Lead-free Green

**APR343**

# SECONDARY SIDE SYNCHRONOUS RECTIFICATION CONTROLLER

## Description

The DIODES APR343 is a secondary side MOSFET driver for synchronous rectification in DCM operation, which integrates the output voltage detection function for primary side control system.

The synchronous rectification can effectively reduce the secondary side rectifier power dissipation and provide high performance solution. By sensing MOSFET drain-to-source voltage, APR343 can output ideal drive signal with less external components. It can provide high-performance solution for 5V output voltage application.

Same as DIODES AP4341, APR343 detects the output voltage and provides a periodical signal when the output voltage is lower than a certain threshold. By fast response to secondary side voltage, APR343 can effectively improve the transient performance of primary side control system.

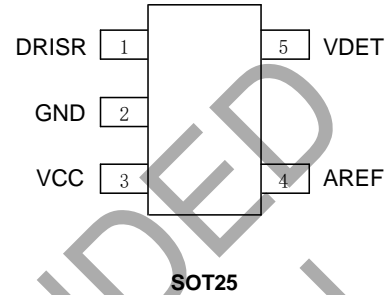The APR343 is available in SOT25 package.

## Features

- Synchronous Rectification for DCM Operation Flyback
- Eliminate Resonant Ring Interference
- Fast Detector of Supply Voltage
- 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/**

## Pin Assignments

**(Top View)**

| Pin | | Pin |
|-----|--|-----|
| DRISR | 1 | 5 VDET |
| GND | 2 | |
| VCC | 3 | 4 AREF |

**SOT25**

## Applications

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

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.

## Typical Applications Circuit
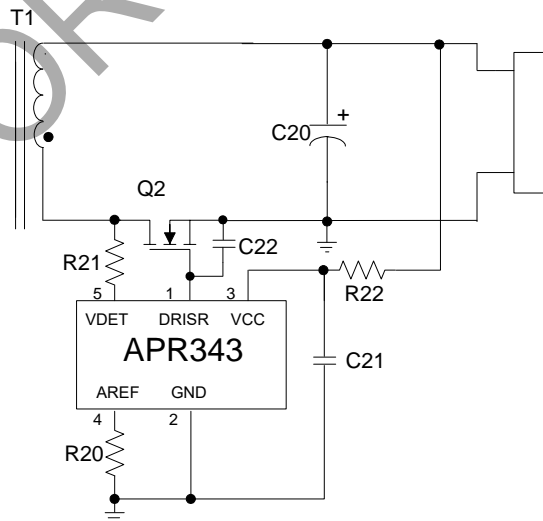
## Pin Descriptions

| Pin Number | Pin Name | Function |
|---|---|---|
| 1 | DRISR | Synchronous rectification MOSFET Gate drive |
| 2 | GND | Ground |
| 3 | VCC | Power supply, connected with system output |
| 4 | AREF | Program a voltage reference with a resistor from AREF to GND, to enable synchronous rectification MOSFET drive signal |
| 5 | VDET | Synchronous rectification sense input and dynamic function output, connected with secondary winding |

## Functional Block Diagram
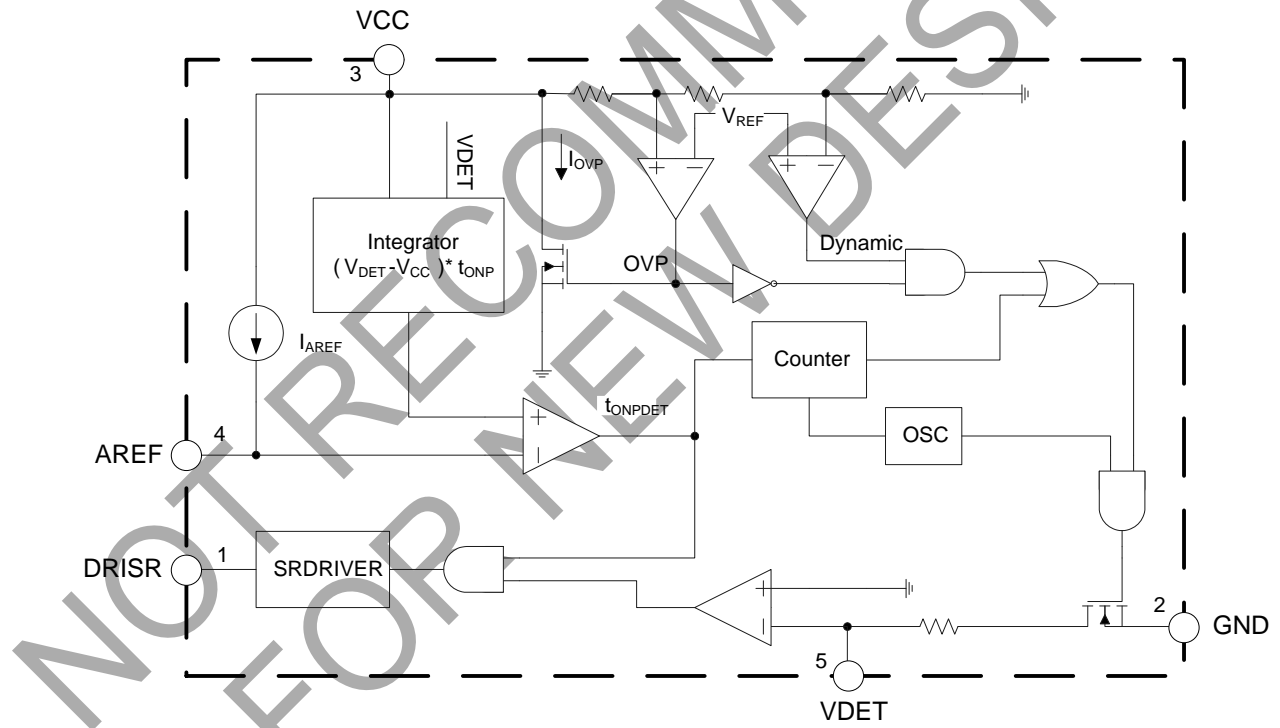
## Absolute Maximum Ratings (Note 4)

| Symbol | Parameter | Rating | Unit |
|---|---|---|---|
| V$_{CC}$ | Supply Voltage | -0.3 to 7.5 | V |
| V$_{DET}$ | Voltage at VDET Pin | -2 to 50 | V |
| V$_{AREF}$, V$_{DRISR}$ | Voltage at AREF, DRISR Pin | -0.3 to 6 | V |
| – | Output Current at VDET | Internally limited | A |
| P$_D$ | Power Dissipation at T$_A$ = +25ºC | 0.6 | W |
| T$_J$ | Operating Junction Temperature | +150 | ºC |
| T$_{STG}$ | Storage Temperature | -65 to +150 | ºC |
| – | Lead Temperature (Soldering, 10 sec) | +300 | ºC |
| θ$_{JA}$ | Thermal Resistance (Junction to Ambient) | 197 | ºC/W |
| θ$_{JC}$ | Thermal Resistance (Junction to Case) | 76 | ºC/W |

Note:     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.

## Recommended Operating Conditions

| Symbol | Parameter | Min | Max | Unit |
|---|---|---|---|---|
| V$_{CC}$ | Supply Voltage | 0 | 6 | V |
| T$_A$ | Ambient Temperature | -40 | +85 | ºC |

## Electrical Characteristics (@V$_{CC}$ = 5V, T$_A$ = +25°C, unless otherwise specified.)

| Symbol | Parameters | Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| **Supply Voltage ( VCC Pin )** | | | | | | |
| I$_{STARTUP}$ | Startup Current | V$_{CC}$ = V$_{STARTUP}$-0.1V | – | 100 | 150 | µA |
| I$_{OP}$ | Operating Current | VDET pin floating<br>V$_{CC}$ = V$_{TRIGGER}$+20mV | 40 | 100 | 150 | µA |
| V$_{STARTUP}$ | Startup Voltage | – | 2.6 | 3.1 | 3.4 | V |
| – | UVLO | – | 2.3 | 2.8 | 3.1 | V |
| **Dynamic Output Section/Oscillator Section** | | | | | | |
| V$_{TRIGGER}$ | Internal Trigger Voltage | – | 5.25 | 5.3 | 5.35 | V |
| – | Duty Cycle | – | 4 | 8 | 12 | % |
| t$_{OSC}$ | Oscillation Period | V$_{CC}$ = 5V | 18 | 30 | 37.5 | µs |
| I$_{TRIGGER}$ | Internal Trigger Current | V$_{CC}$ = V$_{TRIGGER}$, VCC/VDET pin is separately connected to a 20Ω resistor | 30 | – | 42 | mA |
| t$_{DIS}$ | Minimum Period | – | 18 | 30 | 37.5 | ms |
| V$_{DIS}$ | Discharge Voltage | – | 5.28 | 5.44 | 5.52 | V |
| I$_{DIS}$ | Discharge Current | V$_{CC}$ = V$_{DIS}$+0.1V | 1.5 | 3 | 4.5 | mA |
| V$_{DIS}$-V$_{TRIGGER}$ | Trigger Discharger Gap | – | 30 | 110 | – | mV |
| V$_{OVP}$ | Overshoot Voltage for Discharge | – | 5.8 | 5.9 | 6.0 | V |
| I$_{OVP}$ | Overshoot Current for Discharge | V$_{CC}$ = V$_{OVP}$+0.1V, VCC pin is connected to a 20Ω resistor | 40 | – | 100 | mA |
| **Synchronous Rectification Detection and Drive** | | | | | | |
| V$_{THON}$ | Gate Turn On Threshold | – | 0 | – | 1 | V |
| V$_{THOFF}$ | Gate Turn Off Threshold | – | -20 | -12.5 | -5 | mV |
| t$_{DON}$ | Turn On Delay Time | From V$_{THON}$ to V$_{DRISR}$ = 1V | – | 70 | 130 | ns |
| t$_{DOFF}$ | Turn Off Propagation Delay Time | From V$_{THOFF}$ to V$_{DRISR}$ = 3V | – | 100 | 150 | ns |
| t$_{RG}$ | Turn On Rising Time | From 1V to 3V, C$_L$ = 4.7nF | – | 50 | 100 | ns |
| t$_{FG}$ | Turn Off Falling Time | From 3V to 1V, C$_L$ = 4.7nF | – | 50 | 100 | ns |
| t$_{LEB\_S}$ | Minimum On Time | (V$_{DET}$-V$_{CC}$)*t$_{ONP}$ = 25Vµs | 0.9 | 1.8 | 2.7 | µs |
| t$_{LEB\_L}$ | | (V$_{DET}$-V$_{CC}$)*t$_{ONP}$ = 50Vµs | – | – | 6.5 | |
| V$_{DRISR\_HIGH}$ | Drive Output Voltage | V$_{CC}$ = 5V | 3.7 | – | – | V |
| V$_{S\_MIN}$ | Synchronous Rectification (SR) Minimum Operating Voltage (Note 5) | – | – | – | 4.5 | V |
| t$_{OVP\_LAST}$ | Added OVP Discharge Time | – | – | 2.0 | – | ms |
| Kqs | (Note 6) | (V$_{DET}$-V$_{CC}$)*t$_{ONP}$ = 25Vµs | 0.325 | – | 0.625 | mA*µs |

Notes:  5. This item specifies the minimum SR operating voltage of V$_{IN\_DC}$, V$_{IN\_DC}$≥N$_{PS}$*V$_{S\_MIN}$.
　　　　6. This item is used to specify the value of R$_{AREF}$.

## Performance Characteristics

### Startup Voltage vs. Temperature
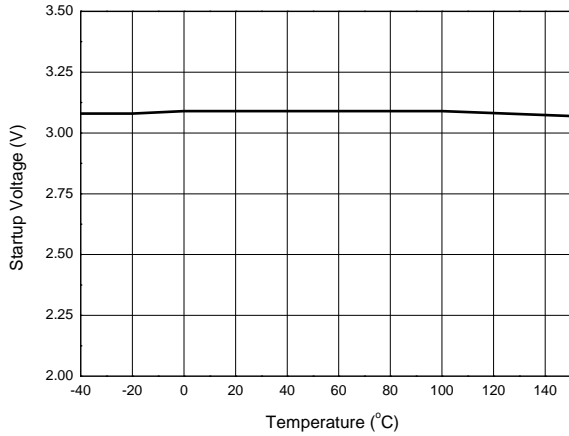


### UVLO vs. Temperature
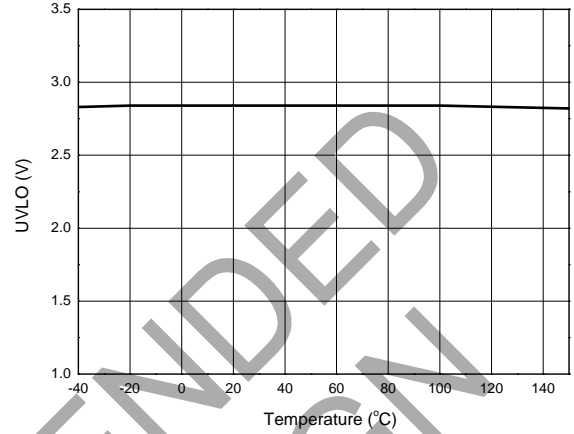


### Internal Trigger Voltage vs. Temperature
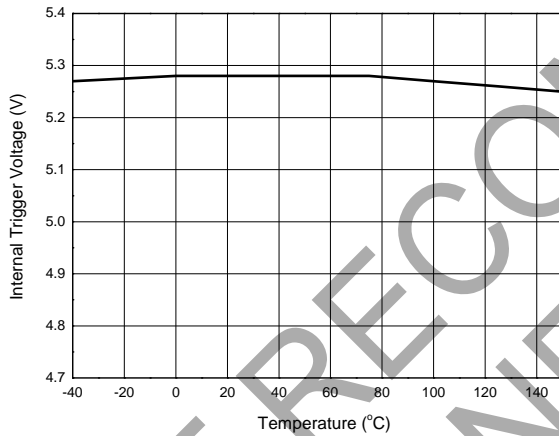


### Internal Trigger Current vs. Temperature



### Overshoot Voltage for Discharge vs. Temperature



### Overshoot Current for Discharge vs. Temperature

## Performance Characteristics (continued)

**Gate Turn Off Threshold vs. Temperature**



**Kqs (See Note 6) vs. Temperature**
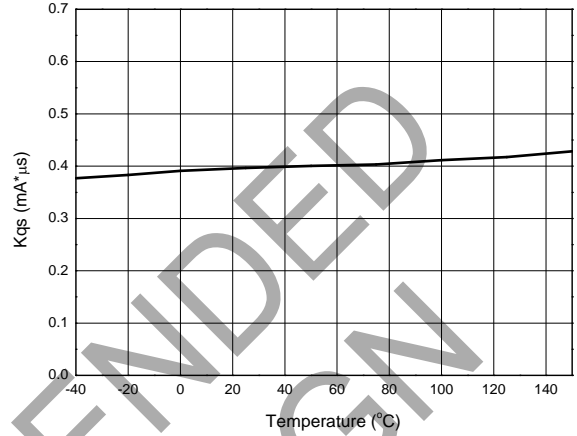


**Operating Current vs. Temperature**
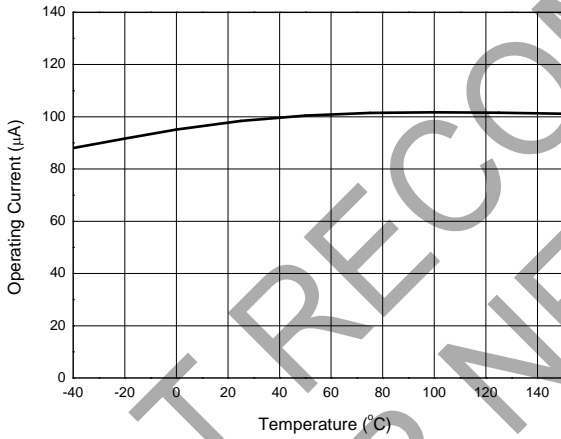
## Output Voltage Detection Function Description
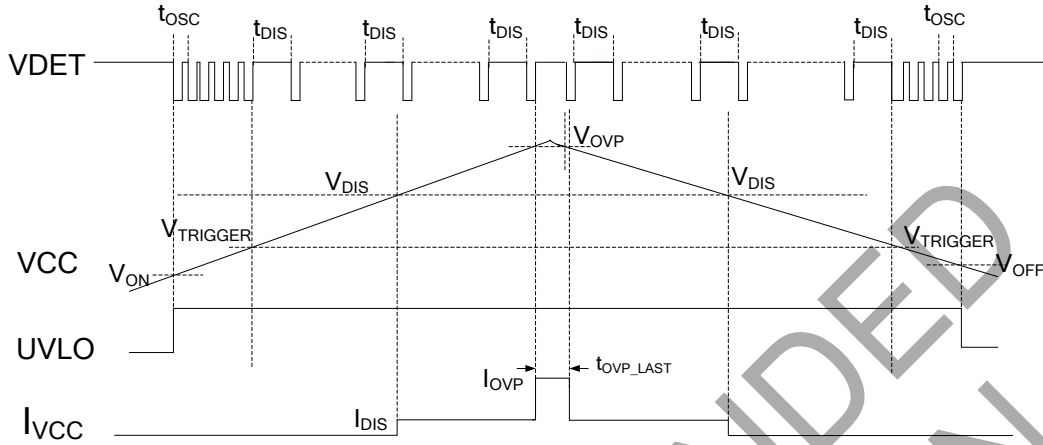


Figure 1. Typical Waveforms 1 of APR343

When $V_{CC}$ is beyond power-on voltage ($V_{ON}$), the APR343 starts up. The VDET pin asserts a periodical pulse and the oscillation 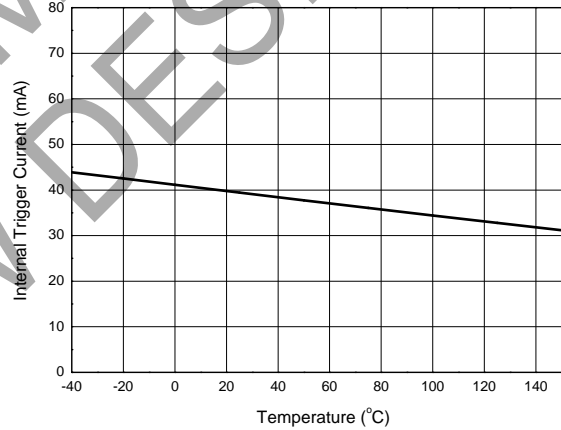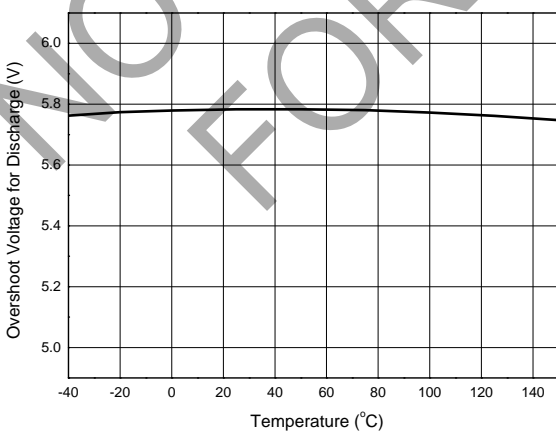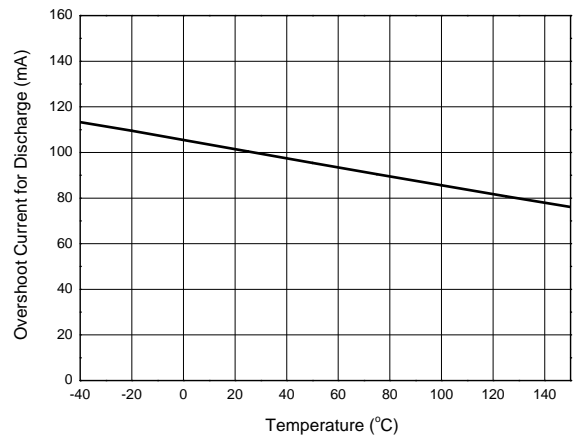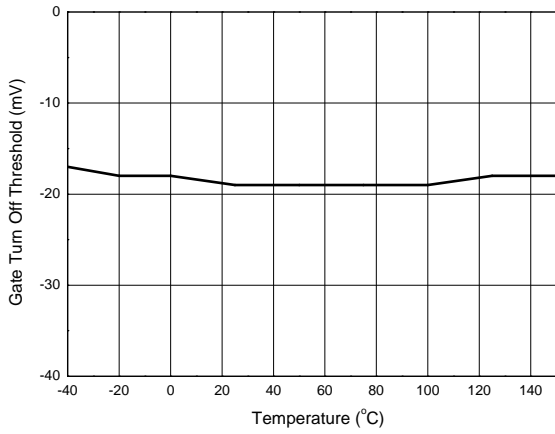period is $t_{OSC}$. When $V_{CC}$ is beyond the trigger voltage ($V_{TRIGGER}$), the periodical pulse at VDET pin is discontinued. When $V_{CC}$ is beyond the discharge voltage ($V_{DIS}$), the discharge circuit will be enabled, and a 3mA current ($I_{DIS}$) will flow into VCC pin. When $V_{CC}$ is higher than the overshoot voltage ($V_{OVP}$), the APR343 will enable a discharge circuit, the discharge current ($I_{OVP}$) will last $t_{OVP\_LAST}$ time. After the $t_{OVP\_LAST}$ time, APR343 will stop the discharge current and detect VCC voltage again. If $V_{CC}$ is still higher than $V_{OVP}$, the $t_{OVP\_LAST}$ time discharge current will be enabled again. Once the OVP discharge current is asserted, the periodical pulse at VDET pin will be disabled.

When the $V_{CC}$ is below the power-off voltage ($V_{OFF}$), the APR343 will be shut down.

## MOSFET Driver Operation Description



Figure 2. Typical Waveforms 2 of APR343

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## MOSFET Driver Operation Description (continued)

The operation of the SR is described with timing diagram shown in Figure 2. APR343 monitors the MOSFET drain-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.

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 $V_{THOFF}$, APR343 pulls the drive signal down after a turn-off delay ($t_{DOFF}$).
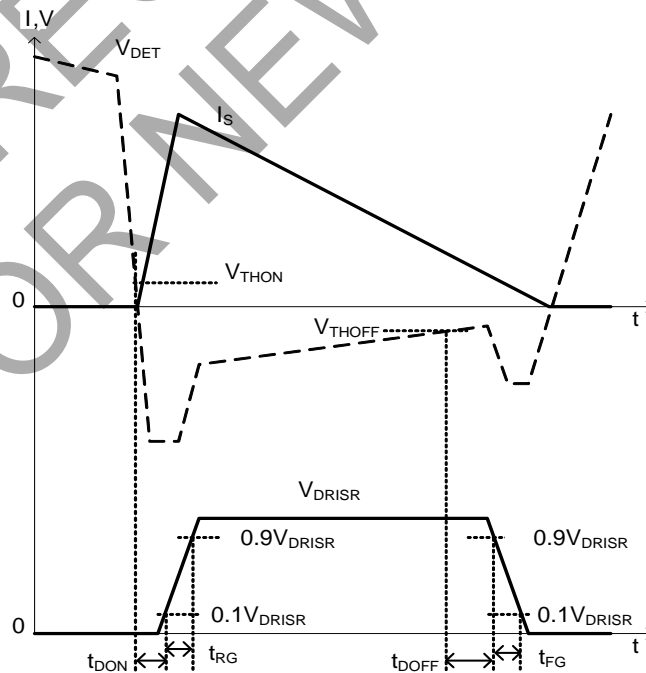
**Minimum On-Time**

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. If $V_{THOFF}$ falls below the threshold before minimum on-time expires, the MOSFET will keep on until the end of the minimum on-time.

The minimum on-time is in direct proportion to the $(V_{DET}-V_{CC})*t_{ONP}$. When $(V_{DET}-V_{CC})*t_{ONP}$=5V*5µs, the minimum on-time is about 1.8µs.

**The Value and Meaning of AREF Resistor**

As to DCM operation flyback converter, after secondary rectifier stops conduction the primary MOSFET drain-to-source ringing waveform is resulted from the resonant of primary inductance and equivalent switch device output capacitance. This ringing waveform probably leads to synchronous rectifier error conduction. To avoid this fault happening, APR343 has a special function design by means of volt-second product detecting. From the sensed voltage of VDET pin to see, the volt-second product of voltage above $V_{CC}$ at primary switch on-time is much higher than the volt-second product of each cycle ringing voltage above $V_{CC}$. Therefore, before every time synchronous rectifier turning on, APR343 judges if the detected volt-second product of VDET voltage above $V_{CC}$ is higher than a threshold and then turn on synchronous rectifier. The purpose of AREF resistor is to determine the volt-second product threshold. APR343 has a parameter, Kqs, which converts $R_{AREF}$ value to volt-second product.

$$Area2 = R_{AREF} * Kqs$$

In general, Area1 and Area3 value depend on system design and always are fixed after system design 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 of conditions. So the AREF resistor design should consider the worst case, the minimum primary peak current condition. Since of system design parameter distribution, Area1 and Area3 have moderate tolerance. So Area2 should be designed between the middle of Area1 and Area3 to keep enough design margin.

$$Area3 < R_{AREF} * Kqs < Area1$$
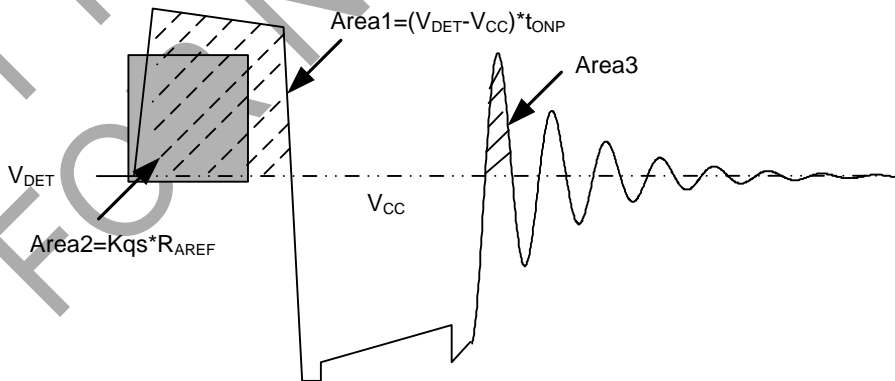


Figure 3. AREF Function

**SR Minimum Operating Voltage**

APR343 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 APR343 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.

## Ordering Information

APR343 X XX – XX
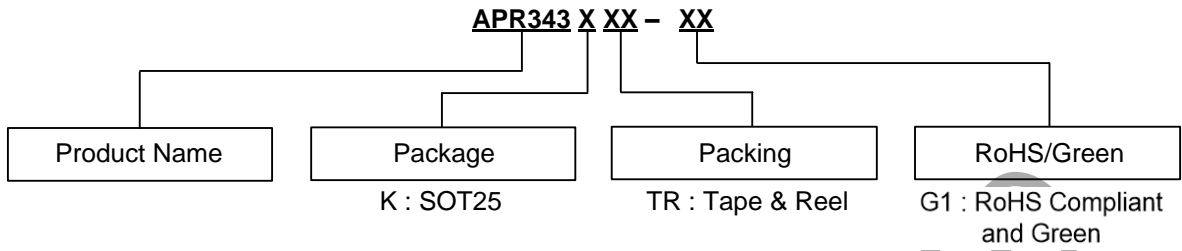
| Product Name | Package | Packing | RoHS/Green |
|---|---|---|---|
|  | K : SOT25 | TR : Tape & Reel | G1 : RoHS Compliant and Green |

| Part Number | Temperature Range | Marking ID | Package | Packing | |
|---|---|---|---|---|---|
|  |  |  |  | Qty. | Carrier |
| APR343KTR-G1 | -40°C to +85°C | GHZ | SOT25 | 3000 | Tape & Reel |

## Marking Information

**(Top View)**



⋀ : Logo
GHZ: Marking ID
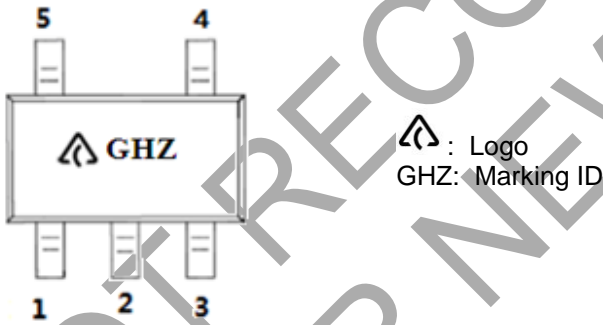
## Package Outline Dimensions (All dimensions in mm(inch).)

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

**(1)   Package Type: SOT25**



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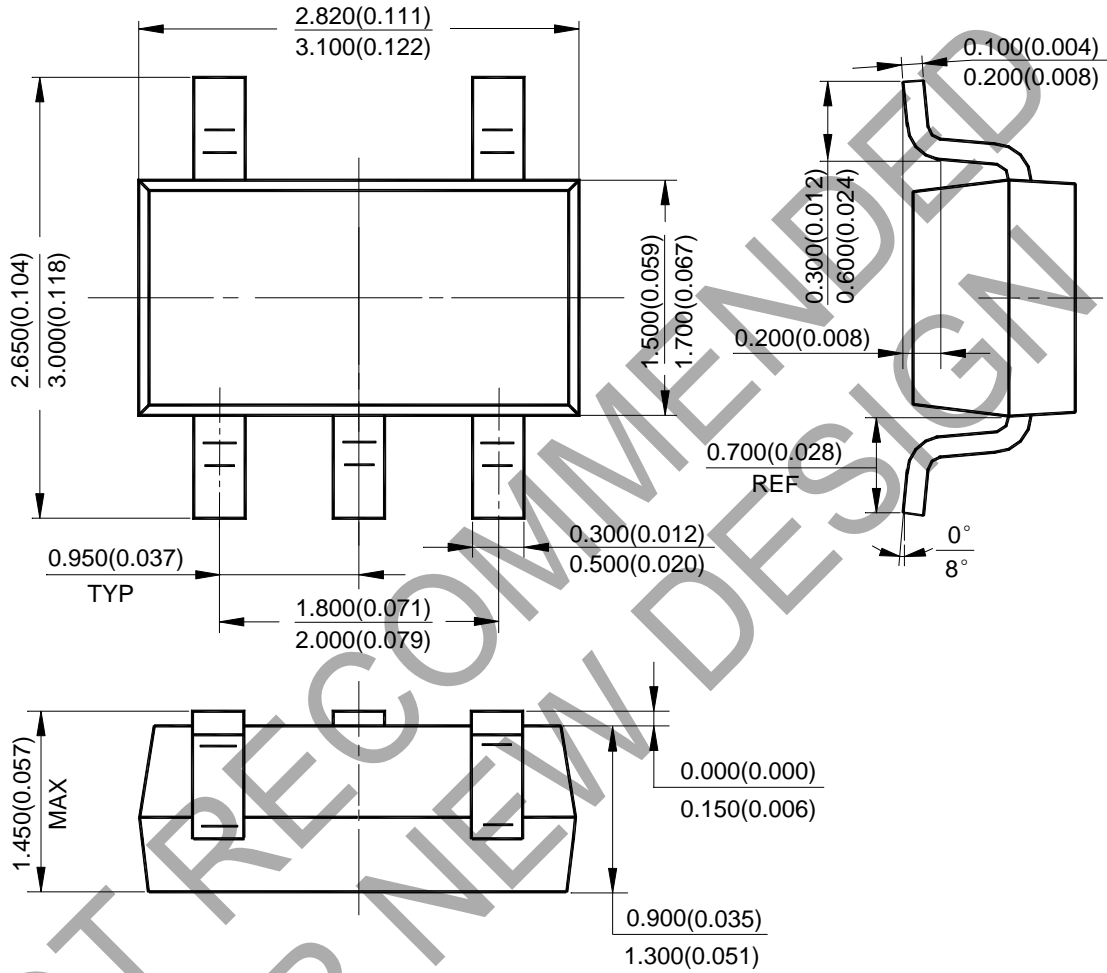
## Suggested Pad Layout

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

**(1)   Package Type: SOT25**
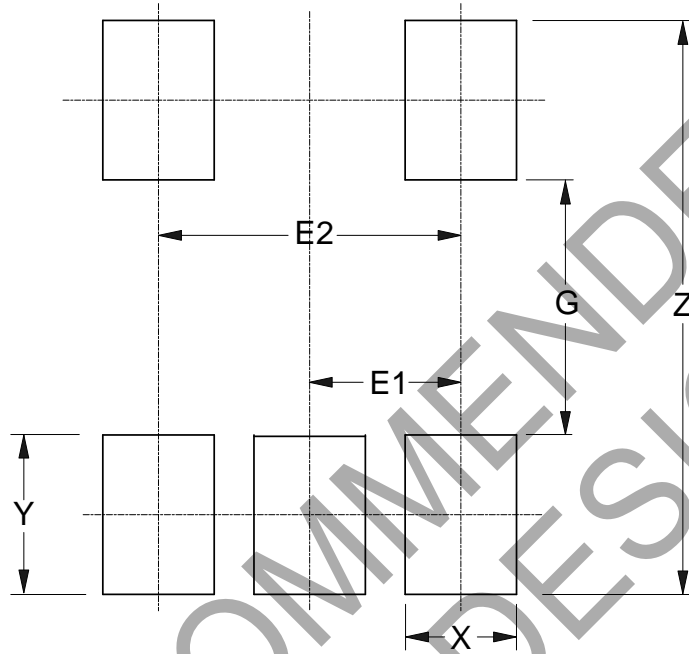


| Dimensions | Z (mm)/(inch) | G (mm)/(inch) | X (mm)/(inch) | Y (mm)/(inch) | E1 (mm)/(inch) | E2 (mm)/(inch) |
|---|---|---|---|---|---|---|
| Value | 3.600/0.142 | 1.600/0.063 | 0.700/0.028 | 1.000/0.039 | 0.950/0.037 | 1.900/0.075 |

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