

## 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.

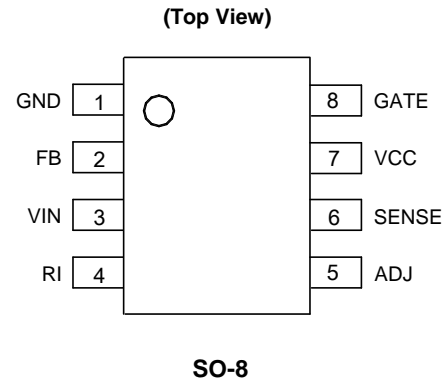
## Features

- 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: 30 $\mu$ A/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)**

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](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.

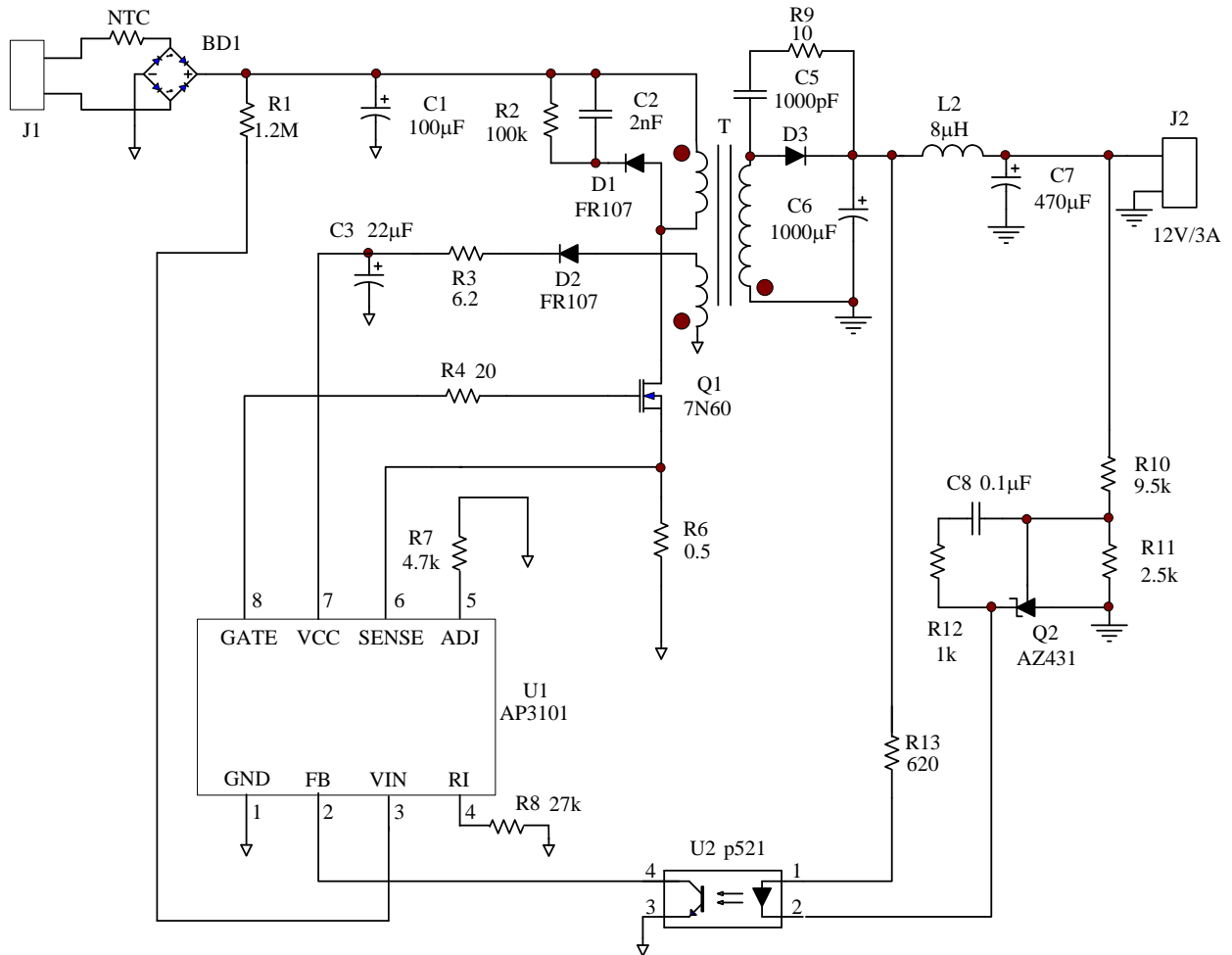
## Pin Assignments



## Applications

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

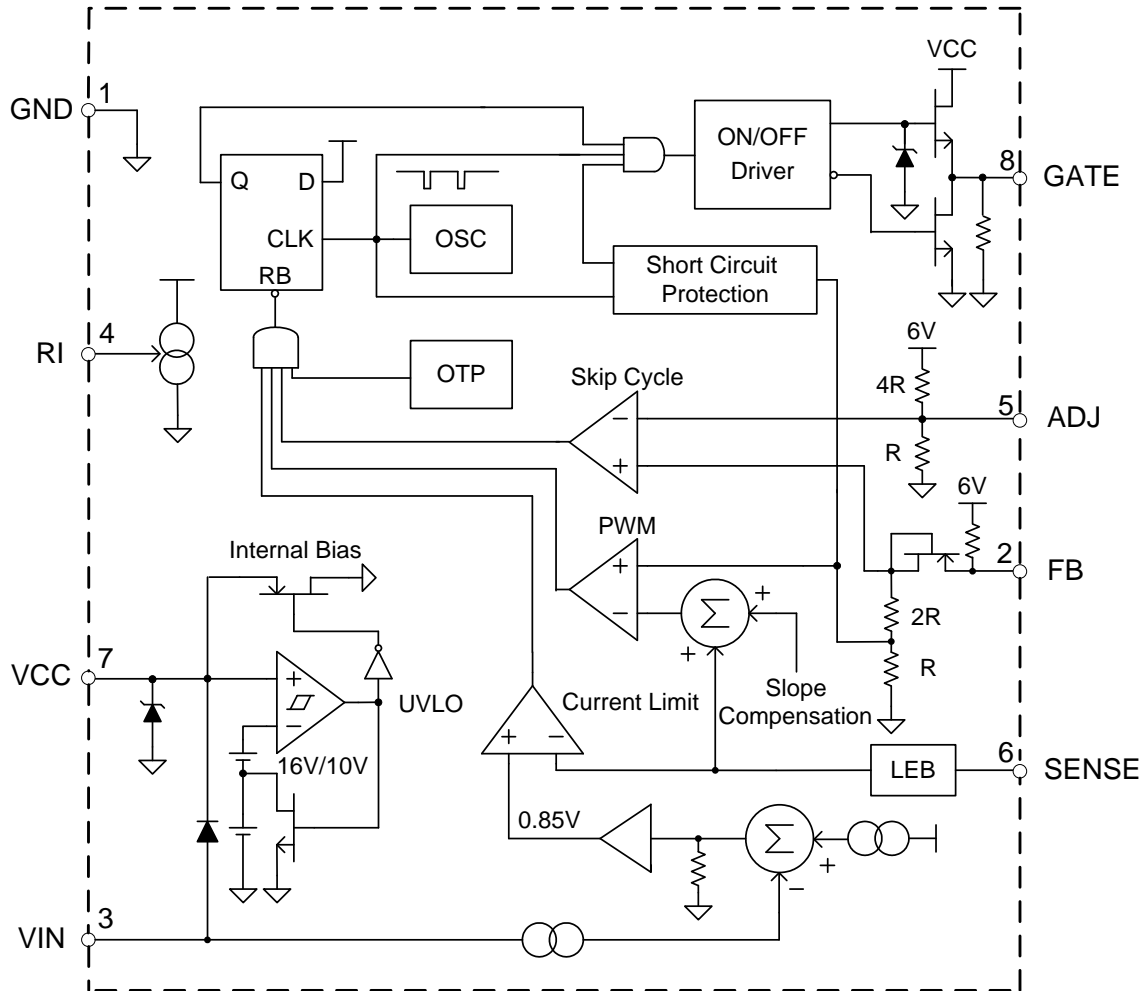
**Typical Applications Circuit**



**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 $T_A < +25^\circ\text{C}$	550	mW
$\theta_{JA}$	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

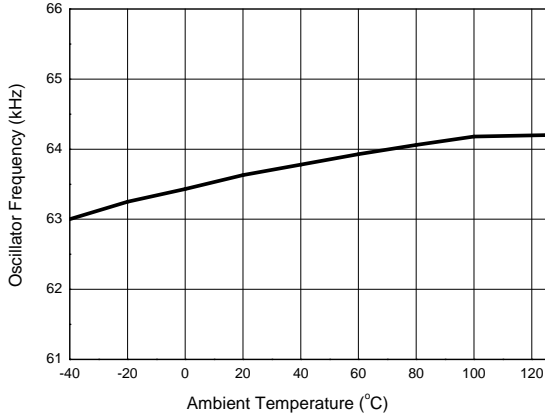
Symbol	Parameter	Min	Max	Unit
$T_A$	Operating Ambient Temperature	-40	+85	°C
$V_{CC}$	Supply Voltage	–	20	V

**Electrical Characteristics** (@T<sub>A</sub>=+25°C, V<sub>CC</sub>=15V, unless otherwise specified.)

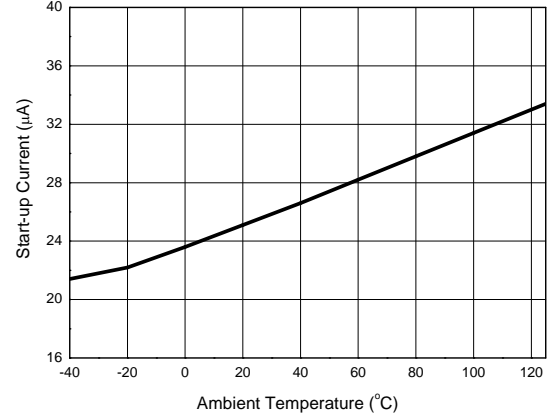
Symbol	Parameter	Conditions	Min	Typ	Max	Unit
<b>UNDER-VOLTAGE LOCKOUT SECTION</b>						
V <sub>THON</sub>	Start-up Voltage	–	15	16	17	V
V <sub>THOFF</sub>	Minimum Operating Voltage	–	9	10	11	V
<b>TOTAL STANDBY CURRENT SECTION</b>						
–	Start-up Current	V <sub>CC</sub> =14.8V	–	30	45	μA
I <sub>CC</sub>	Operating Current	V <sub>FB</sub> =V <sub>SENSE</sub> =0V, C <sub>L</sub> =1nF	–	3	4	mA
<b>PWM SECTION</b>						
D <sub>MAX</sub>	Maximum Duty Cycle	–	70	80	90	%
D <sub>MIN</sub>	Minimum Duty Cycle	–	–	–	0	%
<b>OSCILLATOR SECTION</b>						
f <sub>OSC</sub>	Oscillation Frequency	R <sub>I</sub> =26kΩ	60	65	70	kHz
–	Frequency Change with Voltage	V <sub>CC</sub> =10V to 20V	–	–	2	%
–	Temperature Stability	T <sub>A</sub> =-40°C to +85°C	–	–	5	%
<b>FEEDBACK INPUT SECTION</b>						
–	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
<b>CURRENT SENSE SECTION</b>						
V <sub>TH</sub>	Threshold Voltage	–	0.8	0.85	0.9	V
–	Delay to Output	–	–	150	200	ns
–	Delay Time of Short Circuit Protection	R <sub>I</sub> =26kΩ	–	23	–	ms
<b>OUTPUT SECTION</b>						
V <sub>OL</sub>	Low Level Voltage	I <sub>O</sub> =200mA, V <sub>CC</sub> =12V	–	–	1.5	V
V <sub>OH</sub>	High Level Voltage	I <sub>O</sub> =50mA, V <sub>CC</sub> =12V	8	–	–	V
t <sub>R</sub>	Rise Time	V <sub>CC</sub> =13V, C <sub>L</sub> =1nF	150	250	350	ns
t <sub>F</sub>	Fall Time	V <sub>CC</sub> =13V, C <sub>L</sub> =1nF	30	50	90	ns
<b>SKIP CYCLE SECTION</b>						
V <sub>SKIP</sub>	Default Skip Level	–	–	1.2	–	V
–	Leading Edge Blanking	R <sub>I</sub> =26kΩ	200	270	350	ns
<b>OVER-TEMPERATURE PROTECTION SECTION</b>						
–	Shutdown Temperature	–	–	+155	–	°C
–	Temperature Hysteresis	–	–	+25	–	°C

**Performance Characteristics**

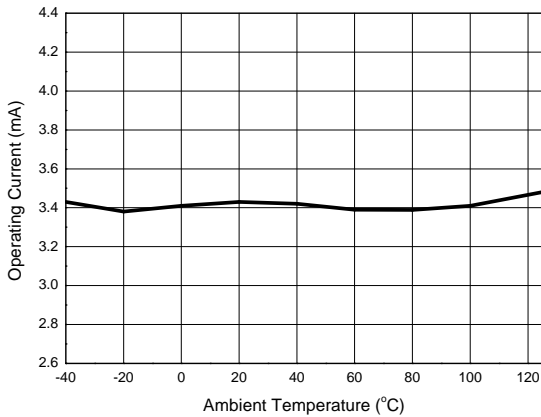
**Oscillator Frequency vs. Ambient Temperature**



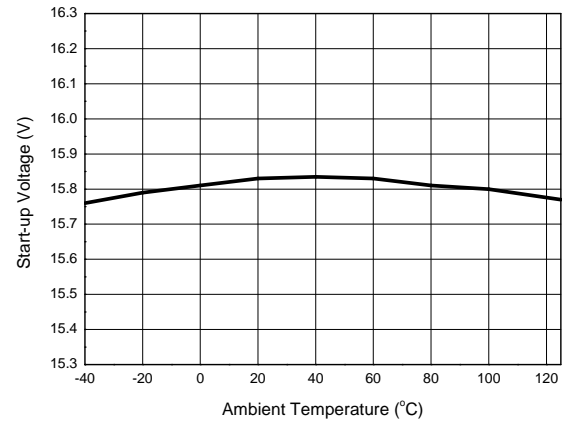
**Start-up Current vs. Ambient Temperature**



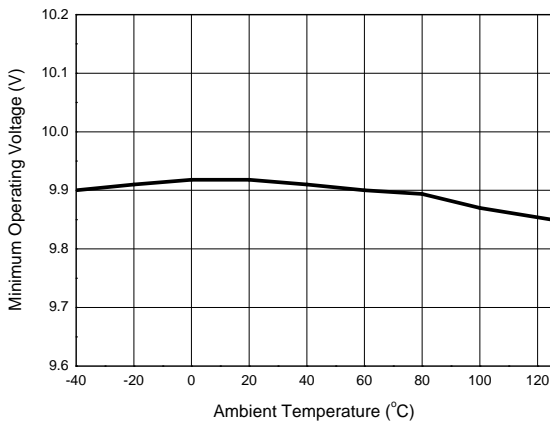
**Operating Current vs. Ambient Temperature**



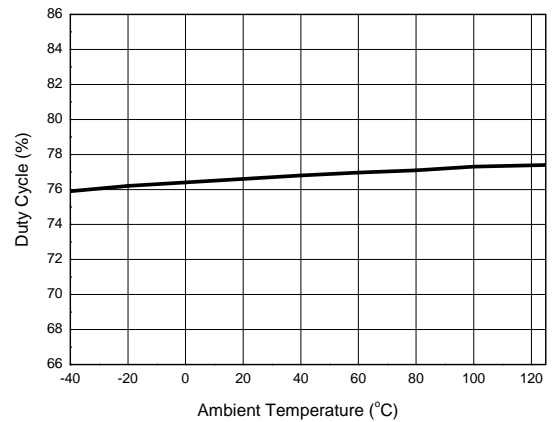
**Start-up Voltage vs. Ambient Temperature**



**Minimum Operating Voltage vs. Ambient Temperature**

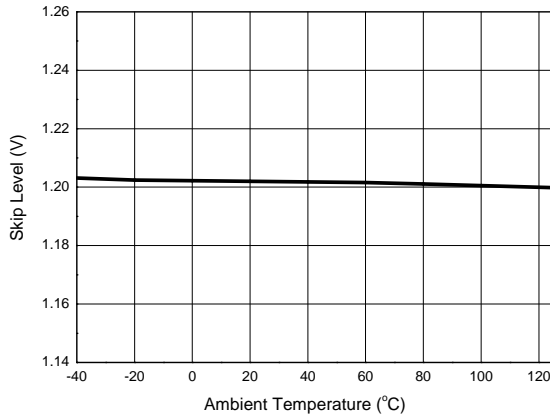


**Duty Cycle vs. Ambient Temperature**

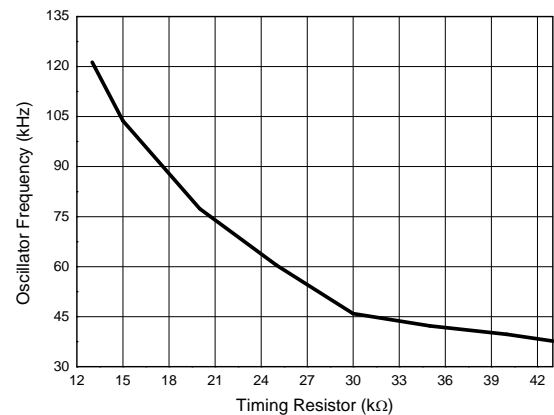


## Performance Characteristics (Cont.)

**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:

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

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<sub>CC</sub> hold-up capacitor. Operating current is lowered to 3mA. It can reduce the requirement of V<sub>CC</sub> 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 V<sub>CC</sub> 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<sub>S</sub> 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:

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

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## Operation Description (Cont.)

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### 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

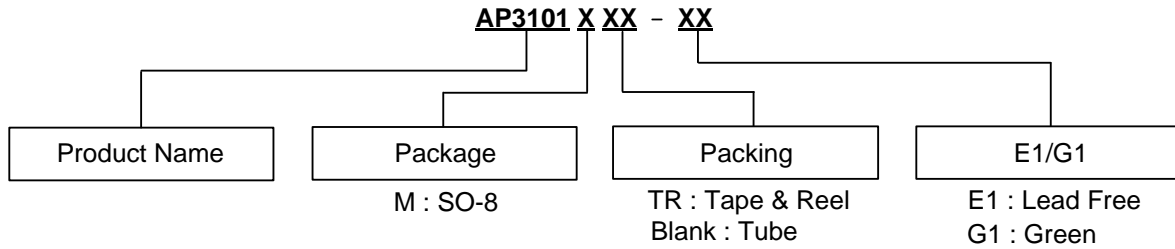
Built-in short circuit protection can protect a SMPS from being damaged when short circuit of output or over load conditions happen. The feedback voltage will keep its value above its upper limit of 4.2V as long as short circuit exists, and then gate driver will be turned off after fixed delay time of 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**



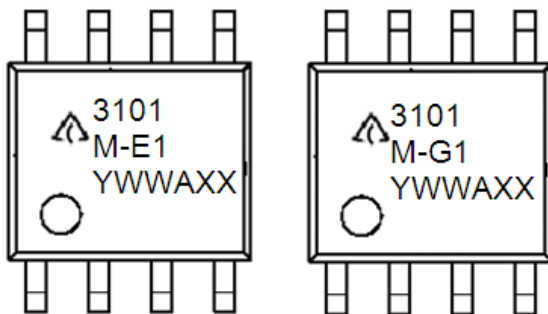
Diodes IC's Pb-free products, as designated with "E1" suffix in the part number, are RoHS compliant. Products with "G1" suffix are available in green packages.



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

**Marking Information**

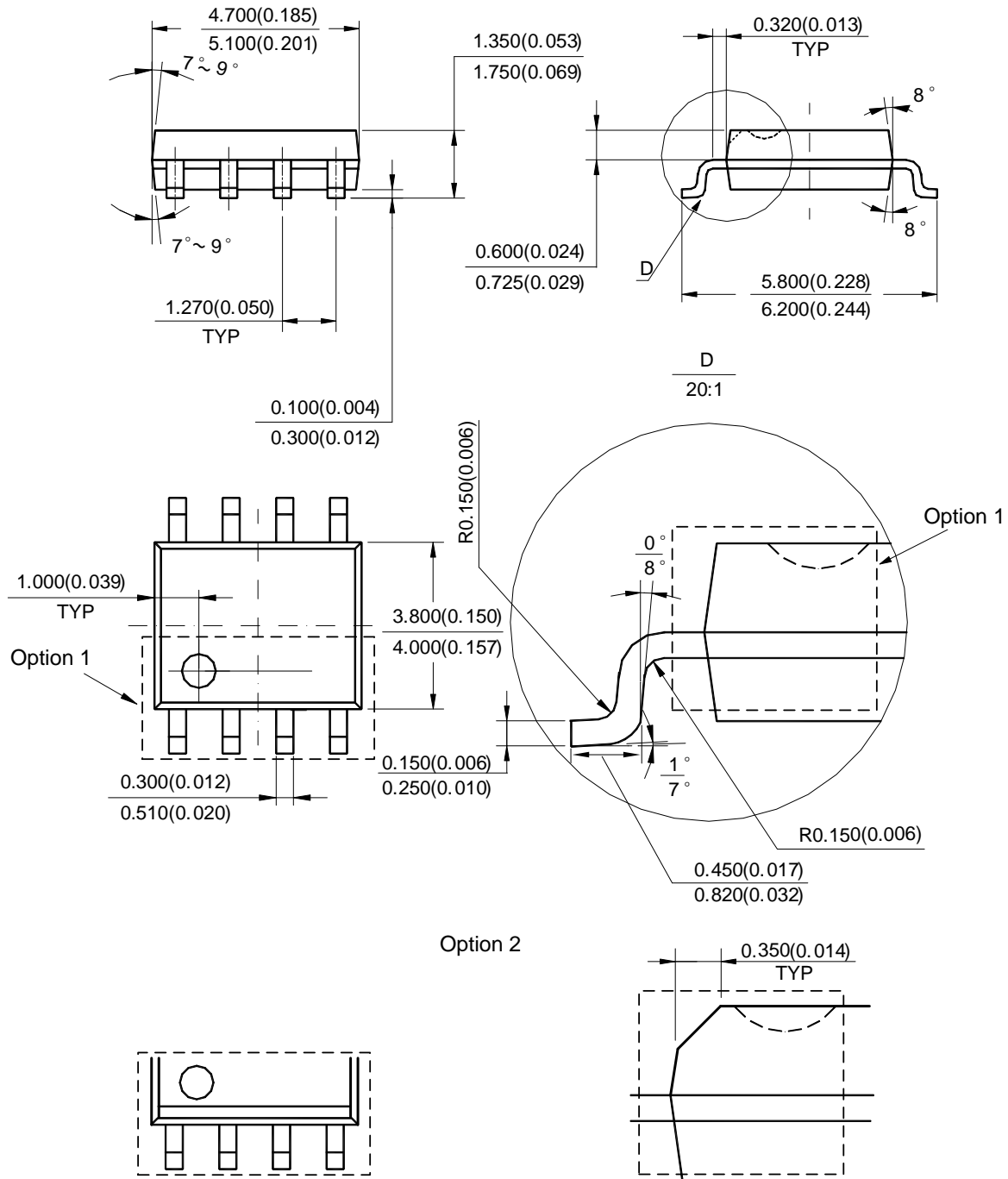
(Top View)



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: 7<sup>th</sup> and 8<sup>th</sup> Digits of Batch No.

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

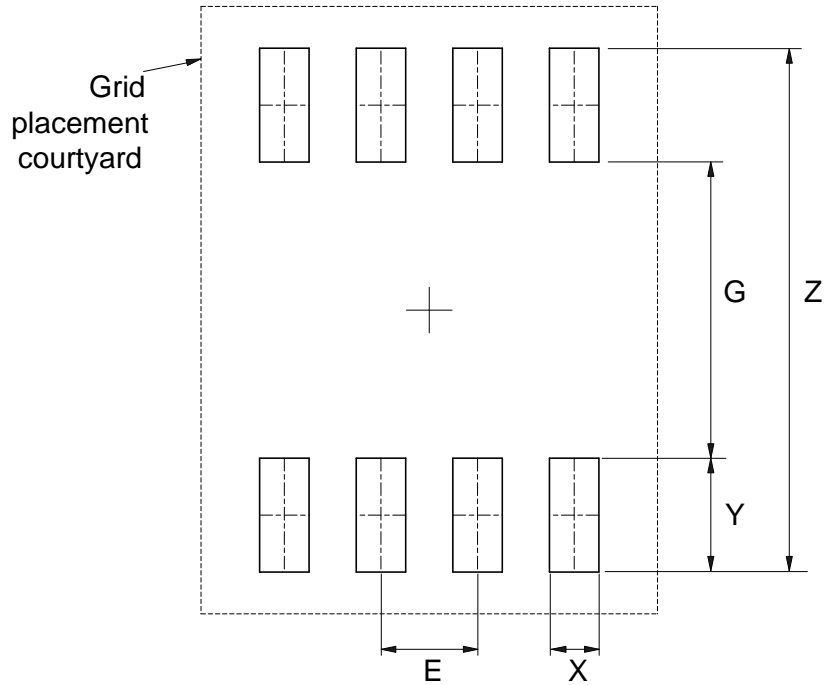
(1) Package Type: SO-8



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

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