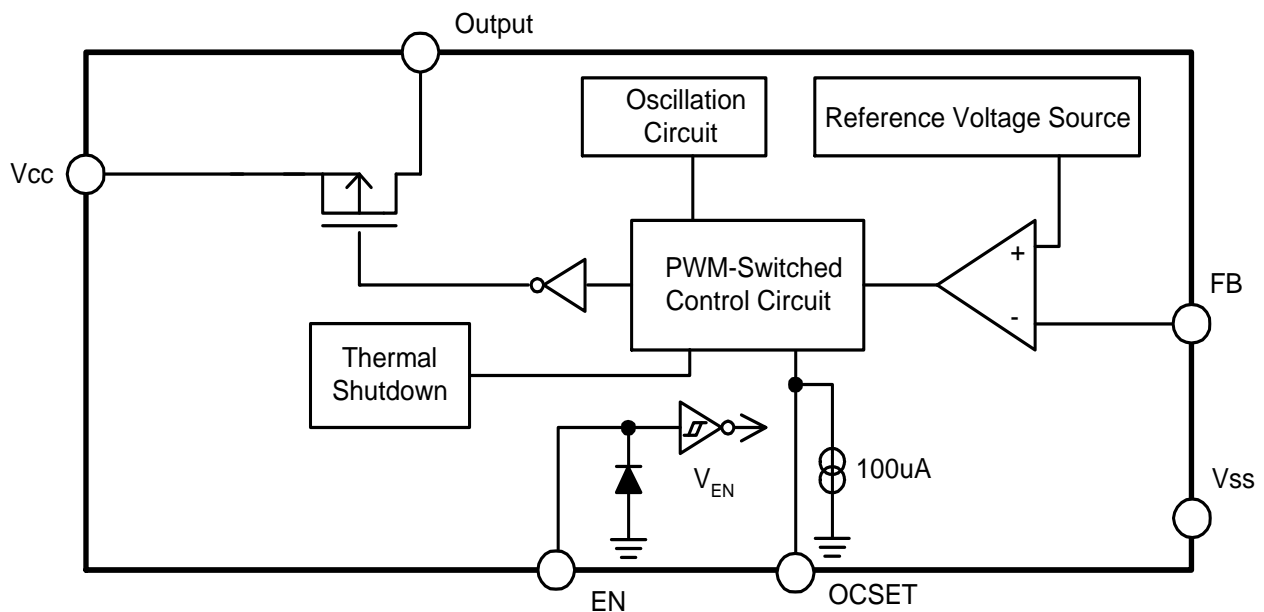


## Pin Descriptions

Pin Number	Pin Name	Description
1	FB	Feedback pin
2	EN	Power-off pin H: Normal operation (Step-down operation) L: Step-down operation stopped (All circuits deactivated)
3	OCSET	Add an external resistor to set max output current
4	V <sub>CC</sub>	IC power supply pin
5, 6	Output	Switch Pin. Connect external inductor/diode here. Minimize trace area at this pin to reduce EMI
7, 8	V <sub>SS</sub>	GND Pin

## Functional Block Diagram



## Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V <sub>CC</sub>	V <sub>CC</sub> Pin Voltage	V <sub>SS</sub> - 0.3 to V <sub>SS</sub> + 20	V
V <sub>FB</sub>	FB Pin Voltage	V <sub>SS</sub> - 0.3 to V <sub>CC</sub>	V
V <sub>EN</sub>	EN Pin Voltage	V <sub>SS</sub> - 0.3 to V <sub>IN</sub> + 0.3	V
V <sub>OUT</sub>	Output Pin Voltage	V <sub>SS</sub> - 0.3 to V <sub>IN</sub> + 0.3	V
P <sub>D</sub>	Power Dissipation	Internally Limited	mW
T <sub>J</sub>	Operating Junction Temperature Range	-40 to +125	°C
T <sub>ST</sub>	Storage Temperature Range	-40 to +150	°C

Caution: The absolute maximum ratings are rated values exceeding which the product could suffer physical damage. These values must therefore not be exceeded under any conditions.

## Recommended Operating Conditions

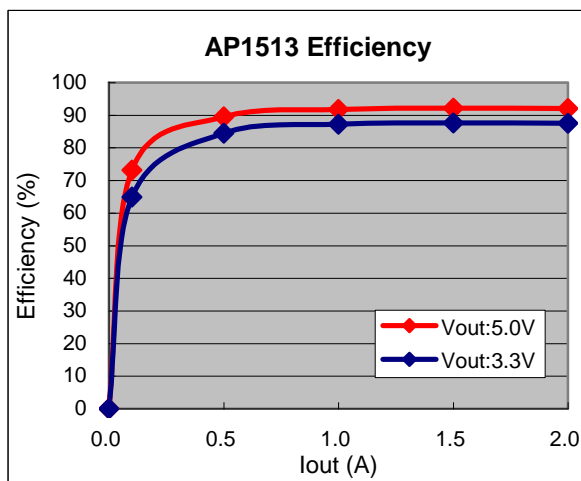
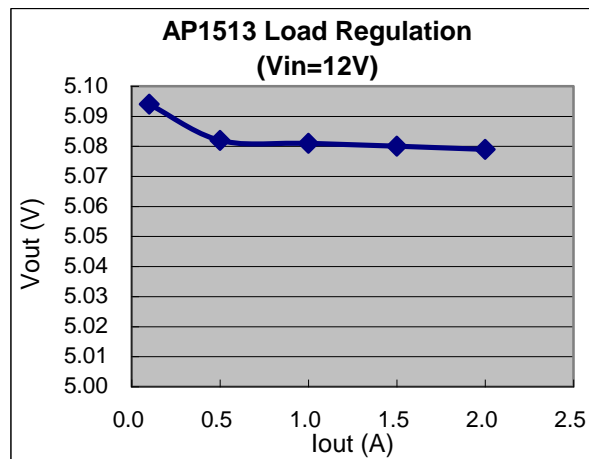
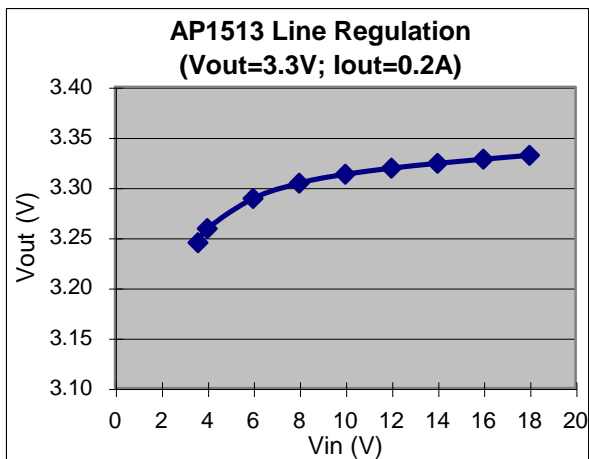
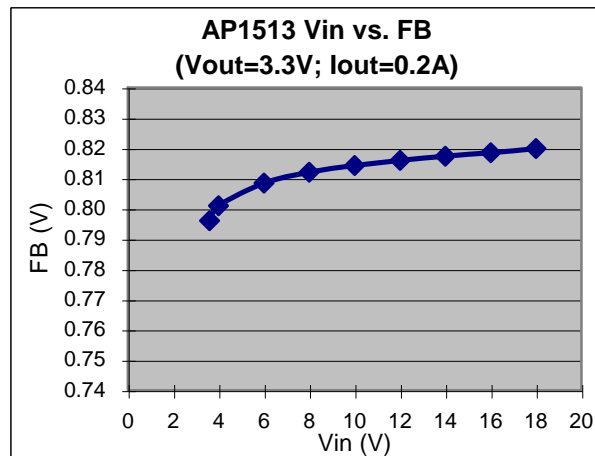
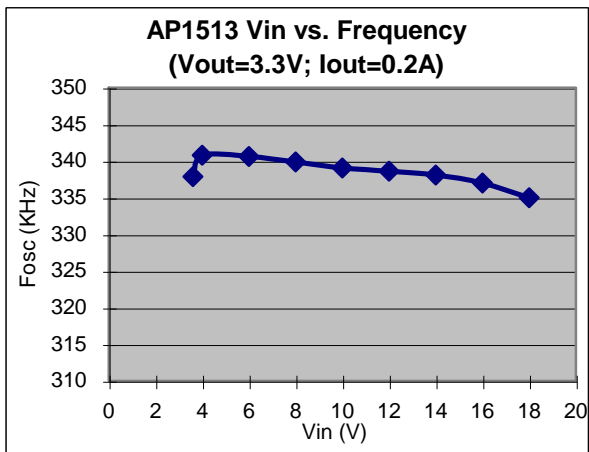
Symbol	Parameter	Min	Max	Unit
$V_{IN}$	Input Voltage	3.6	18	V
$I_{OUT}$	Output Current	0	2	A
$T_A$	Operating Ambient Temperature	-20	+85	°C

## Electrical Characteristics ( $V_{IN} = 12V$ , $T_A = +25^{\circ}C$ , unless otherwise specified.)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Unit
$V_{FB}$	Feedback Voltage	$I_{OUT} = 0.1A$	0.784	0.8	0.816	V
$I_{FB}$	Feedback Bias Current	$I_{OUT} = 0.1A$	—	0.1	0.5	$\mu A$
$I_{SW}$	Switch Current	—	2.5	—	—	A
$I_{SSS}$	Current Consumption During Power Off	$V_{EN} = 0V$	—	10	—	$\mu A$
$\Delta V_{OUT} / V_{OUT}$	Line Regulation	$V_{IN} = 5V$ to $18V$	—	1	2	%
$\Delta V_{OUT} / V_{OUT}$	Load Regulation	$I_{OUT} = 0.1$ to $2A$	—	0.2	0.5	%
$f_{OSC}$	Oscillation Frequency	Measure waveform at Output pin	240	300	400	kHz
$f_{OSC1}$	Frequency of Current Limit or Short Circuit Protect	Measure waveform at Output pin	10	—	—	kHz
$V_{SH}$	EN Pin Input Voltage	Evaluate oscillation at Output pin	2.0	—	—	V
$V_{SL}$		Evaluate oscillation stop at Output pin	—	—	0.8	
$I_{SH}$	EN Pin Input Leakage Current	—	—	20	—	$\mu A$
$I_{SL}$		—	—	-10	—	$\mu A$
$I_{OCSET}$	OCSET Pin Bias Current	—	75	90	105	$\mu A$
$t_{SS}$	Soft-Start Time	—	0.3	2	5	ms
$R_{DS(on)}$	Internal MOSFET $R_{DS(on)}$	$V_{IN} = 5V$ , $V_{FB} = 0V$	—	110	150	m $\Omega$
		$V_{IN} = 12V$ , $V_{FB} = 0V$	—	70	100	
EFFI	Efficiency	$V_{IN} = 12V$ , $V_{OUT} = 5V$ $I_{OUT} = 2A$	—	92	—	%
$\theta_{JA}$	Thermal Resistance Junction-to-Ambient	SO-8 (Note 4)	—	134	—	°C/W
$\theta_{JC}$	Thermal Resistance Junction-to-Case	SO-8 (Note 4)	—	22	—	°C/W

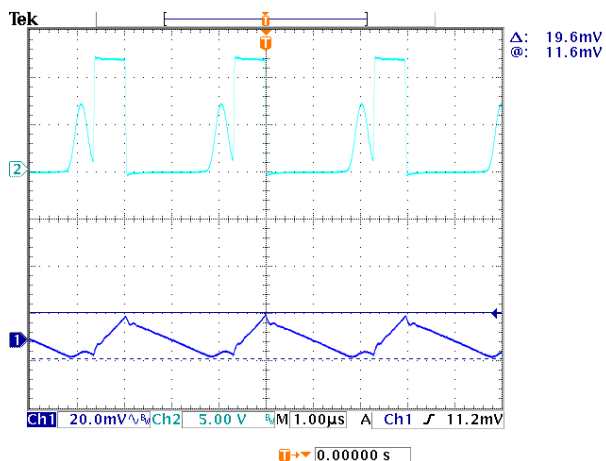
Note: 4. Test conditions: Device mounted on FR-4 PCB, 2"×2", 2oz copper minimum recommended pad layout, single-sided, PC boards.

## Performance Characteristics

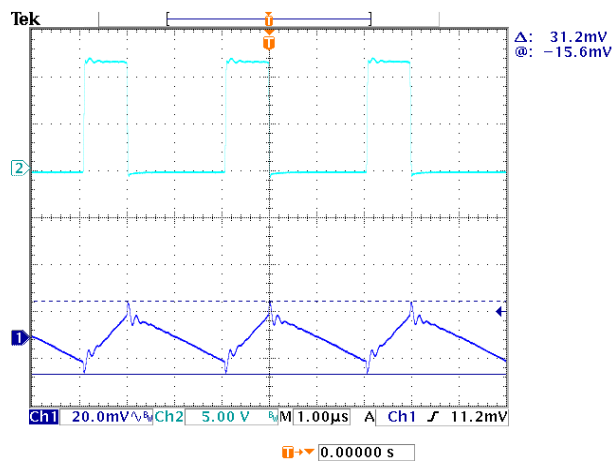


## Performance Characteristics (Cont.)

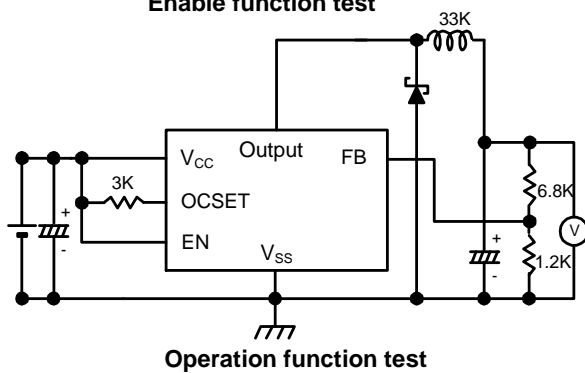
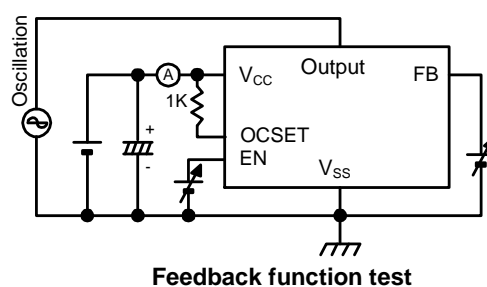
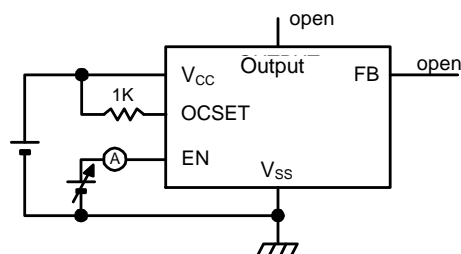
**AP1513  $V_{out}$  Ripple**  
( $V_{in} = 12V$ ;  $V_{out} = 3.3V$ ;  $I_{out} = 0.1A$ )



**AP1513  $V_{out}$  Ripple**  
( $V_{in} = 12V$ ;  $V_{out} = 3.3V$ ;  $I_{out} = 2A$ )



## Test Circuit



## Functional Description

### PWM Control

The AP1513 is a DC/DC converter that employs pulse width modulation (PWM) scheme. Its pulse width varies in the range of 0% to 99%, based on the output current loading. The output ripple voltage caused by the PWM high frequency switching can easily be reduced through an output filter. Therefore, this converter provides a low ripple output supply over a broad range of input voltage & output current loading.

### Under Voltage Lockout

The under voltage lockout circuit of the AP1513 assures that the high-side MOSFET driver remains in the off state whenever the supply voltage drops below 3.3V. Normal operation resumes once  $V_{CC}$  rises above 3.5V.

### Current Limit Protection

The current limit threshold is set by external resistor  $R_{OCSET}$  connected from  $V_{CC}$  supply to OCSET pin. The internal sink current  $I_{OCSET}$  (90 $\mu$ A typical) across this resistor sets the voltage at OCSET pin. When the PWM voltage is less than the voltage at OCSET, an over-current condition is triggered.

The current limit threshold is given by the following equation:

$$I_{PEAK} \times R_{DS(ON)} = I_{OCSET} \times R_{OCSET}$$

$$I_{PEAK} > I_{OUT(MAX)} + \frac{(\Delta I)}{2}$$

where,

$$\Delta I = \frac{V_{IN} - V_{OUT}}{f_s \times L} \times \frac{V_{OUT}}{V_{IN}}$$

$I_{PEAK}$  is the output peak current;  $R_{DS(ON)}$  is the MOSFET ON resistance;  $f_s$  is the PWM frequency (300kHz typical). Also, the inductor value will affect the ripple current  $\Delta I$ .

The above equation is recommended for input voltage range of 5V to 18V. For input voltage lower than 5V or ambient temperature over +100°C, higher  $R_{OCSET}$  is recommended.

### Inductor Selection

For most designs, the operation range with inductors is from 22 $\mu$ H to 33 $\mu$ H. The inductor value can be derived from the following equation:

$$L = \frac{V_{IN} - V_{OUT}}{f_s \times \Delta I} \times \frac{V_{OUT}}{V_{IN}}$$

Where  $\Delta I_L$  is inductor Ripple Current. Large value inductors lower ripple current and small value inductors result in high ripple current. Choose inductor ripple current approximately 15% of the maximum load current 2A,  $\Delta I_L = 0.30A$ . The DC current rating of the inductor should be at least equal to the maximum load current plus half the ripple current to prevent core saturation (2A+0.15A).

### Input Capacitor Selection

This capacitor should be located close to the IC using short leads and the voltage rating should be approximately 1.5 times the maximum input voltage. The RMS current rating requirement for the input capacitor of a buck regulator is approximately 1/2 the DC load current. A low ESR input capacitor sized for maximum RMS current must be used. A 470 $\mu$ F low ESR capacitor for most applications is sufficient.

### Output Capacitor Selection

The output capacitor is required to filter the output voltage and provides regulator loop stability. The important capacitor parameters are the 100kHz Equivalent Series Resistance (ESR), the RMS ripples current rating, voltage rating and capacitance value. For the output capacitor, the ESR value is the most important parameter. The output ripple can be calculated from the following formula.

## Functional Description (Cont.)

$$V_{\text{RIPPLE}} = \Delta I_L \times \text{ESR}$$

The bulk capacitor's ESR will determine the output ripple voltage and the initial voltage drop after a high slew-rate transient.

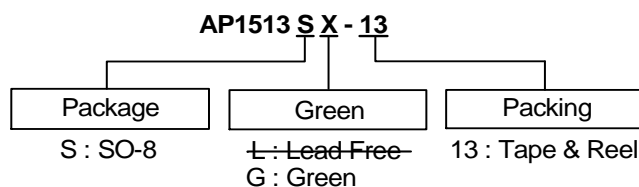
An aluminum electrolytic capacitor's ESR value is related to the capacitance and its voltage rating. In most case, higher voltage electrolytic capacitors have lower ESR values. Most of the time, capacitors with much higher voltage ratings may be needed to provide the low ESR values required for low output ripple voltage.

### PCB Layout Guide

If you need low  $T_C$  &  $T_J$  or large  $P_D$  (Power Dissipation), the dual Output pins (5 & 6) and  $V_{SS}$  pins (7 & 8) on the SO-8 package are internally connected to die pad, The evaluation board should be allowed for maximum copper area at output pins.

1. Connect FB circuits as closely as possible and keep away from inductor flux for pure  $V_{FB}$ .
2. Connect input capacitor to  $V_{CC}$  and  $V_{SS}$  pin as closely as possible to get good power filter effect.
3. Connect  $R_{OCSET}$  to  $V_{CC}$  and OCSET pin as closely as possible.
4. Connect ground side of the input capacitor & Schottky & output capacitor as closely as possible and use ground plane for best performance.

## Ordering Information



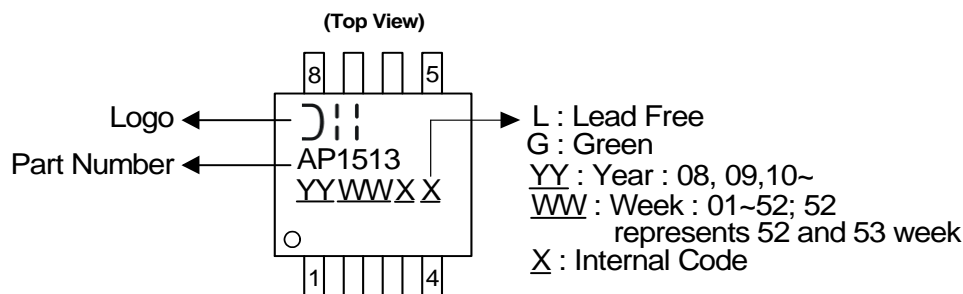
Device (Note 5)	Package Code	Package (Note 6)	Green	Quantity	Part Number Suffix		Status (Note 5)
					Tube	13" Tape and reel	
AP1513SG-13	S	SO-8	Green	2500	NA	-13	In production

Notes: 5. All Lead-Free variants are End of life without replacement.

6. For packaging details, go to our website at: <https://www.diodes.com/design/support/packaging/diodes-packaging/diodes-package-outlines-and-pad-layouts/>.

## Marking Information (Note 5)

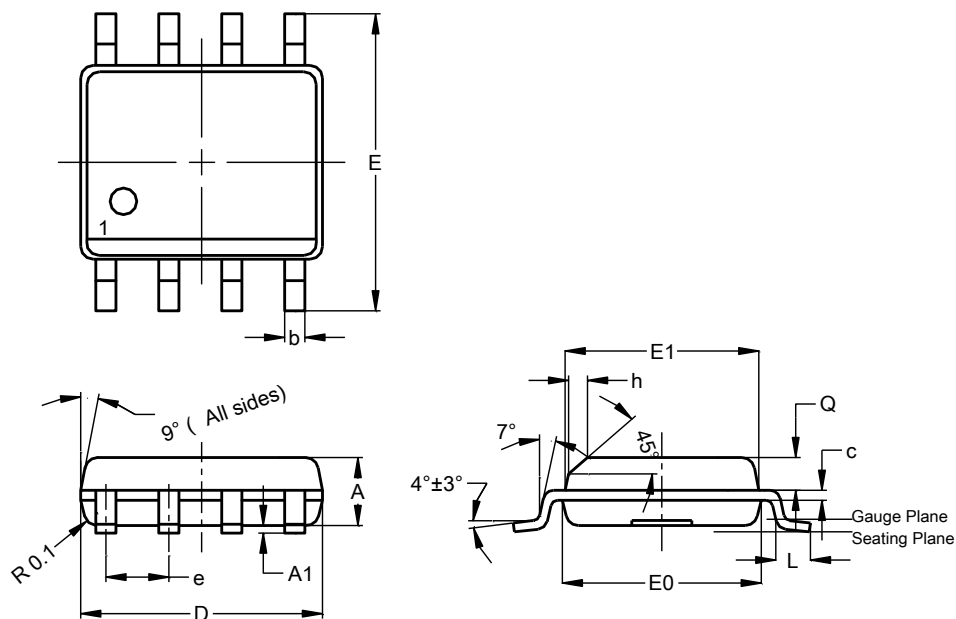
### (1) SO-8



## Package Outline Dimensions

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

### SO-8

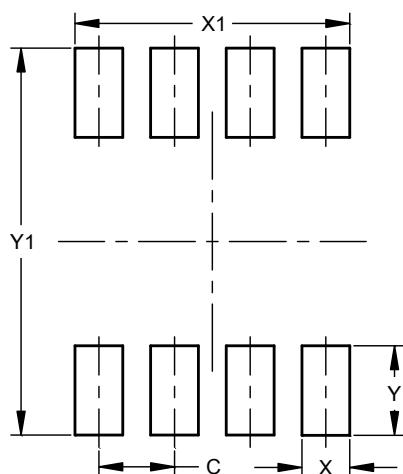


SO-8			
Dim	Min	Max	Typ
A	1.40	1.50	1.45
A1	0.10	0.20	0.15
b	0.30	0.50	0.40
c	0.15	0.25	0.20
D	4.85	4.95	4.90
E	5.90	6.10	6.00
E1	3.80	3.90	3.85
E0	3.85	3.95	3.90
e	--	--	1.27
h	-	--	0.35
L	0.62	0.82	0.72
Q	0.60	0.70	0.65
All Dimensions in mm			

## Suggested Pad Layout

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

### SO-8



Dimensions	Value (in mm)
C	1.27
X	0.802
X1	4.612
Y	1.505
Y1	6.50

#### 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 © 2017, Diodes Incorporated

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