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Lead-free Green

APR348

SECONDARY SIDE SYNCHRONOUS RECTIFICATION CONTROLLER

Description

The APR348 is a secondary-side MOSFET driver for synchronous rectification, which can effectively reduce the secondary-side rectifier power dissipation and provide a high-performance solution.

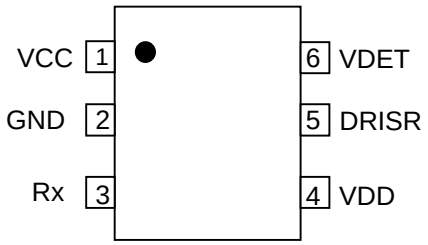
The APR348 can support continuous or discontinuous conduction mode (CCM and DCM) and quasi-resonant flyback operation based on a MOSFET operating on-time control technology. This technology provides minimized turn-on and turn-off delay to reduce power loss and keep safe operation without adding any external components or circuitry.

The APR348 can configure into high-side or low-side application to fit various design requirement. It also has specialized light load mode and determines safe driver pulse generation through load detection. The VDD power supply can be charged by VDET or VCC, which means it can be charged by internal PLR (Pulse linear regulator) at low output voltage and charged by internal LDO at high output voltage. Therefore, it can provide a wide output operation voltage from 3.3V to 20V.

The APR348 is available in SOT26 (Type CJ) package.

Pin Assignments

(Top View)



SOT26 (Type CJ)

Features

- Synchronous Rectification Controller
- Suited for High-Side and Low-Side Flyback Converters in CCM/DCM/QR Operation
- Minimized Turn-On and Turn-Off Delay
- Internal UVLO Protection
- Light Load Mode Control
- Eliminate False Turn-On with Resonant Ring
- Fewest External Components
- Moisture Sensitivity: MSL Level 1 per J-STD-020
- Terminals: Finish – Matte Tin Plated Leads, Solderable per M2003 JESD22-B102, Method 208 (e3)
- Weight: 0.016/0.017 grams (Approximate)
- **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-Q100/101/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Applications

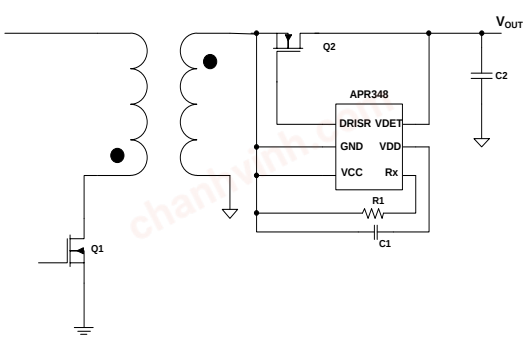
- Adapters/Chargers for Cell/Cordless Phones, ADSL Modems, MP3 and Other Portable Apparatus

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.

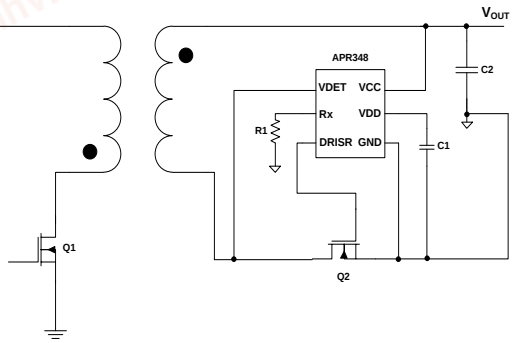
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Typical Applications Circuit



High-Side Application

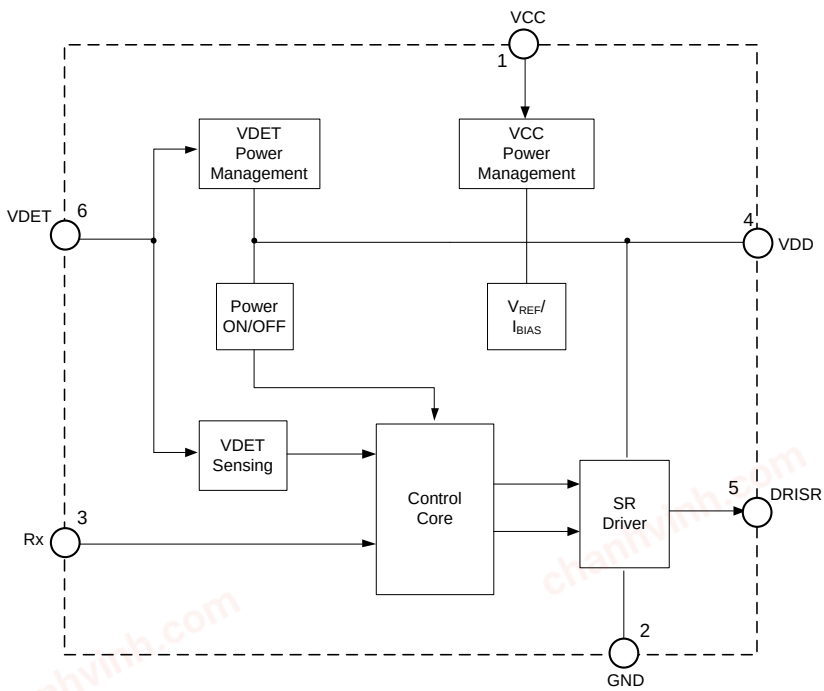


Low-Side Application

Pin Descriptions

Pin Number	Pin Name	Function
1	VCC	Internal Linear Regulator Input
2	GND	Ground, also used as FET source sense reference for VDET
3	Rx	External fixed resistor for Accurate Turn-On Signal
4	VDD	Linear Regulator Output. It provides bias voltage for the internal logic circuit and the MOSFET driver. Connect this pin to a capacitor.
5	DRISR	Synchronous Rectification MOSFET Gate Drive
6	VDET	Synchronous Rectification MOSFET Drain Voltage Sense Input

Functional Block Diagram



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Absolute Maximum Ratings (Note 4)

Symbol	Parameter	Rating	Unit
V_{CC}	Supply Voltage (Note 7)	-0.3 to 28	V
V_{DET}	Voltage at VDET Pin	-0.7 to 150	V
V_{DRISR}	Voltage at DRISR Pin	-0.3 to 7	V
V_{RX}	Voltage at Rx Pin	-0.3 to 7	V
P_D	Power Dissipation at T_A = +25°C	0.6	W
T_J	Operating Junction Temperature (Note 8)	+150	°C
T_{STG}	Storage Temperature	-65 to +150	°C
T_{LEAD}	Lead Temperature (Soldering, 10s)	+300	°C
θ_{JA}	Thermal Resistance (Junction to Ambient) (Note 5)	197	°C/W
θ_{JC}	Thermal Resistance (Junction to Case) (Note 5)	76	°C/W
ESD	Human Body Model (Except VDET Pin) (Note 6)	6,000	V
	Charge Device Model	1500	V

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. Test condition: Device mounted on FR-4 substrate PC board, 2oz copper, with 1inch^2 cooling area.
6. VDET pin are ESD sensitive. (HBM: V_{DET} = 2000V).
7. Setting V_{CC} = 22V in the aging condition. Latch up overvoltage test use V_{CC} = 28V.
8. Setting +85°C in the aging condition.

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Electrical Characteristics (@V_{CC} = 5V, T_A = -40°C < T_A < +85°C, unless otherwise specified.)

Symbol	Parameter	Condition	Min	Typ	Max	Unit
Supply Voltage (VCC Pin)						
$V_{LDO_DISABLE}$	V_{CC} LDO Disable Threshold at VCC Falling	—	4.25	4.55	4.85	V
$V_{LDO_ENSABLE}$	V_{CC} LDO Enable Threshold at VCC Rising	—	4.35	4.65	4.95	V
V_{LDO_HYS}	LDO Operating Hysteresis at VCC Pin	—	—	100	—	mV
Supply Linear Regulator (VDD Pin)						
V_{DD}	Internal Power Supply	V_{CC} = 12V, V_{DET} = 12V	5	5.5	6	V
		V_{CC} = 3V, V_{DET} = 12V	5.3	5.9	6.5	V
$I_{STARTUP}$	V_{DD} Startup Current	V_{CC} = 0, V_{DET} = V_{DD} = V_{DD_ST} - 0.1V	—	125	160	μA
V_{DD_ST}	V_{DD} Startup Voltage	—	3.55	3.75	3.95	V
V_{DD_UVLO}	V_{DD} UVLO Voltage	—	3.30	3.50	3.70	V
$V_{UVLO\ HYSTERESIS}$	UVLO Hysteresis	—	—	0.25	—	V
I_{Q_VDD}	Quiescent Current	V_{DD} = 5.5V, V_{CC} = 0	—	170	220	μA
Synchronous Rectification MOSFET Sense (VDET Pin)						
V_{THON}	Gate Turn-On Threshold	Voltage at VDET Pin	-130	-90	-60	mV
V_{FWD}	Gate Regulation Voltage	Voltage at VDET Pin	-55	-45	-35	mV
V_{THOFF}	Gate Turn-Off Threshold	Voltage at VDET Pin	—	-7	0	mV
Gate Driver (DRISR Pin)						
$V_{DRISR(High)}$	Synchronous Rectification Drive Voltage High	—	V_{DD} - 0.1	—	—	V
$V_{DRISR(Low)}$	Synchronous Rectification Drive Voltage Low	I_{G_LOAD} = 100mA, V_{DD} = 5V	—	70	140	mV
t_{DON}	Turn-On Delay Time	C_{LOAD} = 2.2nF	—	30	60	ns
t_{DOFF}	Turn-Off Propagation Delay Time	C_{LOAD} = 2.2nF	—	25	45	ns
t_{ON_MIN}	Minimum On-Time	—	0.8	1.2	1.6	μs
I_{SOURCE}	Maximum Source Current (Note 9)	—	—	0.6	—	A
I_{SINK}	Maximum Sink Current (Note 9)	—	—	3.5	—	A
Rg	Pull-Down Impendent	I_{G_LOAD} = 100mA, V_{DD} = 5V	—	0.7	1.4	Ω

Note: 9. These parameters are guaranteed by design and characterization.

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Synchronous Rectification Principle Description

Synchronous Rectification MOSFET Turn-On

The APR348 determines the synchronous rectification MOSFET turn-on time by monitoring the MOSFET drain-to-source voltage. Because of the parasitic parameter, the voltage on the MOSFET drain pin has moderate voltage ringing, which may affect the SR controller VDET voltage sense and bring about a turn-on/off fault.

To avoid this conduction fault, the APR348 has internal judge methods to determinate the turn-on moment of synchronous rectification MOSFET. Meanwhile, APR348 has a minimum on-time (t_{ON_MIN}, which is shown in Figure 1) blanking period that keeps the power MOSFET on for a minimum amount of time. When the controlled MOSFET gate turns on, some ringing noises generate. The minimum on-time timer blanks the V_{THOFF} comparator, which keeps the controlled MOSFET on for at least the minimum on-time. During the minimum on-time, the turn-off threshold is blanked unless the V_{DS} ringing voltage goes over 2V during this period.

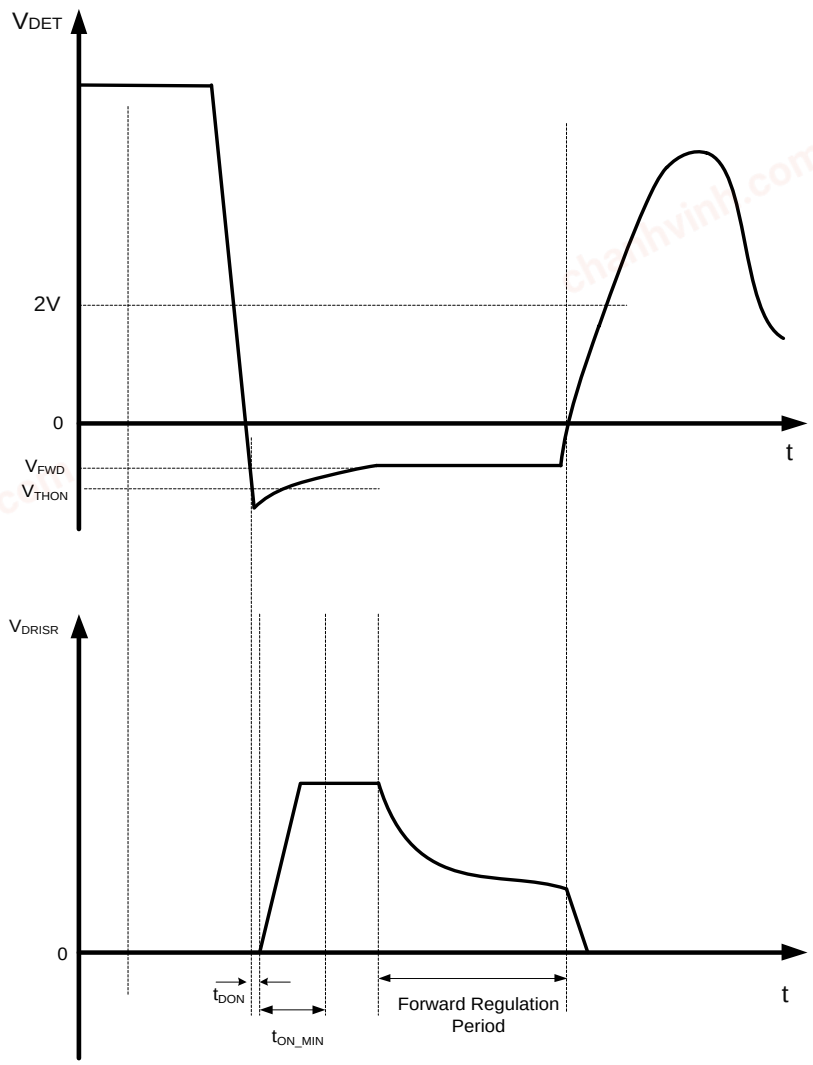


Figure 1. APR348 Switch Period

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Synchronous Rectification Principle Description (continued)

The Value and Meaning of Rx Resistance

After the secondary rectifier stops conduction with DCM operation, the primary MOSFET drain-to-source generates a ringing waveform, which results from the resonant of primary inductance and equivalent switch-device output capacitance. This ringing waveform most likely leads to the synchronous rectifier fault conduction. APR348 integrates an accurate turn-on voltage threshold and internal judge criteria to determine whether synchronous rectification MOSFET can turn on or not. Rx is an external resistor, which multiplies with an internal current source to generate an accurate reference for turn-on threshold judgment. Proposed to use 30kΩ to 40kΩ resistance for Rx value.

Synchronous Rectification Forward Regulation and Turn-Off Stage

Once the synchronous rectification gate outputs high levels and the synchronous rectification MOSFET turns on, the secondary-side current goes through synchronous rectification MOSFET. The voltage drop on synchronous rectification MOSFET is found by $R_{DS(ON)}$ × secondary-side current. After minimum turn-on time t_{ONMIN}, the IC continuously monitors V_{DS} by the VDET pin and generates a pull-down current from the MOSFET gate until V_{DET} > -45mV. The MOSFET drain-to-source voltage would remain at around -45mV with the secondary-side current decreasing. Real MOSFET gate voltage depends on the MOSFET characteristics and drain current. When the primary MOSFET turns on, the secondary V_{DS} would rise up. Once V_{DET} rises to trigger the turn-off threshold, the gate signal will be pulled down to GND. The synchronous rectification MOSFET gate voltage drops quickly from a low voltage to zero after a very short turn-off delay.

Light Load Mode (LL Mode)

The APR348 provides light-load mode when the system goes into burst or no-load condition with interval-time pulses for low standby loss. The IC internal has two timers, one is 640µs and the other is 2.5ms. When the interval time is between 640µs and 2.5ms, the gate drive outputs will skip the first two cycles. When the interval time is over 2.5ms, gate drive outputs will skip the first eight cycles.

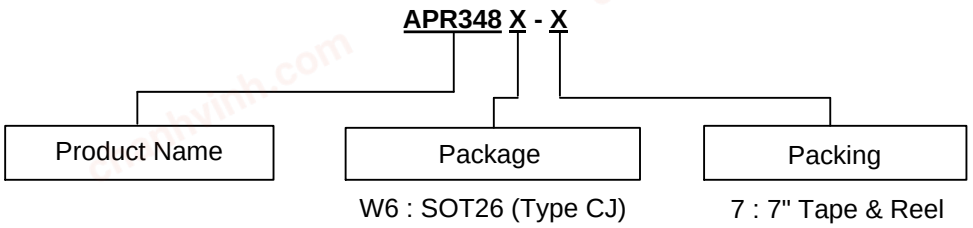
VDD Regulator and UVLO Protection

The VDD is an internal linear regulator output. When the synchronous rectification MOSFET and the IC are connected in low side, the V_{DD} is supplied by both VDET pin and VCC pin. When synchronous rectification MOSFET and IC are connected in high side, the V_{DD} is supplied only via V_{DET}. A large capacitor (typical 4.7µF) at VDD pin is proposed for system design. The APR348 also has the UVLO protection. When V_{DD} drops below V_{DD_UVLO}, the IC will stop working.

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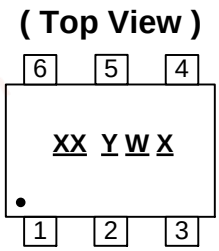
Ordering Information



Package	Temperature Range	Part Number	Identification Code	7'' Tape and Reel	
				Quantity	Part Number Suffix
SOT26 (Type CJ)	-40°C to +85°C	APR348W6-7	DY	3000/Tape and Reel	-7

Marking Information

SOT26 (Type CJ)



XX : Identification Code
Y : Year 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents 52 and 53 week
X : Internal Code

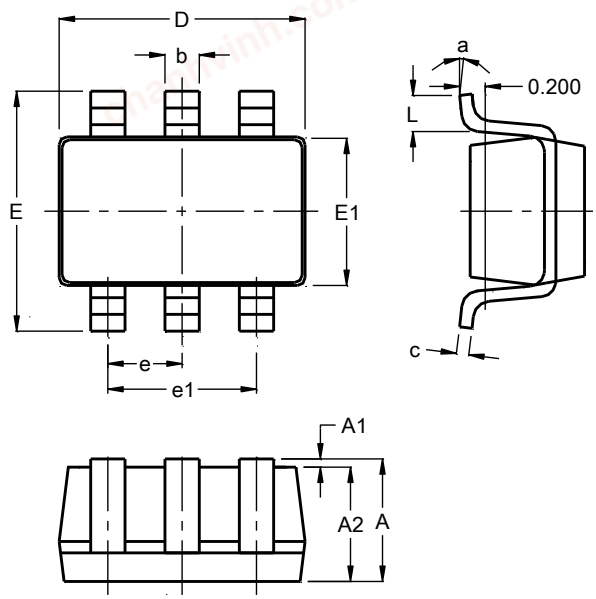
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Package Outline Dimensions

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

SOT26 (Type CJ)

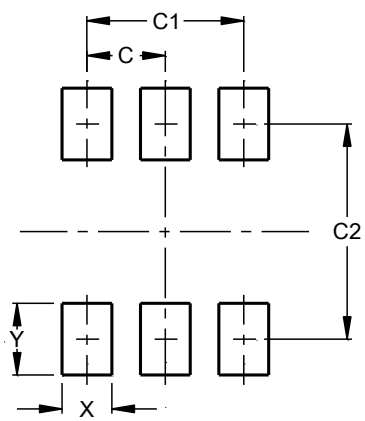


SOT26 (Type CJ)			
Dim	**Min**	**Max**	**Typ**
A	1.050	1.250	--
A1	0.00	0.10	--
A2	1.050	1.150	--
b	0.300	0.500	--
c	0.100	0.200	--
D	2.820	3.020	--
E	2.650	2.950	--
E1	1.500	1.700	--
e	0.950BSC		
e1	1.800	2.000	--
L	0.300	0.600	--
a	0°	8°	--
All Dimensions in mm			

Suggested Pad Layout

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

SOT26 (Type CJ)



Dimensions	Value (in mm)
C	0.95
C1	1.90
C2	2.40
X	0.60
Y	1.00

Mechanical Data

- Moisture Sensitivity: Level 1 per JESD22-A113
- Terminals: Finish – Matte Tin Plated Leads, Solderable per JESD22-B102 (e3)
- Weight: 0.016 grams (Approximate)

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