

**AC/DC, HIGH PF, HIGH EFFICIENCY, UNIVERSAL MAINS LED DRIVER CONTROLLER**

NEW PRODUCT

**Description**

The AP1688 is a high performance AC/DC PFC and constant current controller for universal mains LED driver applications. The device is a buck controller which operates as a boundary conduction mode (BCM) to achieve high efficiency and easy EMI.

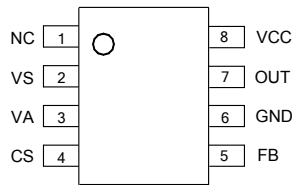
An open loop algorithm is adopted in the AP1688, which will make the system achieve excellent line and load regulations with high PF for universal mains input.

The AP1688 features fast start-up, low start-up current, low operation current and high efficiency. It also has rich protection features including over voltage, short and open circuit, over current, over temperature protection.

The AP1688 is available in SO-8 package.

**Pin Assignments**

(Top View)



(SO-8/ M Package)

**Features**

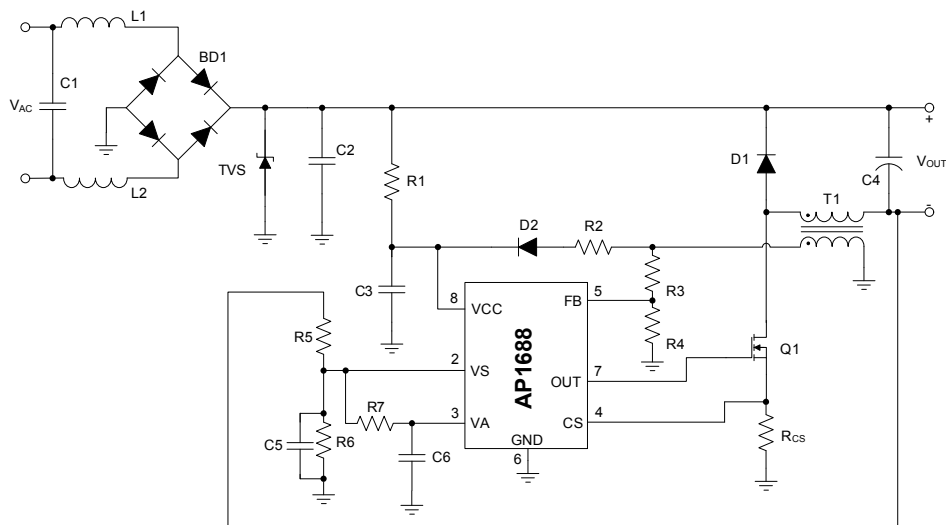
- Optimized for Buck Topology
- Boundary Conduction Mode (BCM) Operation to Achieve High Efficiency
- High Power Factor > 0.9
- High Efficiency > 90%
- System Current Accuracy:  $\pm 5\%$
- Good Line Regulation and Load Regulation
- Low Start-up Current
- Tight CC Regulation Performance for Universal Input Mains Voltage Range
- Eliminates Control Loop Compensation Circuitry
- Easy EMI
- Open-load and Reload Detection
- Over Temperature Protection
- Over Current Protection
- Over Voltage and Short and Open Circuit Protection
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

**Applications**

- Universal Mains LED lighting

- 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.

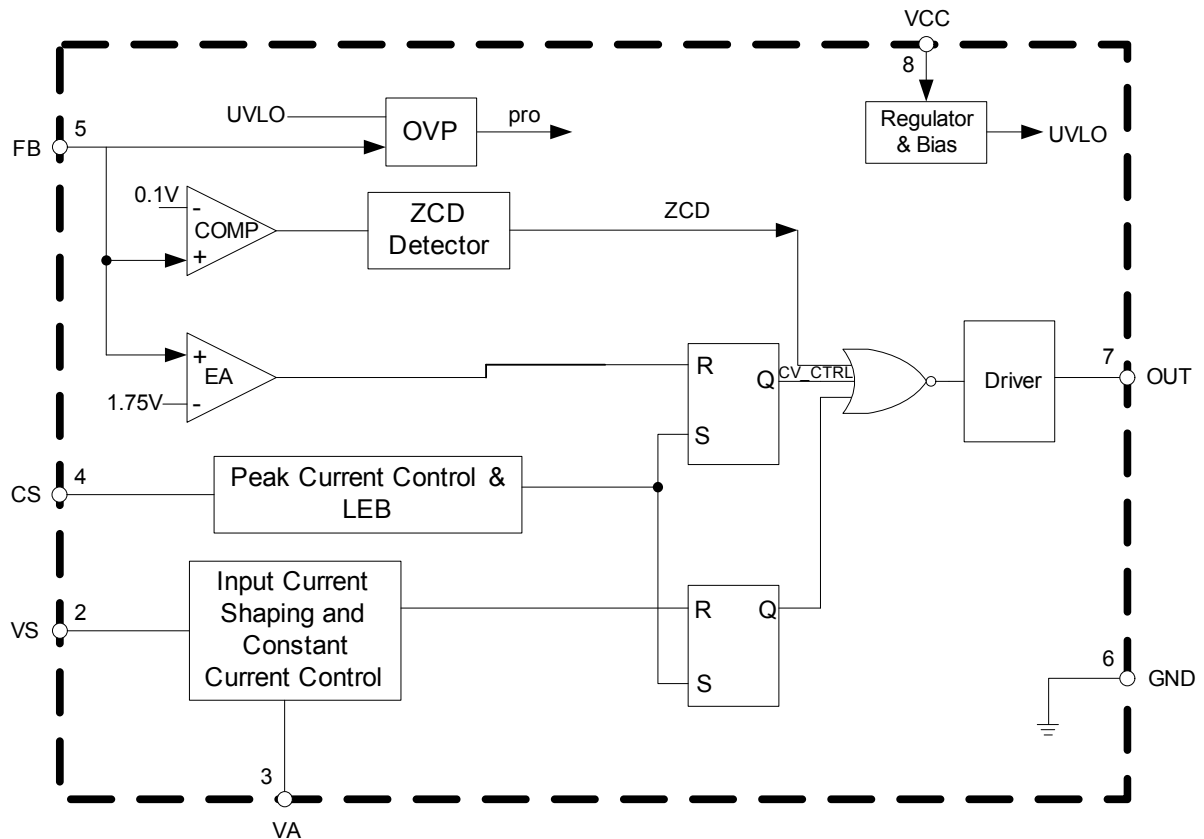
**Typical Applications Circuit**



## Pin Descriptions

| Pin Number | Pin Name | Function  |
|------------|----------|---|
| 1          | NC       | No connection   |
| 2          | VS       | Detects the negative terminal voltage of output.                      |
| 3          | VA       | Detects the average value of the negative terminal voltage of output. |
| 4          | CS       | Primary current sensing   |
| 5          | FB       | The feedback voltage sensing from the auxiliary winding               |
| 6          | GND      | Ground  |
| 7          | OUT      | Gate driver output  |
| 8          | VCC      | Supply voltage of gate driver and control circuits of the IC          |

## 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>                                     | Power Supply Voltage                       | -0.3 to 40  | V    |
| I <sub>OUT</sub>                                    | Driver Output Current                      | 300         | mA   |
| V <sub>VS</sub> , V <sub>VA</sub> , V <sub>CS</sub> | Voltage at VS, VA, CS to GND               | -0.3 to 7   | V    |
| V <sub>FB</sub>                                     | FB Input Voltage                           | -40 to 10   | V    |
| T <sub>J</sub>                                      | Operating Junction Temperature             | +150        | °C   |
| T <sub>STG</sub>                                    | Storage Temperature                        | -65 to +150 | °C   |
| T <sub>LEAD</sub>                                   | Lead Temperature (Soldering, 10 sec)       | +300        | °C   |
| P <sub>D</sub>                                      | Power Dissipation (T <sub>A</sub> = +50°C) | 0.65        | W    |
| θ <sub>JA</sub>                                     | Thermal Resistance (Junction to Ambient)   | 190         | °C/W |
| –   | ESD (Human Body Model)                     | 3000        | V    |
| –   | ESD (Machine Model)                        | 200         | V    |

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**

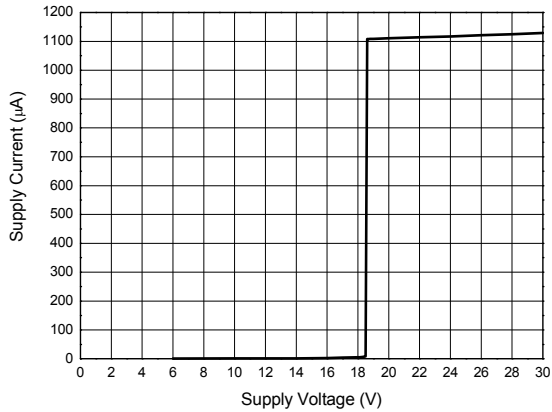
| Symbol          | Parameter            | Min | Max  | Unit |
|-----------------|----------------------|-----|------|------|
| V <sub>CC</sub> | Power Supply Voltage | 12  | 21   | V    |
| T <sub>A</sub>  | Ambient Temperature  | -40 | +105 | °C   |

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

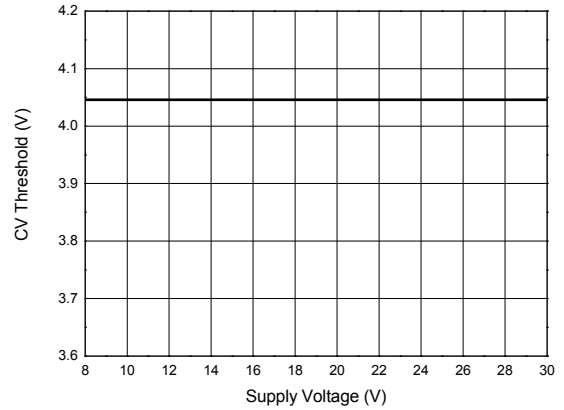
| Symbol                                     | Parameter                        | Conditions  | Min | Typ  | Max  | Unit |
|--|----------------------------------|---|-----|------|------|------|
| <b>UVLO Section</b>                        |                                  |   |     |      |      |      |
| V <sub>TH</sub> (ST)                       | Start-up Threshold               | –   | 18  | 19   | 20   | V    |
| V <sub>OPR</sub> (Min)                     | Minimum Operating Voltage        | After turn on   | 7   | 8    | 9    | V    |
| V <sub>CC_OVP</sub>                        | VCC OVP Voltage                  | –   | 28  | 32   | 36   | V    |
| <b>Standby Current Section</b>             |                                  |   |     |      |      |      |
| I <sub>ST</sub>                            | Start-up Current                 | V <sub>CC</sub> = V <sub>TH</sub> (ST)-0.5V,<br>Before start up       | –   | –    | 20   | μA   |
| I <sub>CC</sub> (OPR)                      | Operating Current                | Static  | –   | 1000 | 1300 | μA   |
| <b>Drive Output Section</b>                |                                  |   |     |      |      |      |
| V <sub>OH</sub>                            | Output High Level Voltage        | I <sub>GD_SOURCE</sub> = 20mA<br>V <sub>CC</sub> = 12V                | 10  | –    | –    | V    |
| V <sub>OL</sub>                            | Output Low Level Voltage         | I <sub>GD_SINK</sub> = 20mA<br>V <sub>CC</sub> = 12V                  | –   | –    | 1    | V    |
| t <sub>R</sub>                             | Output Voltage Rise Time         | C <sub>L</sub> = 1nF  | 100 | 140  | 190  | ns   |
| t <sub>F</sub>                             | Output Voltage Fall Time         | C <sub>L</sub> = 1nF  | 30  | 60   | 90   | ns   |
| V <sub>O_CLAMP</sub>                       | Output Clamp Voltage             | I <sub>GD_SOURCE</sub> = 5mA<br>V <sub>CC</sub> = 20V                 | 12  | 13.5 | 15   | V    |
| V <sub>UVLO</sub>                          | UVLO Saturation Voltage          | V <sub>CC</sub> = 0 to V <sub>CC_ON</sub><br>I <sub>SINK</sub> = 10mA | –   | –    | 1.1  | V    |
| <b>Current Sense Section</b>               |                                  |   |     |      |      |      |
| t <sub>ON</sub> (Min)                      | Minimum On Time                  | –   | 500 | 1000 | 1500 | ns   |
| V <sub>SOCP</sub>                          | Short Circuit Protection Voltage | –   | 3   | 4    | –    | V    |
| <b>Feedback Input Section</b>              |                                  |   |     |      |      |      |
| I <sub>FB</sub>                            | FB Pin Input Leakage Current     | V <sub>FB</sub> = 4V  | –   | 2    | 8    | μA   |
| V <sub>FB</sub> (CV)                       | CV Threshold                     | –   | 3.8 | 4.0  | 4.2  | V    |
| V <sub>FB</sub> (OVP)                      | Over Voltage Protection          | –   | 4.5 | 6    | 7.5  | V    |
| <b>VS Input Section</b>                    |                                  |   |     |      |      |      |
| V <sub>VS</sub> /V <sub>VA</sub> (Max)     | Maximum Ratio                    | V <sub>VS</sub> = V <sub>VA</sub> = 3V                                | 0.8 | 1    | 1.2  | V    |
| V <sub>VS</sub> /V <sub>VA</sub> (Min)     | Minimum Ratio                    | V <sub>VS</sub> = 0V, V <sub>VA</sub> = 3V                            | –   | –    | 0.2  | V    |
| <b>Over Temperature Protection Section</b> |                                  |   |     |      |      |      |
| –  | Shutdown Temperature             | –   | –   | +170 | –    | °C   |
| –  | Temperature Hysteresis           | –   | –   | +20  | –    | °C   |

**Performance Characteristics**

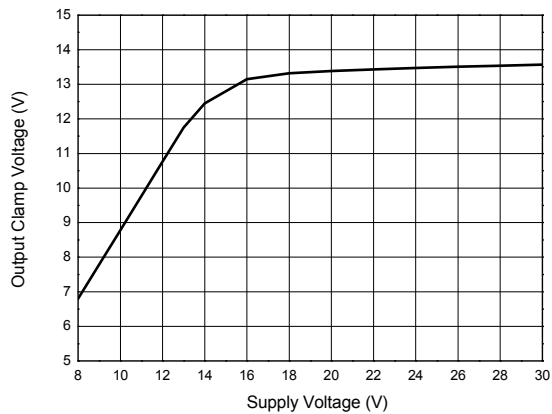
**Supply Current vs. Supply Voltage**



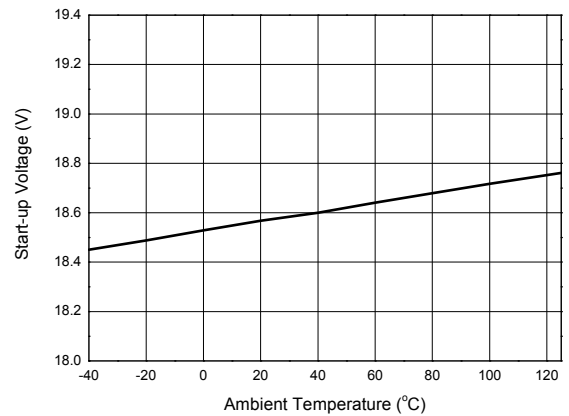
**CV Threshold vs. Supply Voltage**



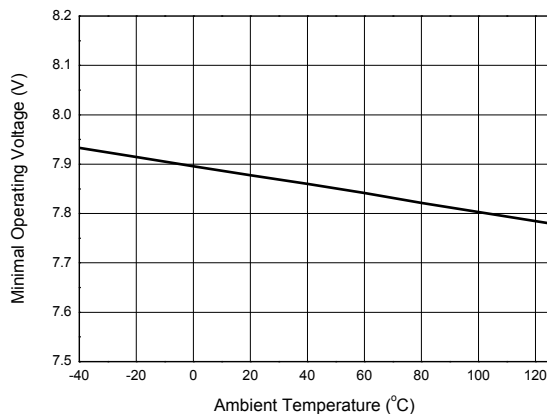
**Output Clamp Voltage vs. Supply Voltage**



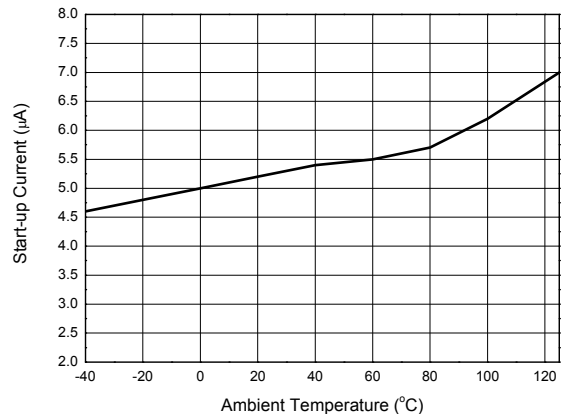
**Start-up Voltage vs. Ambient Temperature**



**Minimal Operating Voltage vs. Ambient Temperature**

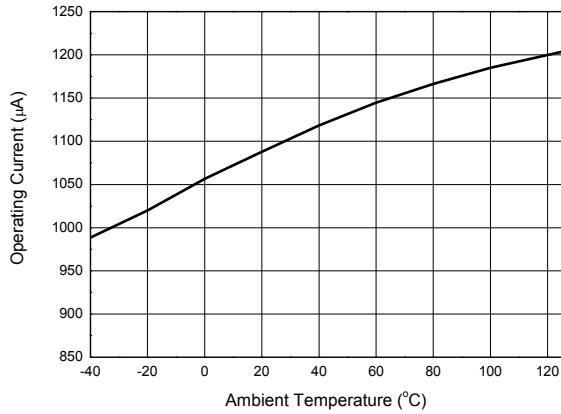


**Start-up Current vs. Ambient Temperature**

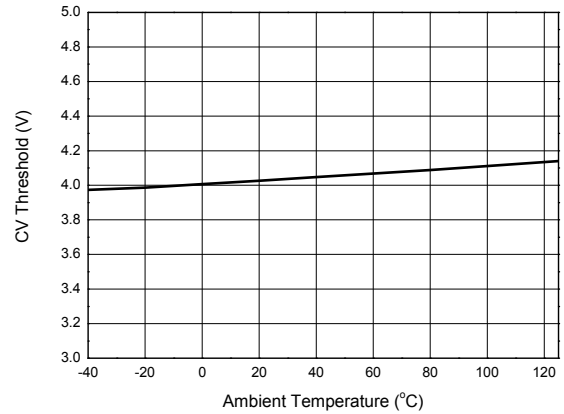


**Performance Characteristics (Cont.)**

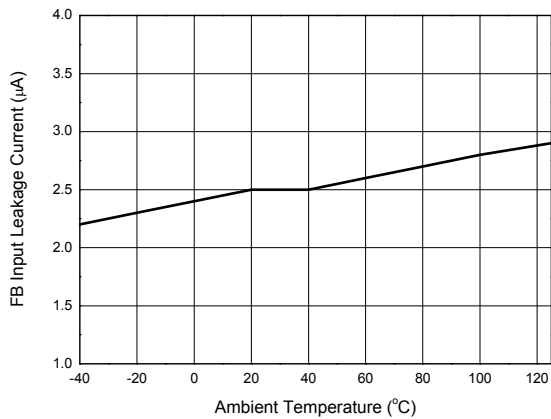
**Operating Current vs. Ambient Temperature**



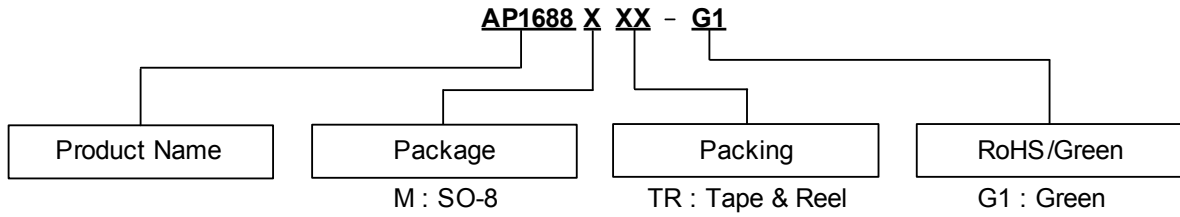
**CV Threshold vs. Ambient Temperature**



**FB Leakage Current vs. Ambient Temperature**



## Ordering Information

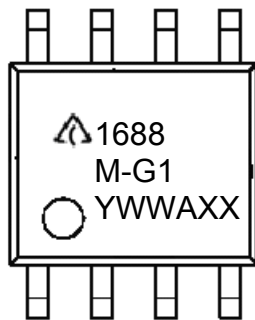


Diodes IC's Pb-free products with "G1" suffix in the part number, are RoHS compliant and green.

| Package | Temperature Range | Part Number  | Marking ID | Packing              |
|---------|-------------------|--------------|------------|----------------------|
| SO-8    | -40 to +105°C     | AP1688MTR-G1 | 1688M-G1   | 4000/13" Tape & Reel |

## Marking Information

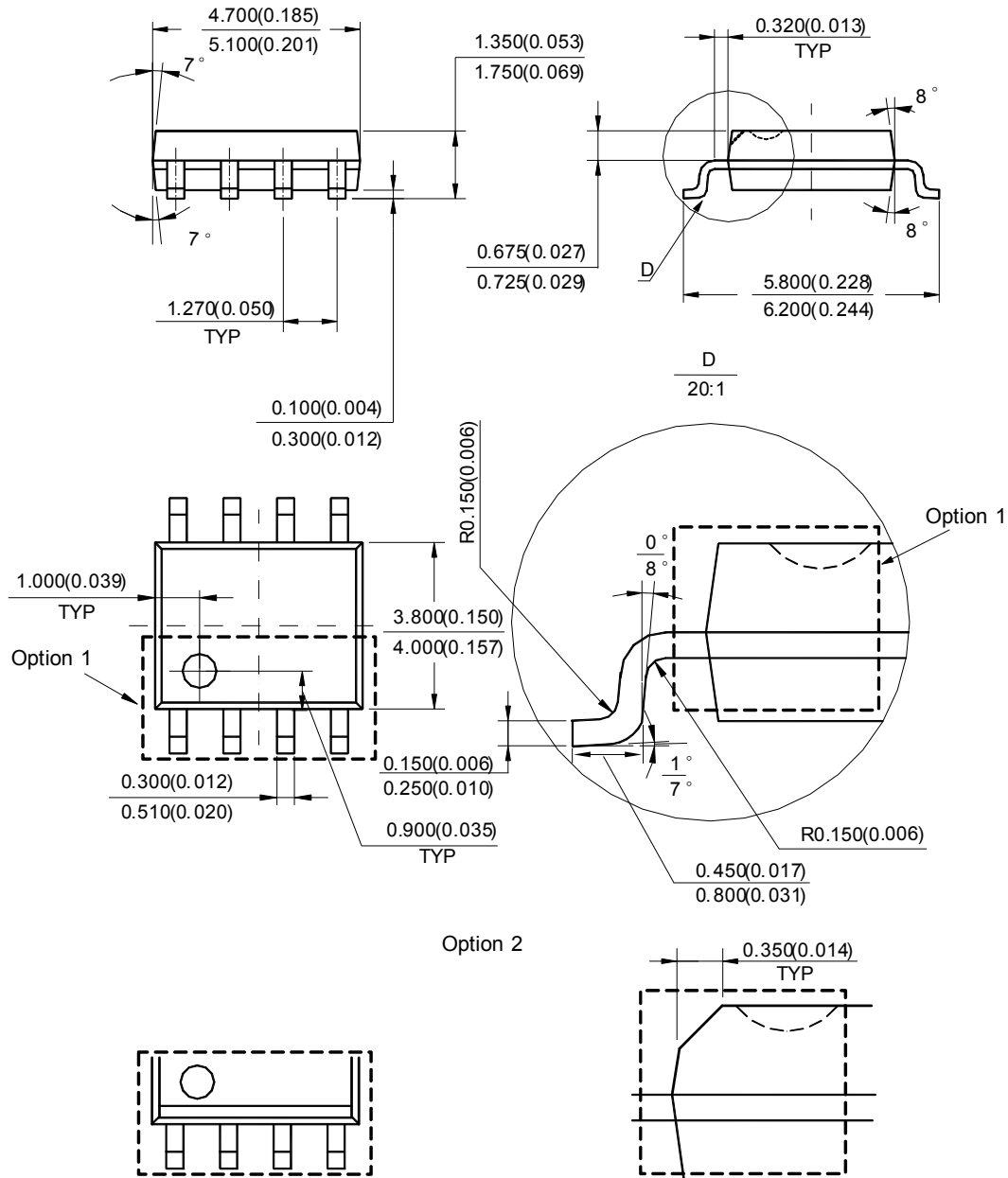
(Top View)



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



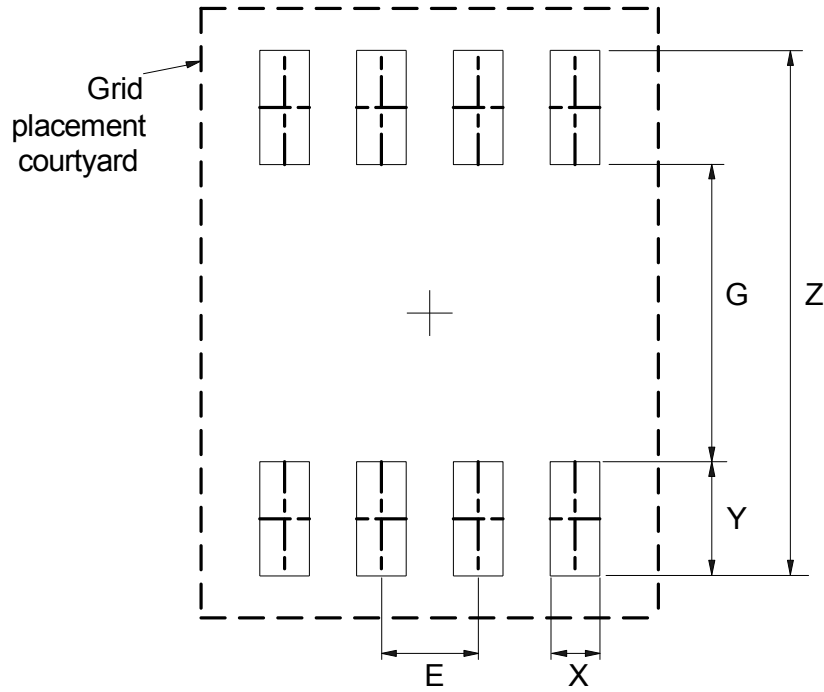
Note: Eject hole, oriented hole and mold mark is optional .

NEW PRODUCT



## Suggested Pad Layout

(1) Package Type: SO-8



| Dimensions | Z<br>(mm)/(inch) | G<br>(mm)/(inch) | X<br>(mm)/(inch) | Y<br>(mm)/(inch) | E<br>(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.

Copyright © 2015, Diodes Incorporated

[www.diodes.com](http://www.diodes.com)