

SECONDARY SIDE SYNCHRONOUS RECTIFICATION SWITCHER

Description

The DIODES™ APR34709 is a secondary side Combo IC, which combines an N-Channel MOSFET and a driver circuit designed for Synchronous Rectification (SR), supports DCM and Quasi-Resonant Flyback Topologies.

The N-Channel MOSFET is optimized for low gate charge, low $R_{DS(ON)}$, fast switching speed and body diode reverse recovery performance.

The synchronous rectification can effectively reduce the secondary side rectifier power dissipation and provide high performance solution. By sensing MOSFET drain-to-source voltage, the APR34709 can output ideal drive signal with less external components.

It can provide high performance solution for 3.3V to 15V output voltage application.

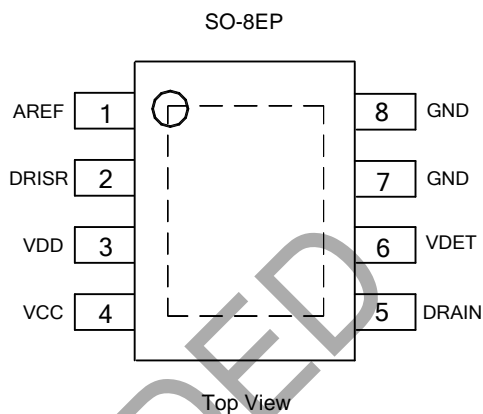
The APR34709 is available in SO-8EP package.

Features

- Synchronous Rectification for DCM Operation Flyback
- Eliminate Resonant Ring Interference
- Fast Detector of Supply Voltages
- Fewest External Components
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/104/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please [contact us](#) or your local Diodes representative. <https://www.diodes.com/quality/product-definitions/>**

- Notes:
1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
 2. See <https://www.diodes.com/quality/lead-free/> 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

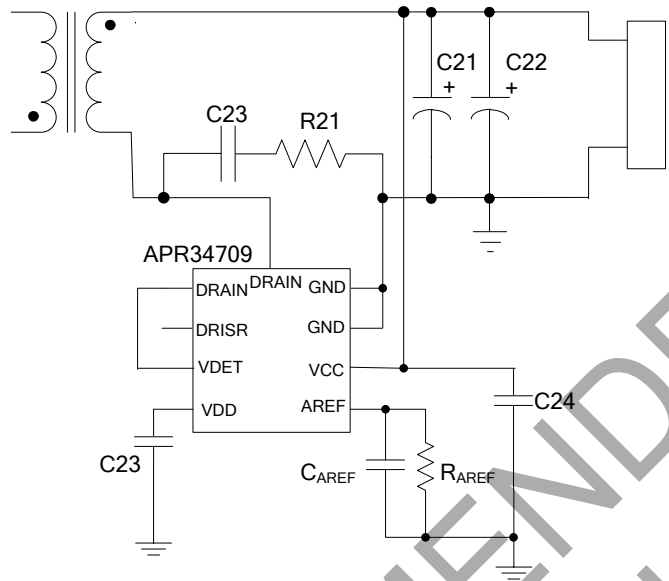


Note: The DRAIN pin of internal MOSFET is exposed PAD, which is at the bottom of IC (the dashed box). The secondary current should flow from GND (pins 7 and 8) to this exposed PAD.

Applications

- Adapters/chargers for cell/cordless phones, ADSL modems, MP3 and other portable apparatus
- Standby and auxiliary power supplies

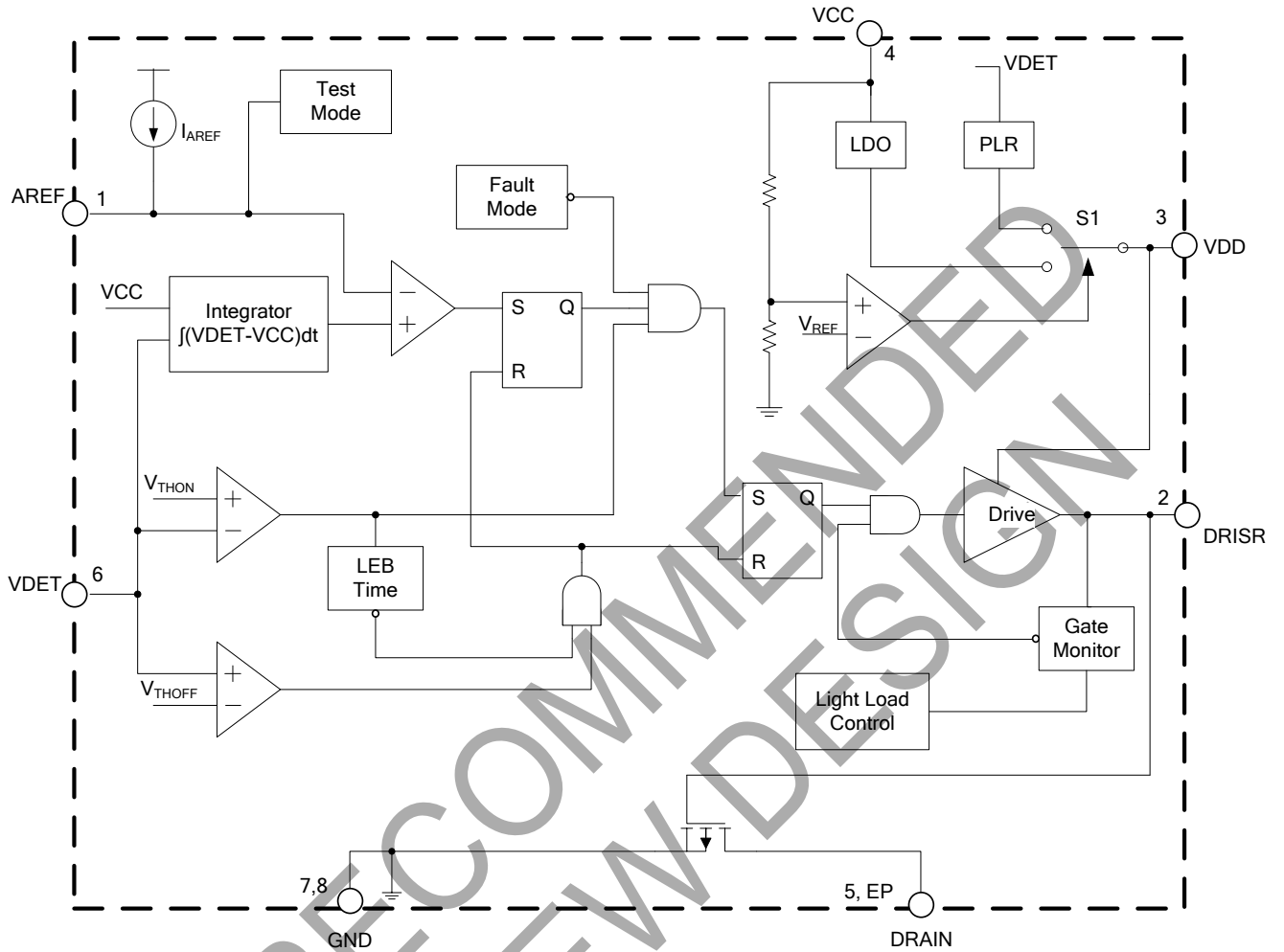
Typical Applications Circuit



Pin Descriptions

Pin Number	Pin Name	Function
1	AREF	Program a voltage reference with a resistor from AREF to GND, to enable synchronous rectification MOSFET drive signal.
2	DRISR	Synchronous rectification MOSFET drive.
3	VDD	Internal power supply. It provides bias voltage for the internal logic circuit and the MOSFET driver. Connect this pin to a capacitor.
4	VCC	Power supply, connected with system output. Input of internal LDO and system output voltage sensing circuit.
5	DRAIN	Drain pin of internal MOSFET. The drain voltage signal can be obtained from this pin.
6	VDET	Synchronous rectification sense input and dynamic function output, connected to DRAIN through a resistor.
7, 8	GND	Source pin of internal MOSFET, connected to Ground.
Exposed PAD	DRAIN	Drain pin of internal MOSFET. The secondary current should flow from GND (pins 7 and 8) to this DRAIN pad.

Functional Block Diagram



NOT RECOMMENDED FOR NEW DESIGN

Absolute Maximum Ratings (Note 4)

Symbol	Parameter	Value	Unit
V _{CC}	Supply Voltage	-0.3 to 28	V
V _{DET} , V _{DRAIN}	Voltage at V _{DET} , DRAIN Pins (Note 5)	-2 to 60	V
V _{AREF} , V _{DRISR}	Voltage at AREF, DRISR Pins	-0.3 to 7	V
I _D	Continuous Drain Current	20	A
I _{DM}	Pulsed Drain Current	80	A
P _D	Power Dissipation at T _A = +25°C	2.2	W
θ _{JA}	Thermal Resistance (Junction to Ambient) (Note 6)	54	°C/W
θ _{JC}	Thermal Resistance (Junction to Case) (Note 6)	11	°C/W
T _J	Operating Junction Temperature	+150	°C
T _{STG}	Storage Temperature	-65 to +150	°C
T _{LEAD}	Lead Temperature (Soldering, 10s)	+300	°C

- Notes:
4. Stresses greater than those listed under *Absolute Maximum Ratings* can 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 can affect device reliability.
 5. V_{DET} pin is ESD sensitive.
 6. Test condition: Device mounted on FR-4 substrate PC board, 2oz copper, with 1inch² cooling area.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V _{CC}	Supply Voltage	3.3	16	V
T _A	Ambient Temperature	-40	+85	°C

NOT RECOMMENDED FOR NEW DESIGN

Electrical Characteristics (@T_A = +25°C, V_{CC} = 5V, unless otherwise specified.)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
Supply Voltage (VCC Pin)						
I _{STARTUP}	Startup Current	V _{CC} = V _{STARTUP} -0.1V	—	150	—	μA
I _{OP}	Operating Current	V _{DET} Pin Floating V _{CC} = 5V	—	150	—	μA
V _{STARTUP}	Startup Voltage	—	—	2.4	—	V
V _{UVLO}	UVLO Voltage	—	—	2.2	—	V
V _{DD_ENABLE}	VDD Enable Falling Threshold at VCC Pin	—	—	4.6	—	V
V _{DD_DISABLE}	VDD Disable Rising Threshold at VCC Pin	—	—	4.75	—	V
V _{DD_HYS}	VDD Disable Hysteresis at VCC Pin	—	—	150	—	mV
VDD Pin						
V _{DD_MAX}	Internal Power Supply	—	—	5.5	—	V
Gate Driver						
V _{THON}	Gate Turn On Threshold	—	0	—	1	V
V _{THOFF}	Gate Turn Off Threshold	—	—	—	0	mV
t _{DON}	Turn On Delay Time	From V _{THON} to V _{DRISS} = 1V	—	70	180	ns
t _{DOFF}	Turn Off Propagation Delay Time	From V _{THOFF} to V _{DRISS} = 4V	—	100	150	ns
t _{RG}	Turn On Rising Time	From 1V to 4V, V _{CC} = 5V C _L = 4.7nF	—	50	100	ns
t _{FG}	Turn Off Falling Time	From 4V to 1V, V _{CC} = 5V C _L = 4.7nF	—	20	100	ns
t _{ON_MIN}	Minimum On Time	—	1.2	1.6	2	μs
t _{OFF_MIN}	Minimum Off Time	—	—	2	—	μs
V _{DRISS}	SR Drive Voltage	V _{CC} < 4.6V	—	—	V _{DD} -0.1	V
		4.75V < V _{CC} < 5.5V	—	—	V _{CC} -0.1	
		V _{CC} > 5.5V	—	—	V _{DD_MAX} -0.1	
K _{qs}	(Note 7)	—	—	0.42	—	mA*μs
V _{S_MIN}	Synchronous Rectification (SR) Minimum Operating Voltage (Note 8)	—	—	—	4.5	V
Green Mode (Note 9)						
t _{LL}	Minimum Off Time to Enter Green Mode	—	—	600	—	μs

Notes: 7. This item is used to specify the value of R_{AREF}.
8. This item specifies the minimum SR operating voltage of V_{IN_DC}, V_{IN_DC} ≥ N_{PS}*V_{S_MIN}.
9. The parameter is guaranteed by design and characterization.

Electrical Characteristics (@T_A = +25°C, unless otherwise specified.) (continued)

MOSFET Static Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V _{DSS(BR)}	Drain to Source Breakdown Voltage	V _{GS} = 0V, I _D = 0.25mA	60	—	—	V
V _{GS(TH)}	Gate Threshold Voltage	V _{DS} = V _{GS} , I _D = 0.25mA	0.7	1.3	2	V
I _{DSS}	Zero Gate Voltage Drain Current	V _{DS} = 60V, V _{GS} = 0V	—	—	1	μA
I _{GSS}	Gate to Source Leakage Current	V _{GS} = 4.5V, V _{DS} = 0V	—	—	±50	μA
R _{DS(ON)}	Drain to Source On-State Resistance	V _{GS} = 4.5V, I _D = 3A	—	8	—	mΩ

MOSFET Dynamic Characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
C _{iss}	Input Capacitance	V _{GS} = 0V, V _{DS} = 25V f = 1MHz	—	1872	—	pF
C _{oss}	Output Capacitance		—	506	—	
C _{rss}	Reverse Transfer Capacitance		—	43	—	
Q _{gs}	Gate to Source Charge	V _{GS} = 0V to 10V, V _{DD} = 25V I _D = 15A	—	3.1	—	nC
Q _{gd}	Gate to Drain Charge (Miller Charge)		—	4.8	—	
Q _g	Total Gate Charge	V _{GS} = 4.5V	—	15	—	
R _g	Gate Resistance	—	—	1.8	—	Ω

NOT RECOMMENDED FOR NEW DESIGN

Synchronous Rectification Principle Description

SR MOSFET Turn On

The APR34709 determines the synchronous rectification MOSFET turning on time by monitoring the MOSFET drain-to-source voltage. When the drain voltage is lower than the turn-on threshold voltage V_{THON} , the IC outputs a positive drive voltage after a turn-on delay time (t_{DON}). The MOSFET will turn on and the current will transfer from the body diode into the MOSFET's channel. Because of parasitic parameter, the voltage on MOSFET drain pin has moderate voltage ringing at this moment, which maybe impact on the V_{DET} voltage and resulting in the turning-off fault. To prevent fault situation from happening, a Minimum On-Time (t_{ONMIN}) blanking period is used to maintain the power MOSFET on for a minimum amount of time.

In Figure 1, the turn on blanking time t_{ONMIN} is to prevent the MOSFET drain-to-source voltage ringing effect.

Turn Off Operation

The DCM operation of the SR is described with timing diagram shown in Figure 1.

In the process of drain current decreasing linearly toward zero, the drain-source voltage rises synchronically. When it rises over the turn off threshold voltage V_{THOFF} , the APR34709 pulls the drive signal down after a turn-off delay (t_{DOFF}).

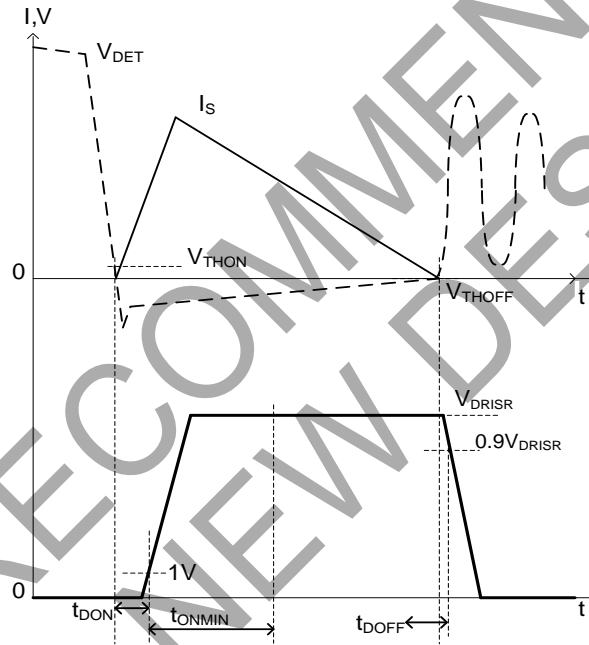


Figure 1. Typical Waveforms of APR34709 in DCM

Synchronous Rectification Principle Description (continued)

Minimum On/Off Time

When the controlled MOSFET gate is turned on, some ringing noise is generated. The minimum on-time timer blanks the V_{THOFF} comparator, keeping the controlled MOSFET on for at least the minimum on time. During the minimum on time, the turn off threshold is totally blanked.

After the SR driver turns off, the SR control block initiates a minimum off time timer during which the SR will remain off to prevent the ringing from turning on the synchronous MOSFET.

The Value and Meaning of AREF Resistor

As to DCM operation Flyback converter, after the secondary rectifier stops conducting, the primary MOSFET drain-to-source ringing waveform results from the resonant of primary inductance and the equivalent output capacitance. This ringing waveform probably leads to Synchronous Rectifier error conduction. To prevent this fault from happening, the APR34709 has a special function design by means of volt-second product detecting. Regarding the sensed voltage of VDET pin, the volt-second product of voltage above V_{CC} at primary switch on time is much higher than that of each cycle ringing voltage above V_{CC} . Therefore, every time before Synchronous Rectifier turns on, the APR34709 judges if the detected volt-second product of VDET voltage above V_{CC} is higher than a threshold and then turns on synchronous Rectifier. The purpose of AREF resistor is to determine the volt-second product threshold. The APR34709 has a parameter, K_{qs} , which converts R_{AREF} value to volt-second product.

$$Area2 = R_{AREF} * K_{qs}$$

In general, the Area1 and Area3 values depend on the system design and are always fixed if the system design is frozen. As to Diodes Incorporated's PSR design, the Area1 value changes with primary peak current value and Area3 value generally keeps constant at all conditions. So the AREF resistor design should consider the worst case, the minimum primary peak current condition. Because of system design parameter distribution, Area1 and Area3 have moderate tolerance. So Area2 should be designed in the middle of Area1 and Area3 to ensure enough design margins.

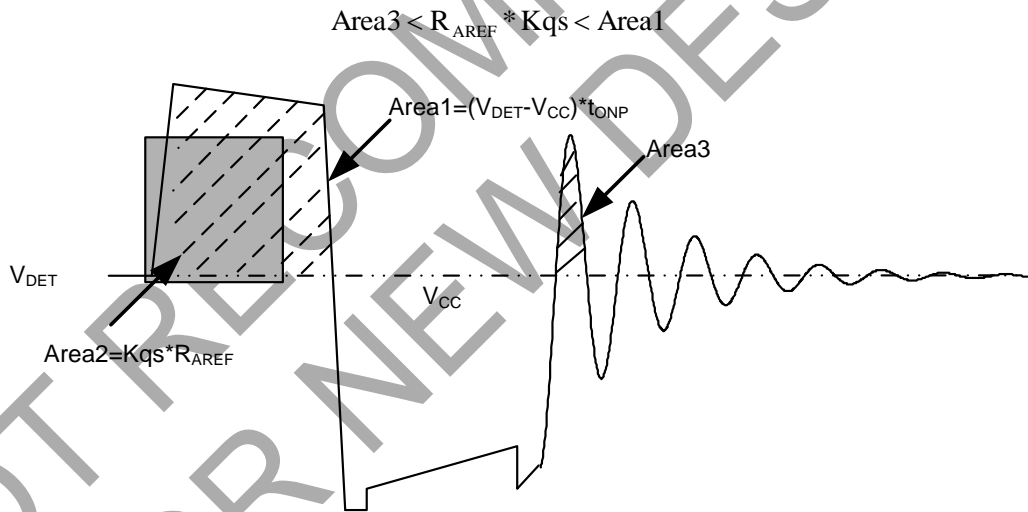


Figure 2. AREF Function

SR Minimum Operating Voltage

The APR34709 sets a minimum SR operating voltage by comparing the difference between V_{DET} and output voltage (V_{CC}). The value of $V_{DET} - V_{CC}$ must be higher than its internal reference, then the APR34709 will begin to integrate the area of $(V_{DET} - V_{CC}) * t_{ONP}$. If not, the area integrating will not begin and the SR driver will be disabled.

Synchronous Rectification Principle Description (continued)

Recommended Application Circuit Parameters

The C_{AREF} is suggested to parallel with the AREF resistor to keep the volt-second product threshold stable. And the recommended value of C_{AREF} is 20nF.

The recommended value of C24 is 100nF. The value of VDD capacitor C23 is 4.7 μ F.

Green Mode at Light Load

When the system is running with light load, rectifier conduction loss no longer dominates the secondary-side power loss, in which condition it is preferred the SR MOSFET keeps off to save the driver loss.

The APR34709 can sense the non-switching duration cycle by cycle, when the non-switching duration keeps longer than the internal light load timing t_{LL} , the IC will shut down the gate driver and keep it off for the next two cycles.

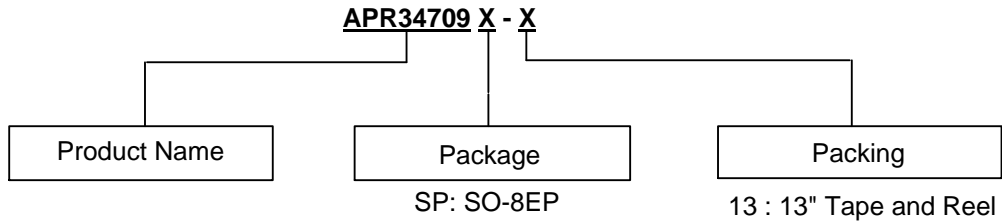
VDD

The VDD is the output of Pulse Linear Regulator and the internal linear regulator. It provides bias voltage for the controller. A capacitor (C23, typical 4.7 μ F) should be connected between the VDD pin and GND pins.

A Pulse Linear Regulator is integrated in the controller to provided voltage to the VDD pin of the APR34709, so that the APR34709 can operate at Constant Current (CC) Mode, in which the system output voltage may drop to as low as 2V. The bias voltage is disabled when system output voltage is higher than 4.75V, in that case the system output provides voltage to VDD pin of the APR34709 through its internal LDO.

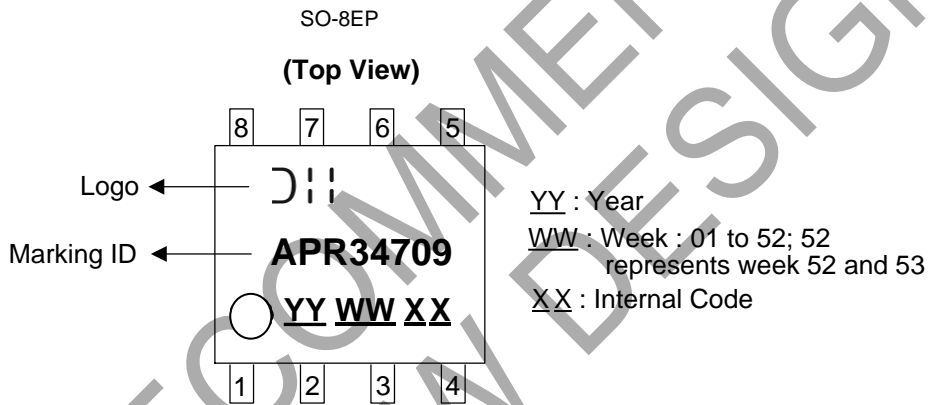
NOT RECOMMENDED
FOR NEW DESIGN

Ordering Information



Part Number	Part Number Suffix	Package	Temperature Range	Marking ID	Packing	
					Qty.	Carrier
APR34709SP-13	-13	SO-8EP	-40 to +85°C	APR34709	4000	13" Tape and Reel

Marking Information

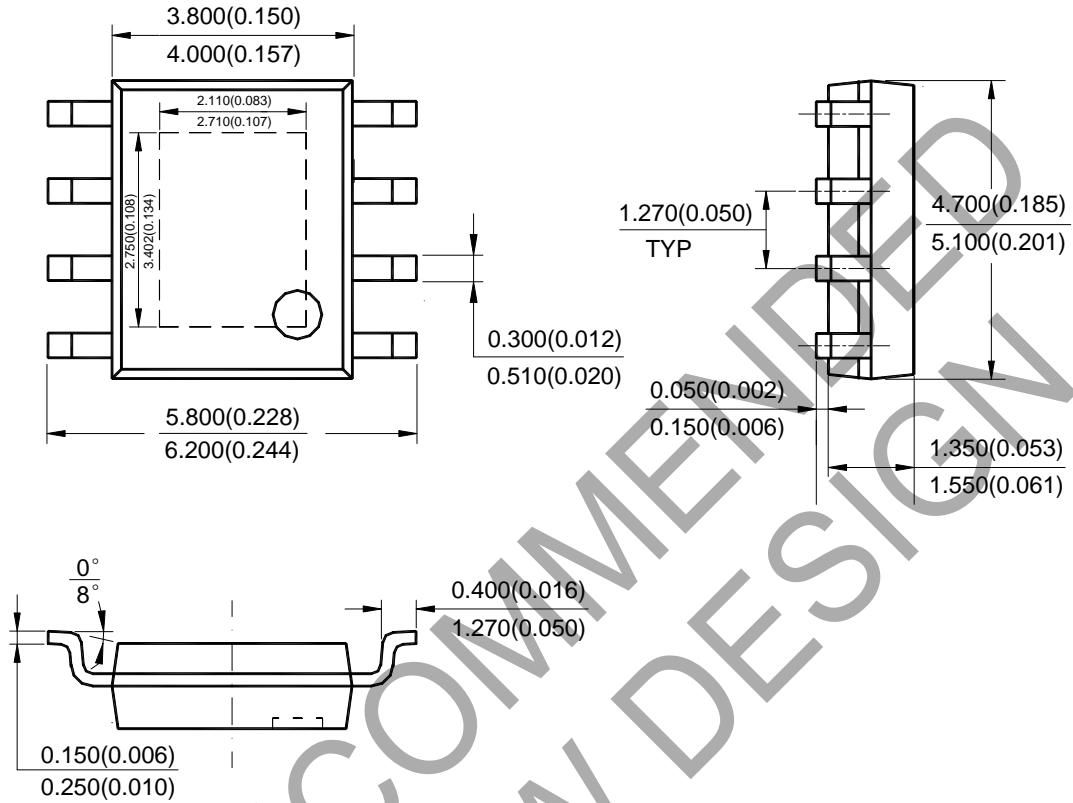


NOT RECOMMENDED FOR NEW DESIGN

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

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

(1) Package Type: SO-8EP



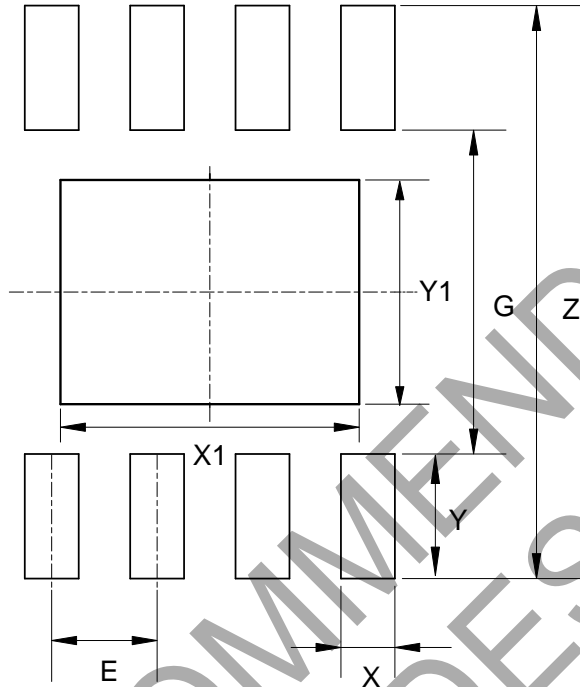
Note: Eject hole, oriented hole and mold mark is optional.

NOT RECOMMENDED FOR NEW DESIGN

Suggested Pad Layout

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

(1) Package Type: SO-8EP



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	X1 (mm)/(inch)	Y1 (mm)/(inch)	E (mm)/(inch)
Value	6.900/0.272	3.900/0.154	0.650/0.026	1.500/0.059	3.600/0.142	2.700/0.106	1.270/0.050

NOT RECOMMENDED FOR NEW DESIGN

IMPORTANT NOTICE

1. DIODES INCORPORATED (Diodes) AND ITS SUBSIDIARIES MAKE NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARDS TO ANY INFORMATION CONTAINED IN THIS DOCUMENT, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS (AND THEIR EQUIVALENTS UNDER THE LAWS OF ANY JURISDICTION).
2. The Information contained herein is for informational purpose only and is provided only to illustrate the operation of Diodes' products described herein and application examples. Diodes does not assume any liability arising out of the application or use of this document or any product described herein. This document is intended for skilled and technically trained engineering customers and users who design with Diodes' products. Diodes' products may be used to facilitate safety-related applications; however, in all instances customers and users are responsible for (a) selecting the appropriate Diodes products for their applications, (b) evaluating the suitability of Diodes' products for their intended applications, (c) ensuring their applications, which incorporate Diodes' products, comply the applicable legal and regulatory requirements as well as safety and functional-safety related standards, and (d) ensuring they design with appropriate safeguards (including testing, validation, quality control techniques, redundancy, malfunction prevention, and appropriate treatment for aging degradation) to minimize the risks associated with their applications.
3. Diodes assumes no liability for any application-related information, support, assistance or feedback that may be provided by Diodes from time to time. Any customer or user of this document or products described herein will assume all risks and liabilities associated with such use, and will hold Diodes and all companies whose products are represented herein or on Diodes' websites, harmless against all damages and liabilities.
4. Products described herein may be covered by one or more United States, international or foreign patents and pending patent applications. Product names and markings noted herein may also be covered by one or more United States, international or foreign trademarks and trademark applications. Diodes does not convey any license under any of its intellectual property rights or the rights of any third parties (including third parties whose products and services may be described in this document or on Diodes' website) under this document.
5. Diodes' products are provided subject to Diodes' Standard Terms and Conditions of Sale (<https://www.diodes.com/about/company/terms-and-conditions/terms-and-conditions-of-sales/>) or other applicable terms. This document does not alter or expand the applicable warranties provided by Diodes. Diodes does not warrant or accept any liability whatsoever in respect of any products purchased through unauthorized sales channel.
6. Diodes' products and technology may not be used for or incorporated into any products or systems whose manufacture, use or sale is prohibited under any applicable laws and regulations. Should customers or users use Diodes' products in contravention of any applicable laws or regulations, or for any unintended or unauthorized application, customers and users will (a) be solely responsible for any damages, losses or penalties arising in connection therewith or as a result thereof, and (b) indemnify and hold Diodes and its representatives and agents harmless against any and all claims, damages, expenses, and attorney fees arising out of, directly or indirectly, any claim relating to any noncompliance with the applicable laws and regulations, as well as any unintended or unauthorized application.
7. While efforts have been made to ensure the information contained in this document is accurate, complete and current, it may contain technical inaccuracies, omissions and typographical errors. Diodes does not warrant that information contained in this document is error-free and Diodes is under no obligation to update or otherwise correct this information. Notwithstanding the foregoing, Diodes reserves the right to make modifications, enhancements, improvements, corrections or other changes without further notice to this document and any product described herein. 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.
8. Any unauthorized copying, modification, distribution, transmission, display or other use of this document (or any portion hereof) is prohibited. Diodes assumes no responsibility for any losses incurred by the customers or users or any third parties arising from any such unauthorized use.
9. This Notice may be periodically updated with the most recent version available at <https://www.diodes.com/about/company/terms-and-conditions/important-notice>

DIODES is a trademark of Diodes Incorporated in the United States and other countries.
The Diodes logo is a registered trademark of Diodes Incorporated in the United States and other countries.
© 2022 Diodes Incorporated. All Rights Reserved.

www.diodes.com