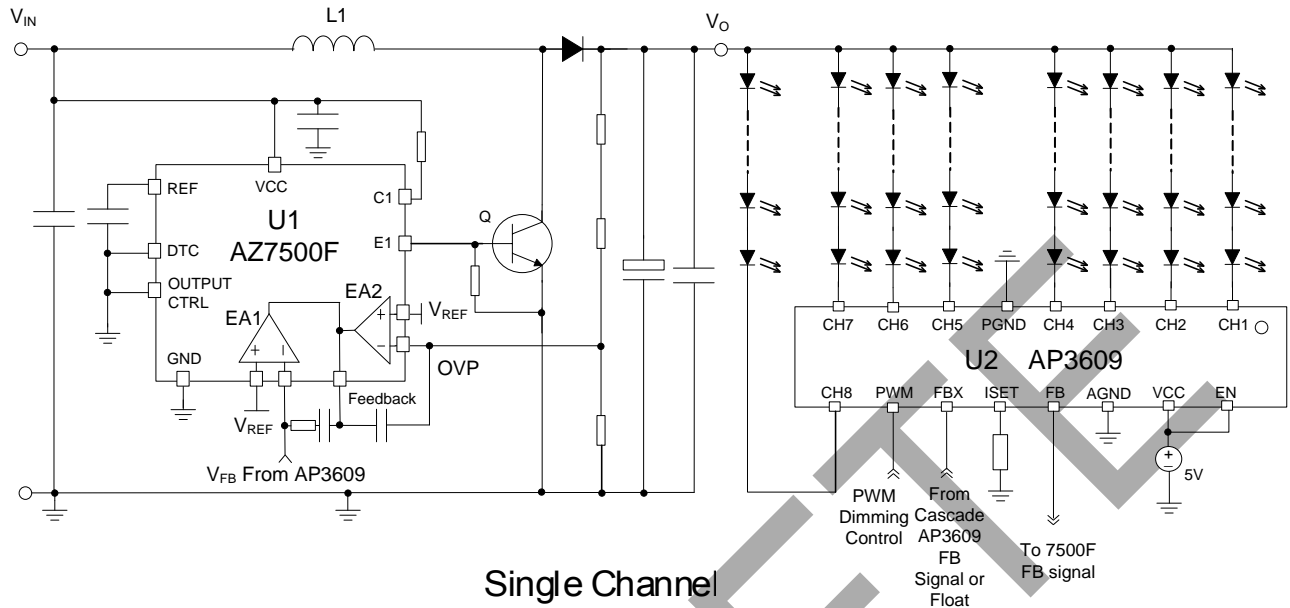
Applications

- Notebook
- LCD Display Modules
- LCD Monitor
- LCD TV

OBSOLETE

Typical Applications Circuit

OBSOLETE - PART DISCONTINUED



Pin Descriptions

Pin Number	Pin Name	Function
1, 2, 3, 4, 6, 7, 8, 9	CH1 to CH8	White LED cathode connection pin. These pins should be connected to GND if not used
5	PGND	Ground pin. It would be useful when connected with PGND and exposed pad
10	PWM	PWM dimming control pin. Adding a PWM signal to this pin to control LED dimming (see Figure 1 for detail dimming control mode). If not used, connect it to the high level
11	FBX	This pin is an interface terminal. Connecting it with FB pin can achieve parallel application. If not used, leave it unconnected
12	ISET	LED current set pin. An external resistor is connected to this pin to set the current of each channel according to $I_{CHANNEL} = 1.194 * 400 / ISET$
13	FB	Feedback pin. This pin is an interface terminal, which samples the voltage of each channel, and outputs the lowest voltage of the string to DC/DC converter
14	AGND	Ground pin. It would be useful when connected with PGND and exposed pad
15	VCC	Input voltage pin
16	EN	Enable pin. Logic high enables the IC and logic low disables the IC

OBSOLETE - PART DISCONTINUED

OBSOLETE

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Value	Unit
V _{CC}	Input Voltage	-0.3 to 6	V
V _{ISET}	ISET Pin Voltage	-0.3 to 6	V
V _{EN}	EN Pin Voltage	-0.3 to 6	V
V _{FB}	Feedback Pin Voltage	-0.3 to 6	V
V _{PWM}	PWM Pin Voltage	-0.3 to 6	V
V _{CHX}	Voltage per Channel (Note 2)	-0.3 to 40	V
θ _{JA}	Thermal Resistance (Junction to Ambient, no Heat Sink)	80	°C/W
T _J	Operating Junction Temperature	+150	°C
T _{STG}	Storage Temperature Range	-65 to +150	°C
T _{LEAD}	Lead Temperature (Soldering, 10sec)	+260	°C
–	ESD (Machine Model)	200	V
–	ESD (Human Body Model)	6000	V

Notes 1: Stresses greater than those listed under "Absolute Maximum Ratings" may 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 may affect device reliability.

2: Breakdown voltage.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit	
V _{CC}	Input Voltage	4.2	5.5	V	
f _{PWM}	Recommended PWM Dimming Frequency	0.1	25	kHz	
I _{CHX}	Full Scale Setting Current per Channel	V _{CHX} ≥ 0.5V	10	25	mA
		V _{CHX} ≥ 1V	10	65	
		V _{CHX} ≥ 1.5V	10	110	
T _A	Operating Temperature Range	-40	+85	°C	

Electrical Characteristics (Limits in standard typeface are guaranteed for $V_{IN}=V_{EN}=5V$, $R_{ISET}=8k\Omega$, $T_A=+25^\circ C$, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Input Section						
V_{IN}	Input Voltage	–	4.2	–	5.5	V
I_Q	Quiescent Current	No Load	–	0.5	1	mA
I_{SDB}	Shutdown Quiescent Current	$V_{EN}=0V$	–	0.1	1	μA
V_{UVLO}	Under Voltage Lockout Threshold	Falling Edge	3.6	3.8	4.0	V
V_{HUVLO}	Under Voltage Lockout Hysteresis	–	–	200	–	mV
Current Sink Section						
V_{ISET}	ISET Reference Voltage	–	1.170	1.194	1.218	V
K	Current Multiplication Ratio	I_{CHX}/I_{SET}	370	400	430	–
I_{CHX_MAX}	Maximum Output Current per Channel	$V_{CHX}=0.5V$	23	45	–	mA
		$V_{CHX}=1V$	65	70	–	
		$V_{CHX}=1.5V$	110	120	–	
$I_{CH-MATCH}$	Current Matching between Any Two Channels	$I_{CHX}=60mA$ $V_{CHX}=1V$	-1.5	–	1.5	%
V_{CHX_SAT}	Current Sink Saturation Voltage per Channel	$I_{CHX}=20mA$	–	–	0.45	V
		$I_{CHX}=60mA$	–	–	0.8	
		$I_{CHX}=100mA$	–	–	1.2	
–	Output Current Line Regulation	$V_{CC}=4.2V$ to $5.5V$	–	–	2	%/V
–	Output Current Load Regulation	$V_{CHX}=0.5V$ to $2.8V$	–	–	4	%

Electrical Characteristics (Cont. Limits in standard typeface are guaranteed for $V_{IN}=V_{EN}=5V$, $R_{ISET}=8k\Omega$, $T_A=+25^\circ C$, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Enable Section						
V_{IH_EN}	EN Pin High Level Threshold Voltage	–	1.8	–	–	V
V_{IL_EN}	EN Pin Low Level Threshold Voltage	–	–	–	0.8	V
PWM Dimming Section						
V_{IH_PWM}	PWM High Level Threshold Voltage	–	1.8	–	–	V
V_{IL_PWM}	PWM Low Level Threshold Voltage	–	–	–	0.8	V
Interface Section						
I_{FB}	Feedback Output Current	–	5	15	–	μA
Total Device						
V_{CHECK}	Self-check Voltage @ Open LED	–	–	3.0	–	V
T_{OTSD}	Thermal Shutdown Temperature	–	–	+160	–	$^\circ C$
T_{HYS}	Thermal Shutdown Hysteresis	–	–	+20	–	$^\circ C$

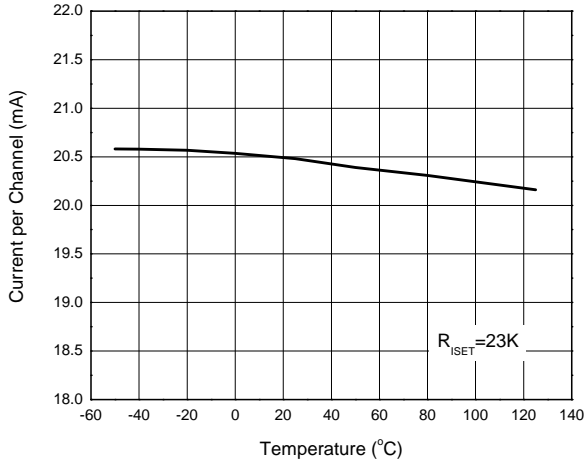
OBSOLETE – PART DISCONTINUED

OBSOLETE

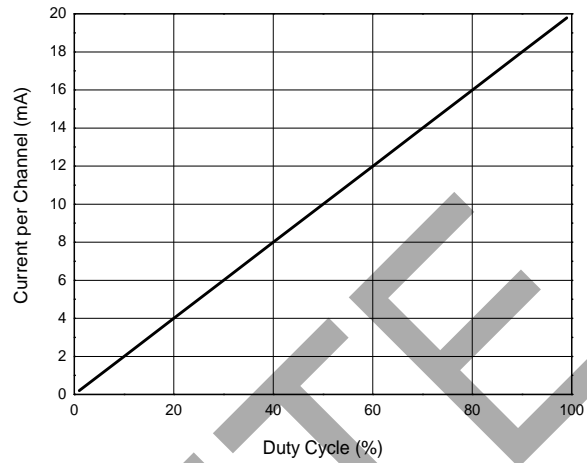
Performance Characteristics ($V_{IN}=V_{EN}=5V$, $R_{ISET}=8k\Omega$, $T_A=+25^\circ C$, unless otherwise specified.)

OBSOLETE - PART DISCONTINUED

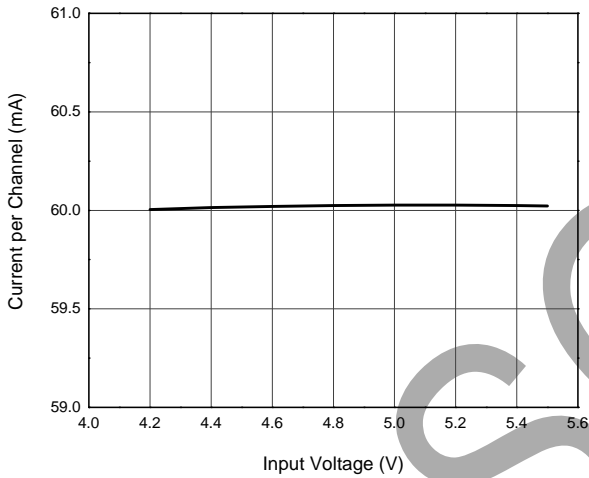
Current Per Channel vs. Temperature



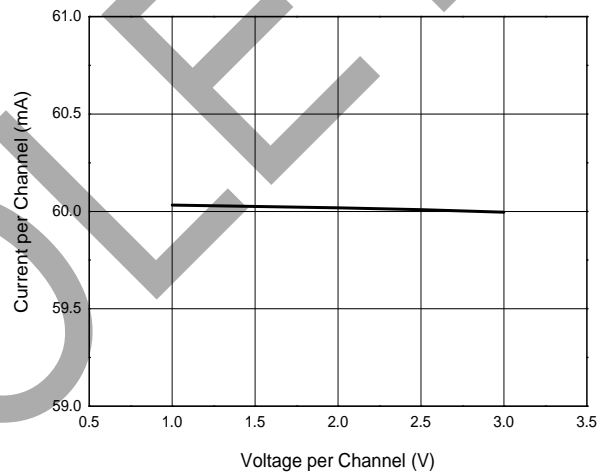
Current Per Channel vs. Duty Cycle



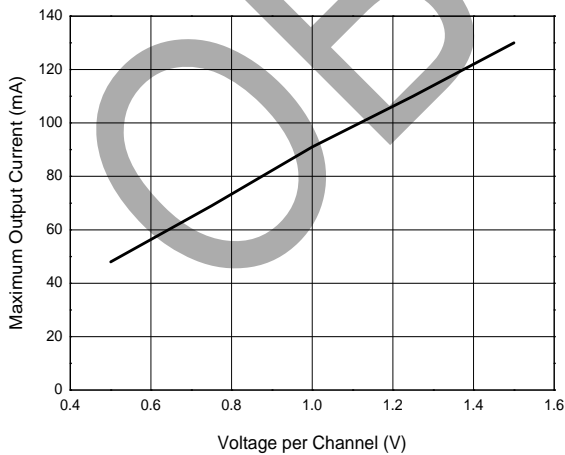
Current Per Channel vs. Input Voltage



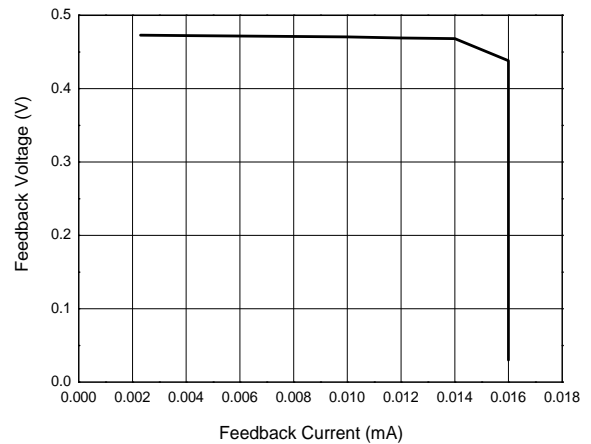
Current Per Channel vs. Voltage Per Channel



Maximum Output Current vs. Voltage Per Channel



Feedback Voltage vs. Feedback Current



OBSOLETE - PART DISCONTINUED

Function Description

The AP3609 is designed for LED display application which contains eight well-matched current sinks to provide constant current through LED. The full scale LED current can be adjusted from 10mA to 100mA per channel with an external resistor. If there is some channel unused, the channel pin should be connected to ground. The LED bright dimming can be achieved through PWM dimming.

The AP3609 can work with a DC/DC converter to drive LED arrays for good performance. The device can keep working when LED opens without damage, and it features under voltage lockout protection and over temperature protection. The detailed information will be discussed in open LED self-check and protection section.

1. LED Current Setting

The maximum LED current can be set up to 100mA per channel by ISET pin. When the LED current is greater than 100mA, two or more channels can be paralleled to achieve larger drive current. To set the reference current I_{SET} , connect a resistor R_{ISET} between this pin and ground. The value of R_{ISET} can be calculated by the following formula:

This reference current is multiplied internally with a gain (K) of 400, and then mirrored on all enabled channels. This sets the maximum LED current, referred to as 100% current (I_{CHX_MAX}). The value can be calculated by the following formula:

The LED current can be reduced from 100% by PWM dimming control.

2. PWM Dimming Mode

The LED current can be adjusted by applying the PWM signal to PWM pin. On this mode, all enabled channels are adjusted at the same time and the brightness can be adjusted from $1\% \cdot I_{CHX_MAX}$ to $100\% \cdot I_{CHX_MAX}$ (@ $f_{Dimming}=2kHz$). During the "high level" time of the PWM signal, the LED turns on and the 100% current flows through LED. During the "low level" time of the PWM signal, the LED turns off and almost no current flows through LED. So the average current through LED is changed and the brightness is adjusted. The external PWM signal frequency applied to PWM pin can be allowed to 100Hz or higher.

An example for PWM dimming is shown in Figure 1. All 8 channels are set to the maximum current I_{CHX_MAX} at the beginning. When a 50% duty cycle PWM signal is applied to PWM pin, average current valued $50\% \cdot I_{CHX_MAX}$ flows through the 8 channels. When an 80% duty cycle PWM signal is applied to PWM pin, average current valued $80\% \cdot I_{CHX_MAX}$ flows through the 8 channels.

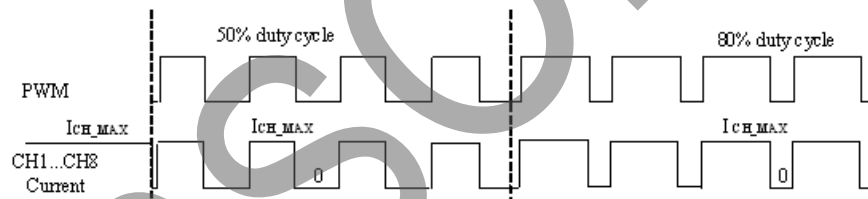


Figure 1. PWM Dimming Example of AP3609

3. Open LED Self-Check and Protection

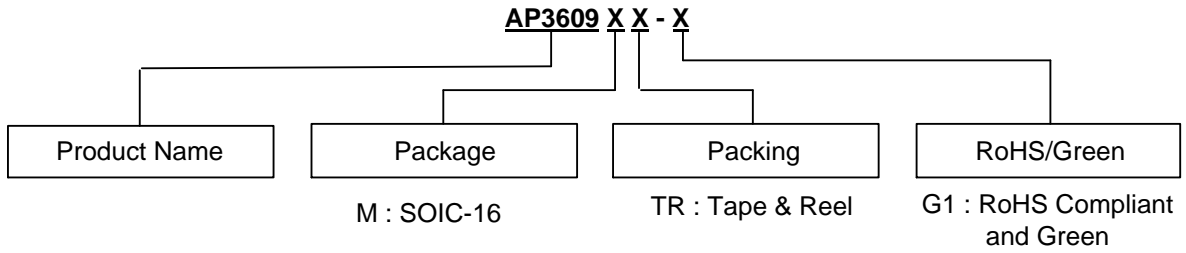
The AP3609 can work with a DC/DC converter to achieve good performance, such as self-check and protection against open LED. The FB pin samples voltage of each channel, and outputs the lowest voltage to DC/DC converter. When AP3609 gets shutdown signal from EN pin or PWM voltage is low, AP3609 outputs a high Z signal (floating). The FB voltage should be decided by external pull-up resistor connected to it. Then the DC/DC converter can be controlled by AP3609.

If any enabled LED string opens, voltage on the corresponding CHX pin goes to zero and the FB pin outputs the zero voltage to boost converter. So the boost converter operates in open loop and the voltage on remaining CHX pin goes higher. Once the voltage on remaining CHX pin reaches the self-check voltage 3V, the AP3609 begins looking up the open string. After finding the open channel, AP3609 removes the corresponding CHX pin from boost control loop, then the boost circuit is controlled in the normal manner. Once the circuit returns normal operation, the voltage on the CHX pin is regulated to the normal level. It is necessary to pay attention that the open strings are removed from boost regulation, but not disabled. If the open LED string is reconnected, it will sink current up to the programmed current level.

4. Parallel Operation Mode

The AP3609 can be paralleled to drive more strings of LED. Connecting an AP3609 FB pin with another AP3609 FBX pin can achieve parallel application. More details please refer to Figure of typical applications of AP3609.

Ordering Information



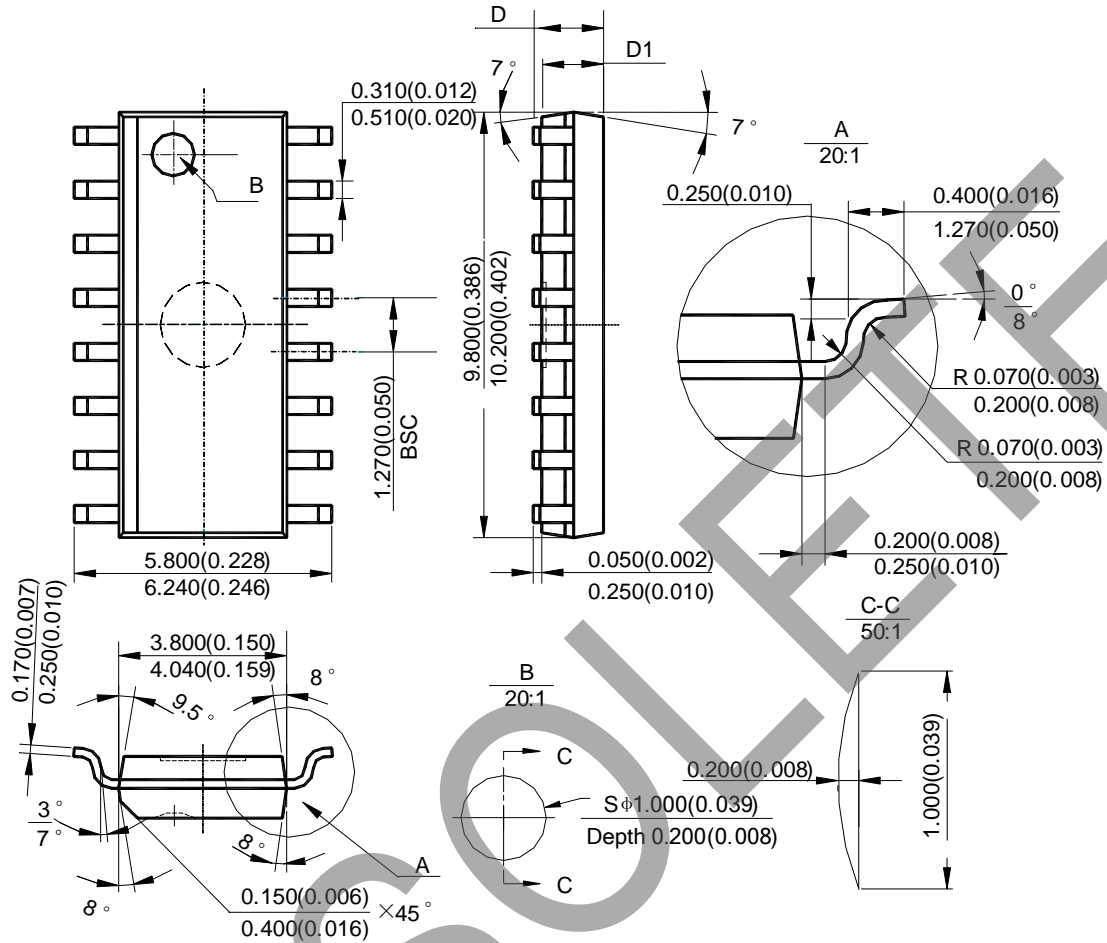
Package	Temperature Range	Part Number	Marking ID	Packing
SOIC-16	-40 to +85°C	AP3609MTR-G1	AP3609M-G1	Tape & Reel

OBSOLETE

OBSOLETE - PART DISCONTINUED

Package Outline Dimensions (All dimensions in mm(inch).)

(1) Package Type: SOIC-16



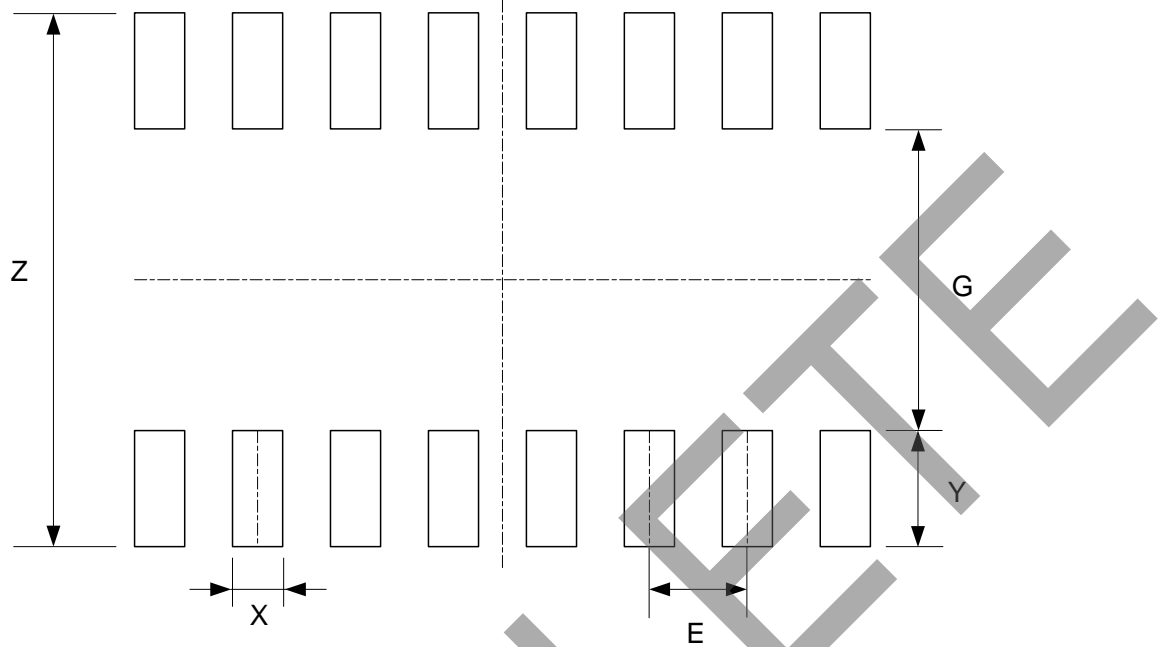
Note: Eject hole, oriented hole and mold mark is optional.

Symbol	D				D1			
	min(mm)	max(mm)	min(inch)	max(inch)	min(mm)	max(mm)	min(inch)	max(inch)
Option1	1.350	1.750	0.053	0.069	1.250	1.650	0.049	0.065
Option2	-	1.260	-	0.050	1.020	-	0.040	-

OBSOLETE - PART DISCONTINUED

Suggested Pad Layout

(1) Package Type: SOIC-16



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E (mm)/(inch)
Value	6.900/0.272	3.900/0.154	0.650/0.026	1.500/0.059	1.270/0.050

OBSOLETE - PART DISCONTINUED

OBSOLETE

IMPORTANT NOTICE

DIODES INCORPORATED MAKES NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).

Diodes Incorporated and its subsidiaries reserve the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. Diodes Incorporated does not assume any liability arising out of the application or use of this document or any product described herein; neither does Diodes Incorporated convey any license under its patent or trademark rights, nor the rights of others. Any Customer or user of this document or products described herein in such applications shall assume all risks of such use and will agree to hold Diodes Incorporated and all the companies whose products are represented on Diodes Incorporated website, harmless against all damages.

Diodes Incorporated does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel. Should Customers purchase or use Diodes Incorporated products for any unintended or unauthorized application, Customers shall indemnify and hold Diodes Incorporated and its representatives harmless against all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized application.

Products described herein may be covered by one or more United States, international or foreign patents pending. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks.

This document is written in English but may be translated into multiple languages for reference. Only the English version of this document is the final and determinative format released by Diodes Incorporated.

LIFE SUPPORT

Diodes Incorporated products are specifically not authorized for use as critical components in life support devices or systems without the express written approval of the Chief Executive Officer of Diodes Incorporated. As used herein:

A. Life support devices or systems are devices or systems which:

1. are intended to implant into the body, or
2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

Copyright © 2019, Diodes Incorporated

www.diodes.com