AP3101

GREEN MODE PWM CONTROLLER

Description

The AP3101 is a green PWM controller operating in current mode. It is specifically designed for off-line AC-DC adapter and battery charger applications where the needs for low standby power and better protection function are increasing.

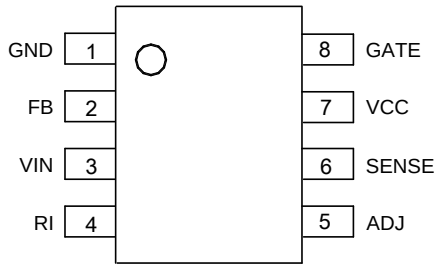
The AP3101 features adjustable oscillator frequency in normal operation, which is done by an external resistor. It automatically switches to skip cycle mode when output power drops below a given level. The IC also features low start-up and operation current for its BiCMOS process.

The AP3101 provides comprehensive protection features including leading edge blanking, synchronized slope compensation, over-current, over-temperature and short circuit protection.

The AP3101 is available in SO-8 package.

Pin Assignments

(Top View)



SO-8

Features

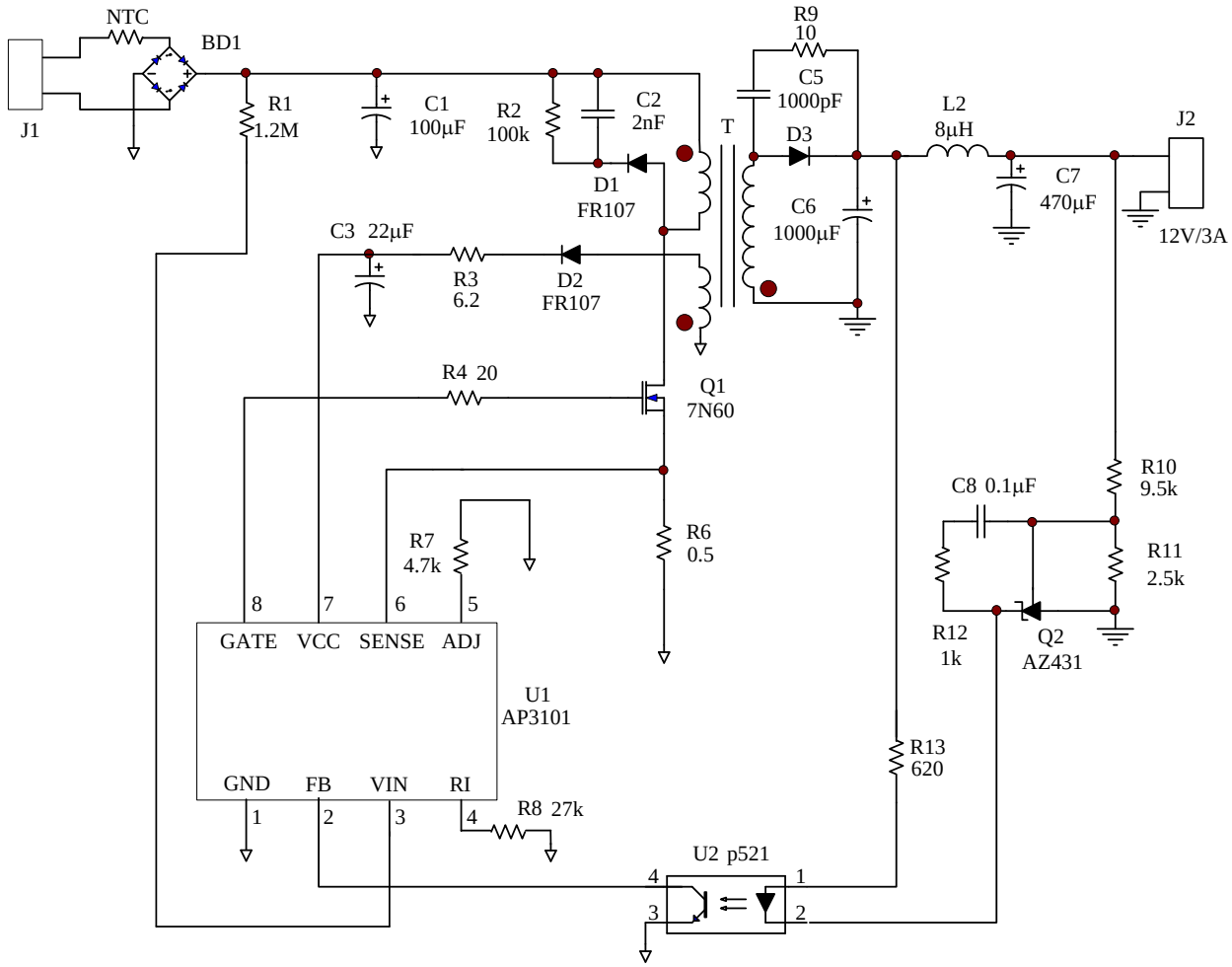
- Green Current Mode PWM Controller
- Adjustable Skip Level
- Leading Edge Blanking (LEB)
- Cycle by Cycle Current Limit
- Built-in Short Circuit Protection
- Built-in Synchronized Slope Compensation
- Low Start-up/Operating Current: 30μA/3mA
- Adjustable Oscillator Frequency
- Totem Pole Output Including Soft Driving
- Under-Voltage Lockout (UVLO)
- Accurate Over-Temperature Protection with Hysteresis
- Lead-Free Package: SO-8
  - **Totally Lead-Free; RoHS Compliant (Notes 1 & 2)**
- Lead-Free Package, Available in “Green” Molding Compound: SO-8
  - **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
  - **Halogen and Antimony Free. “Green” Device (Note 3)**

Applications

- Off-line AC-DC Adapter
- Battery Charger Applications

Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html 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.

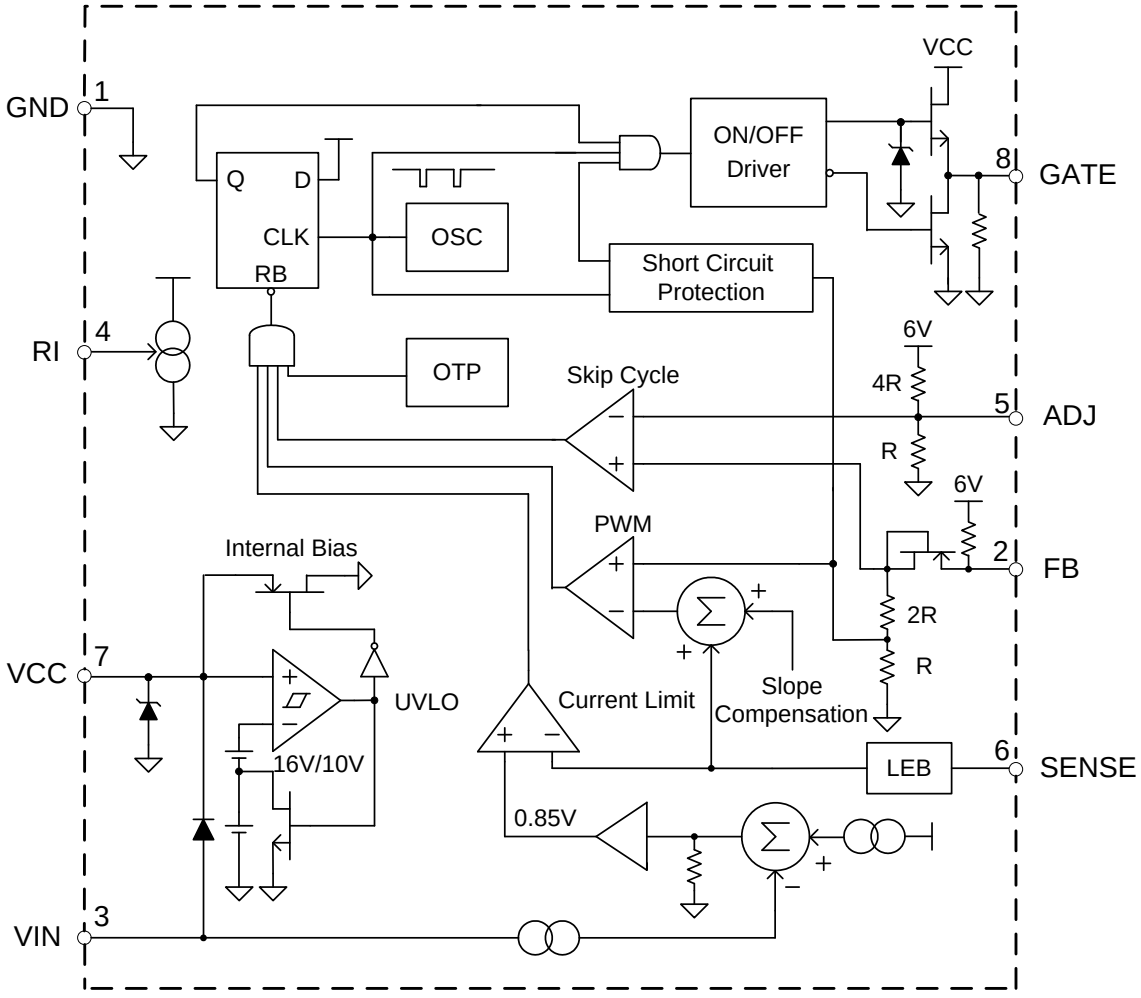
Typical Applications Circuit



Pin Descriptions

Pin Number	Pin Name	Function
1	GND	Power ground
2	FB	Feedback
3	VIN	Start-up current in
4	RI	Reference setting
5	ADJ	Adjust the level of skip cycle
6	SENSE	Current sense
7	VCC	The positive supply of the control IC
8	GATE	Driver output

Functional Block Diagram



Absolute Maximum Ratings (Note 4)

Symbol	Parameter	Rating	Unit
V_{CC}	Supply Voltage	30	V
I_O	Gate Output Current	600	mA
–	Input Voltage to FB	-0.3 to 7	V
–	Input Voltage to SENSE	-0.3 to 7	V
–	Input Voltage to RI	-0.3 to 7	V
–	Input Voltage to ADJ	-0.3 to 7	V
–	Operating Junction Temperature	+150	°C
T_{STG}	Storage Temperature Range	-65 to +150	°C
–	ESD (Human Body Model)	4	kV
–	ESD (Machine Model)	400	V
P_D	Power Dissipation at T_A<+25°C	550	mW
θ_{JA}	Thermal Resistance (Junction to Ambient)	186	°C/W

Note 4: 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.

Recommended Operating Conditions

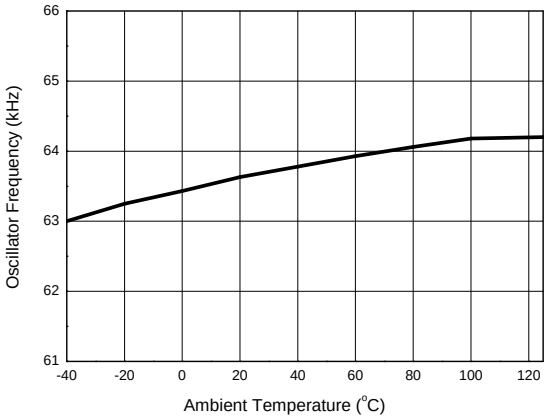
Symbol	Parameter	Min	Max	Unit
T_A	Operating Ambient Temperature	-40	+85	°C
V_{CC}	Supply Voltage	–	20	V

Electrical Characteristics (@T_A=+25°C, V_{CC}=15V, unless otherwise specified.)

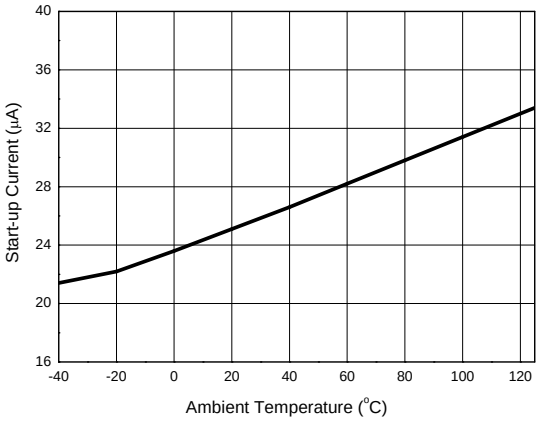
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
UNDER-VOLTAGE LOCKOUT SECTION						
V_{THON}	Start-up Voltage	–	15	16	17	V
V_{THOFF}	Minimum Operating Voltage	–	9	10	11	V
TOTAL STANDBY CURRENT SECTION						
–	Start-up Current	V_{CC}=14.8V	–	30	45	μA
I_{CC}	Operating Current	V_{FB}=V_{SENSE}=0V, C_L=1nF	–	3	4	mA
PWM SECTION						
D_{MAX}	Maximum Duty Cycle	–	70	80	90	%
D_{MIN}	Minimum Duty Cycle	–	–	–	0	%
OSCILLATOR SECTION						
f_{OSC}	Oscillation Frequency	R_I=26kΩ	60	65	70	kHz
–	Frequency Change with Voltage	V_{CC}=10V to 20V	–	–	2	%
–	Temperature Stability	T_A=-40°C to +85°C	–	–	5	%
FEEDBACK INPUT SECTION						
–	The Ratio of Input Voltage to Current Sense Voltage	–	2.5	3	3.5	V/V
–	Input Impedance	–	3	4.5	6	kΩ
–	Source Current	–	–	–	-2	mA
–	Input Voltage for Zero Duty	–	–	–	1.2	V
CURRENT SENSE SECTION						
V_{TH}	Threshold Voltage	–	0.8	0.85	0.9	V
–	Delay to Output	–	–	150	200	ns
–	Delay Time of Short Circuit Protection	R_I=26kΩ	–	23	–	ms
OUTPUT SECTION						
V_{OL}	Low Level Voltage	I_O=200mA, V_{CC}=12V	–	–	1.5	V
V_{OH}	High Level Voltage	I_O=50mA, V_{CC}=12V	8	–	–	V
t_R	Rise Time	V_{CC}=13V, C_L=1nF	150	250	350	ns
t_F	Fall Time	V_{CC}=13V, C_L=1nF	30	50	90	ns
SKIP CYCLE SECTION						
V_{SKIP}	Default Skip Level	–	–	1.2	–	V
–	Leading Edge Blanking	R_I=26kΩ	200	270	350	ns
OVER-TEMPERATURE PROTECTION SECTION						
–	Shutdown Temperature	–	–	+155	–	°C
–	Temperature Hysteresis	–	–	+25	–	°C

Performance Characteristics

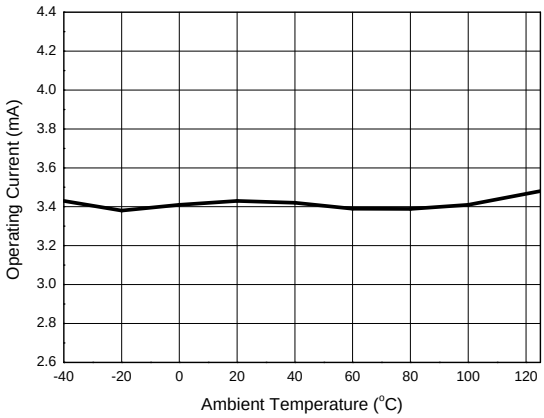
Oscillator Frequency vs. Ambient Temperature



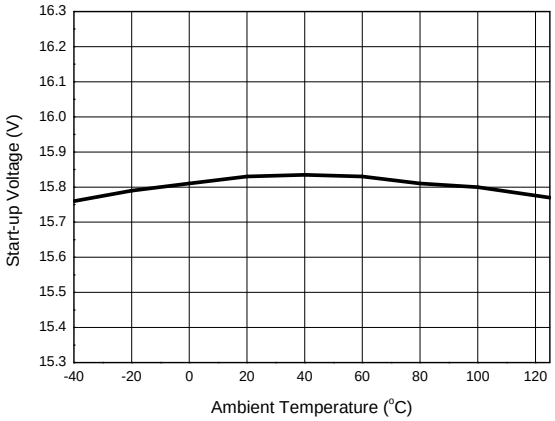
Start-up Current vs. Ambient Temperature



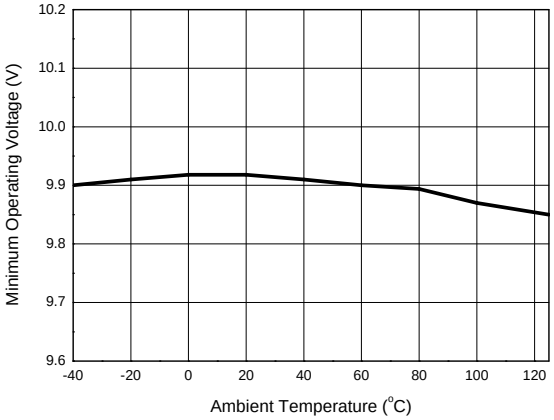
Operating Current vs. Ambient Temperature



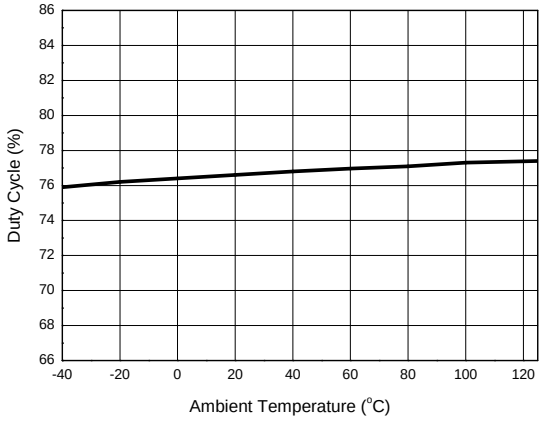
Start-up Voltage vs. Ambient Temperature



Minimum Operating Voltage vs. Ambient Temperature

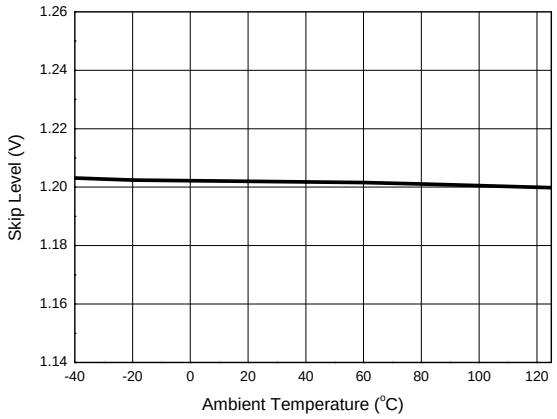


Duty Cycle vs. Ambient Temperature

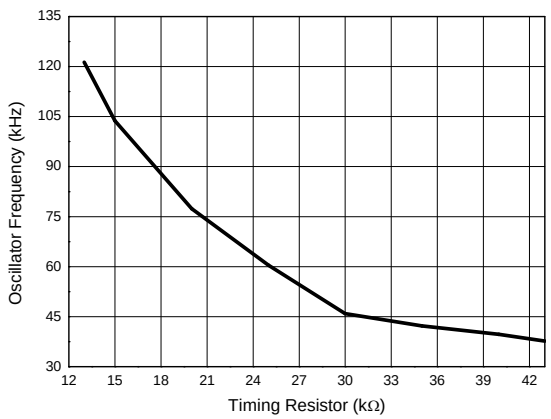


Performance Characteristics (Cont.)

Skip Level vs. Ambient Temperature



Oscillator Frequency vs. Timing Resistor



Operation Description

The AP3101 is specially designed for off-line AC-DC adapter and battery charger applications. It offers the designer a cost effective solution with minimal external components.

Oscillator

The oscillation frequency is programmed by the value of resistor R1 connected from pin RI to ground. The resistor will make a constant current source to determine the oscillation frequency by charging and discharging an internal capacitor. The oscillation frequency can be expressed as:

$$f \approx \frac{1690}{R1(k\Omega)}(kHz)$$

The recommended oscillation frequency is 50 to 100kHz.

Start-up Current and Operating Current

The typical start-up current is only 30μA. With such a low start-up current, the start-up resistor may have a very high resistance value even in 85V line voltage; however, higher resistance will cause longer start-up time. So we must select a proper start-up resistor and a proper V_{CC} hold-up capacitor. Operating current is lowered to 3mA. It can reduce the requirement of V_{CC} hold-up capacitor value and the power loss in AP3101.

Under-Voltage Lockout (UVLO)

An UVLO comparator is included in AP3101 to detect the voltage on the VCC pin. It ensures AP3101 to draw adequate energy from hold-up capacitor during power on. The turn-on threshold is 16V and the turn-off threshold is 10V.

Current Sense Comparator and PWM Latch

AP3101 operates as a current mode controller, the output switch conduction is initiated by every oscillator cycle and terminated when the peak inductor current reaches the threshold level established by the FB pin. The inductor current signal is converted to a voltage signal by inserting a referenced sense resistor R_S in series with the source of the MOSFET. The peak inductor current under normal operating conditions is controlled by the voltage at FB pin:

$$I_{pk} = (V_{FB} - 0.9) / 3R_S$$

Abnormal operating conditions occur when the power supply output is overloaded or the output voltage sensing is lost. Under these conditions, the current sense comparator threshold will be internally clamped to 0.85V. Therefore the maximum peak switch current is:

$$I_{PK(max)} = 0.85 / R_S$$

Operation Description (Cont.)

Leading Edge Blanking

A narrow spike on the leading edge of the current waveform can usually be observed when the power MOSFET is turned on. A 270ns leading-edge blank is built-in to prevent the false-triggering caused by the turn-on spike; so the RC filter on the current sense input can be removed. During this period, the current limit comparator is disabled and the gate driver cannot be switched off.

Built-in Slope Compensation

It is well known that a continuous current mode SMPS may become unstable when the duty cycle exceeds 50%. The built-in slope compensation can improve the stability, so there is no need for design engineer to spend much time on that.

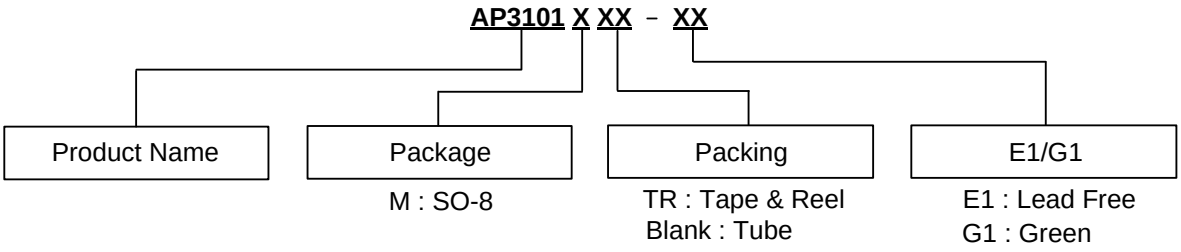
Short Circuit Protection

Built-in short circuit protection can protect a SMPS from being damaged when short circuit of output or over load conditions happen. The feedback voltage will keep its value above its upper limit of 4.2V as long as short circuit exists, and then gate driver will be turned off after fixed delay time of 23ms. When V_{CC} of AP3101 dropped under the minimum operating voltage, the device will be turned off and the system will try to restart. The SMPS will not recover its normal operation until the short circuit or over load is removed.

Green Mode Operation

ADJ pin is the non-inverting input of skip cycle comparator. The voltage at FB pin minus 0.9V is compared with the voltage at ADJ pin. If the voltage at ADJ pin is higher, AP3101 will start to blank its output pulse. In normal operation, AP3101 works at fixed switching frequency, and V_{FB} is in high level. When load power becomes lighter, the V_{FB} will decrease. When V_{FB} drops to the threshold, AP3101 will enter the skip cycle mode and operate intermittently. The threshold is adjustable by changing the value of the resistor connected from pin ADJ to the ground.

Ordering Information



Diodes IC's Pb-free products, as designated with "E1" suffix in the part number, are RoHS compliant. Products with "G1" suffix are available in green packages.

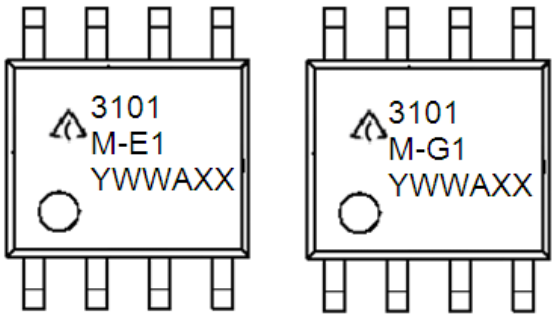
Package	Temperature Range	Part Number		Marking ID		Packing
		Lead Free	Green	Lead Free	Green	
SO-8	-40 to +85°C	AP3101M-E1	AP3101M-G1	3101M-E1	3101M-G1	100/Tube
		AP3101MTR-E1	AP3101MTR-G1	3101M-E1	3101M-G1	4000/Tape & Reel

Lead-Free

Lead-free Green

Marking Information

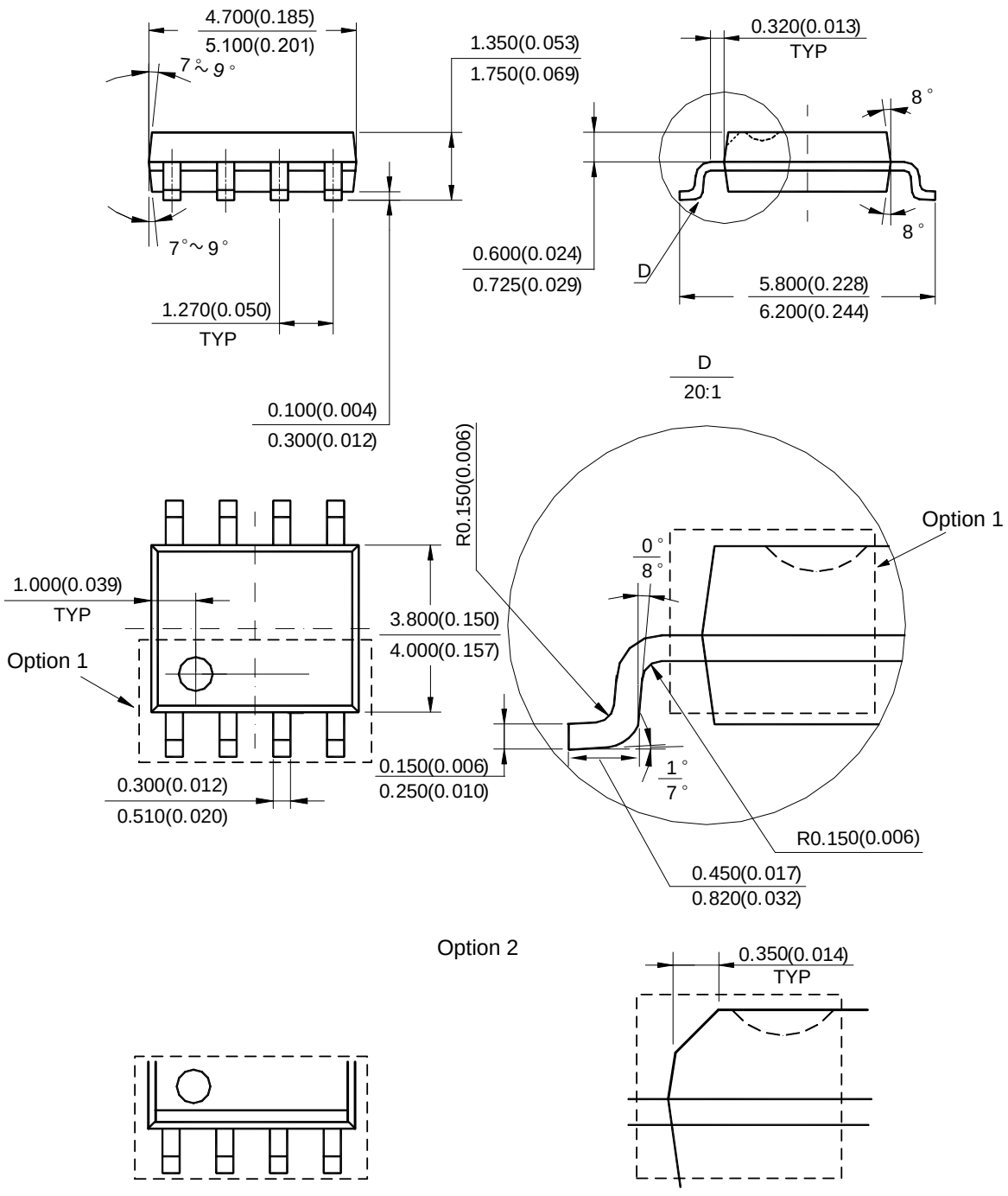
(Top View)



First and Second Lines: Logo and Marking ID
(See Ordering Information)
Third Line: Date Code
Y: Year
WW: Work Week of Molding
A: Assembly House Code
XX: 7th and 8th Digits of Batch No.

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

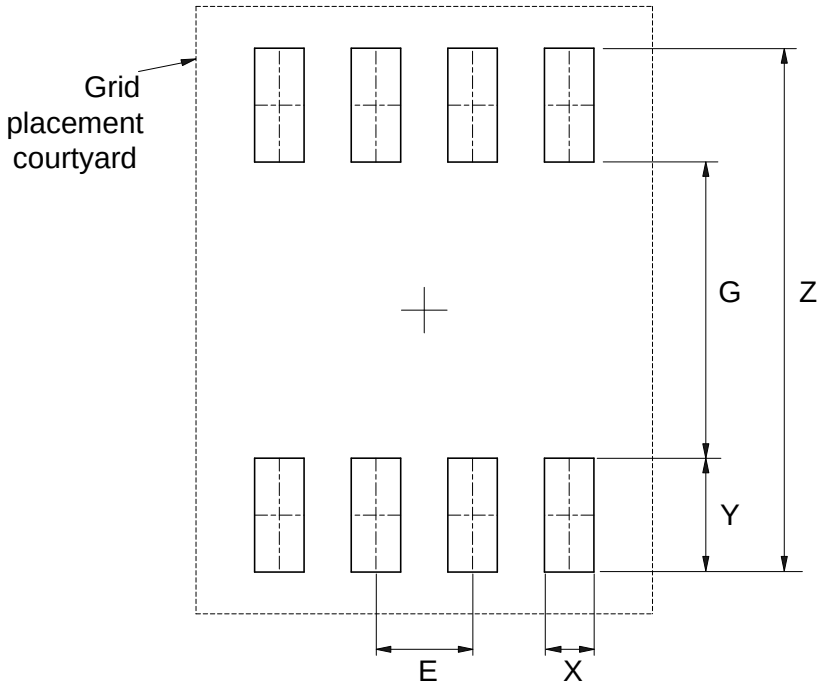
(1) Package Type: SO-8



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

Suggested Pad Layout

(1) Package Type: SO-8



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

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.

www.diodes.com