

3A, 4MHz HIGH EFFICIENCY SYNCHRONOUS BUCK CONVERTER

Description

The AP3409/A is a current mode, PWM synchronous buck DC/DC converter, capable of driving a 3A load with high efficiency, excellent line and load regulation. It operates in continuous PWM mode.

The AP3409/A integrates synchronous P-channel and N-channel power MOSFET switches with low on-resistance. It is ideal for portable applications powered from a single Li-ion battery. 100% duty cycle and low on-resistance P-channel internal power MOSFET can maximize the battery life.

The switching frequency of AP3409/A can be programmable from 300kHz to 4MHz, which allows small-sized components, such as capacitors and inductors. A standard series of inductors from several different manufacturers are available. This feature greatly simplifies the design of switch-mode power supplies.

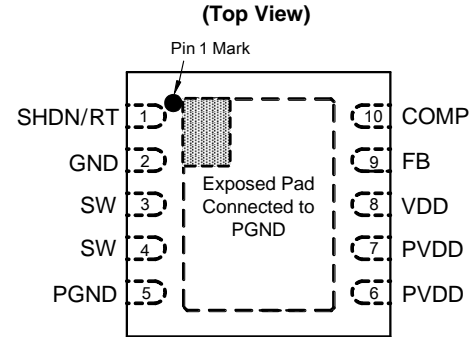
The AP3409/A is available in U-DFN3030-10 package.

Features

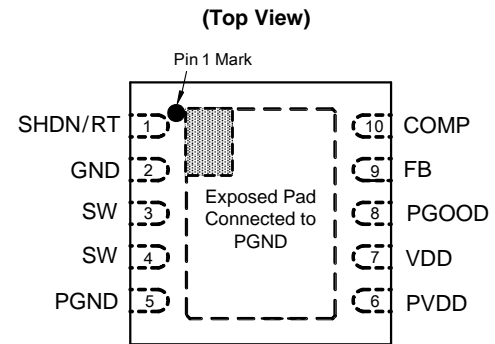
- Input Voltage Range: 2.6V to 5.5V
- Adjustable Output from 0.8V to 5V
- 0.8V Reference Voltage with $\pm 2\%$ Precision
- Output Current: 3A
- High Efficiency up to 95%
- Low $R_{DS(ON)}$ Internal Switches
- Programmable Frequency: 300kHz to 4MHz
- Current Mode Control
- Forced Continuous-mode Operation
- 100% Duty Cycle
- Built-in Soft-start
- Built-in Short Circuit Protection
- Built-in Thermal Shutdown Protection
- Built-in Current Limit Function
- PGOOD Output Voltage Monitoring (For AP3409A)
- U-DFN3030-10 package
- **Totally Lead-free & Fully RoHS Compliant (Note 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

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 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



**U-DFN3030-10 (DN Package)
For AP3409**

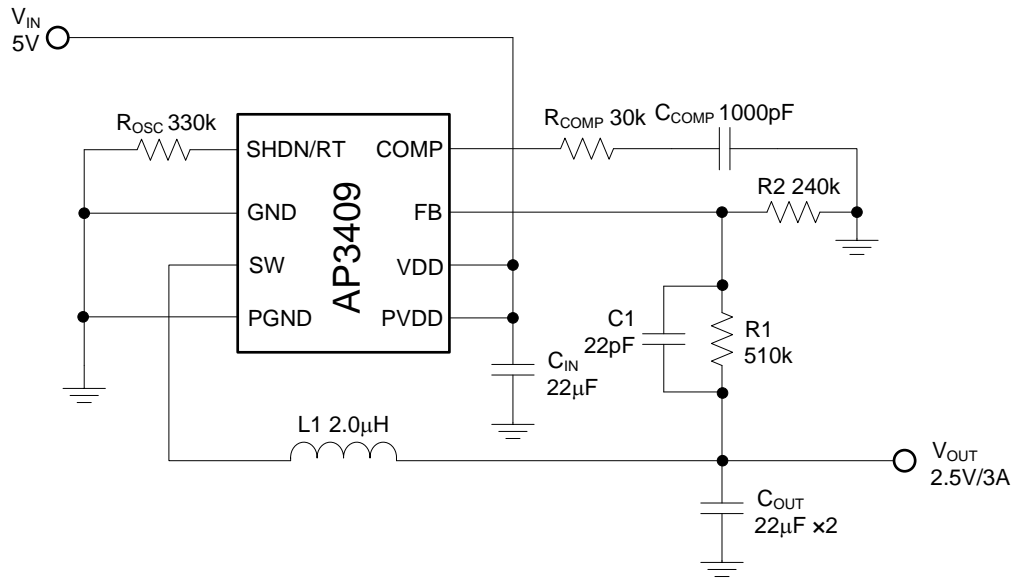


**U-DFN3030-10 (DN Package)
For AP3409A**

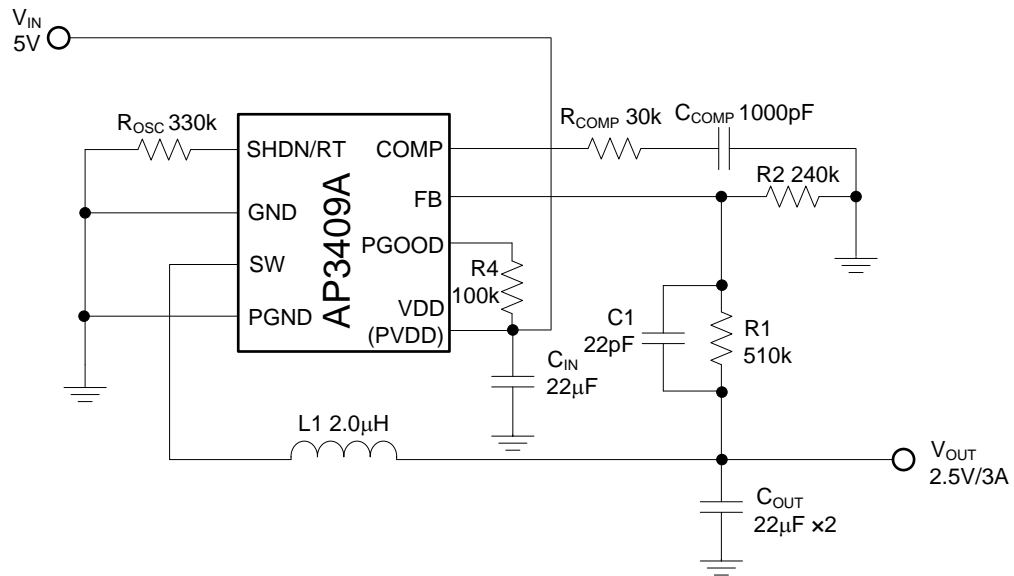
Applications

- Portable Media Player
- Digital Still and Video Cameras
- Notebook

Typical Applications Circuit (Note 4)



Typical Application of AP3409



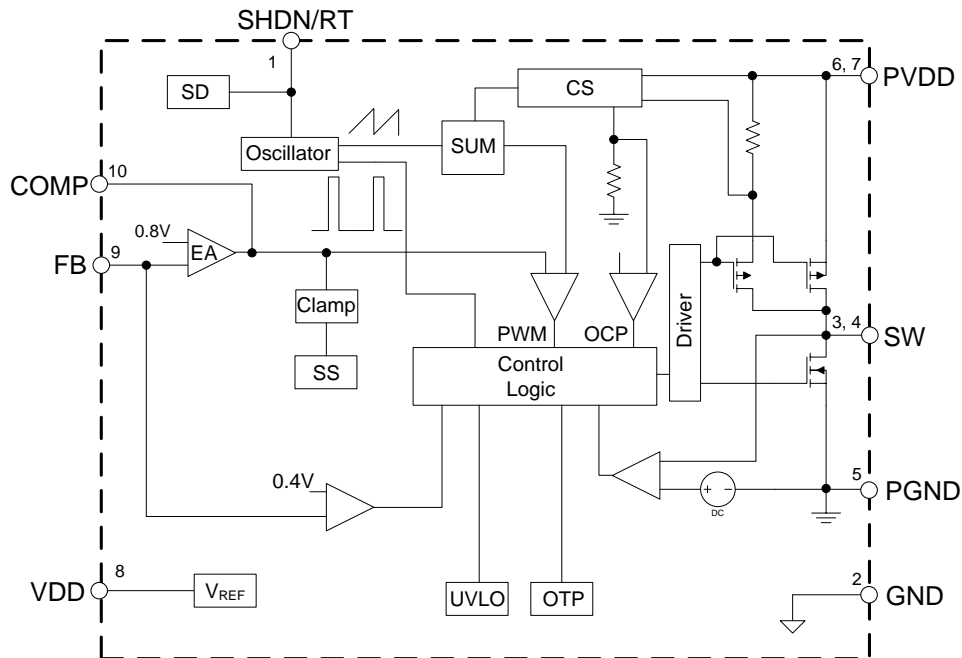
Typical Application of AP3409A

Notes 4: $V_{OUT} = \frac{V_{FB} \times (R1 + R2)}{R2}$

Pin Descriptions

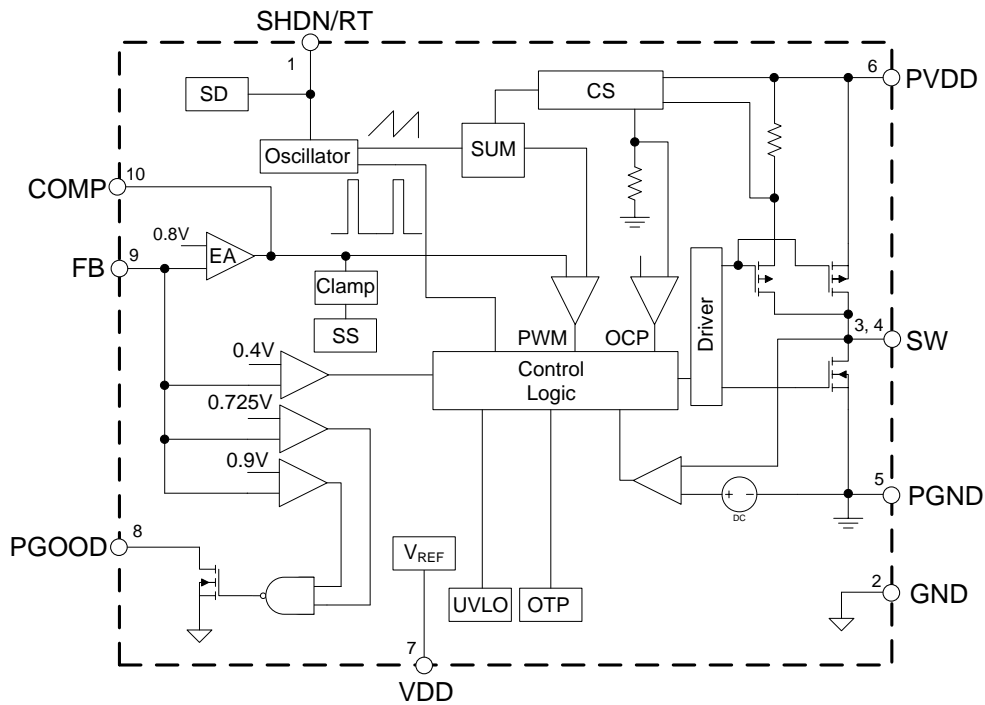
| Pin Number | | Pin Name | Function |
|------------|---------|----------|--|
| AP3409 | AP3409A | | |
| 1 | 1 | SHDN/RT | Oscillator resistor input. Connect a resistor to GND from this pin to set the switching frequency. Forcing this pin to V_{DD} to shutdown the device |
| 2 | 2 | GND | Signal ground. All small-signal ground, such as the compensation components and exposed pad should be connected to this, which in turn connects to PGND at one point |
| 3, 4 | 3, 4 | SW | Internal power switch output. Connect this pin with one terminal of the inductor |
| 5 | 5 | PGND | Power ground. Connect this pin as close as possible to C_{IN} and C_{OUT} |
| 6, 7 | 6 | PVDD | Power Input Supply. Decouple this pin to PGND with a capacitor |
| 8 | 7 | VDD | Signal input supply. Decouple this pin to GND with a capacitor. Normally V_{DD} is equal to V_{PVDD} |
| - | 8 | PGOOD | Power good indicator. This pin is open-drain logic output that is pulled to ground when the output voltage is not within $\pm 12.5\%$ of regulation point |
| 9 | 9 | FB | Feedback voltage. This pin is the inverting input of internal error amplifier. It senses the converter output voltage through an external resistor divider. The internal reference voltage is 0.8V, which determines the output voltage through the resistor divider |
| 10 | 10 | COMP | Compensation input. This pin is the output of internal error amplifier. Connect external compensation elements to this pin to stabilize the control loop |

Functional Block Diagram



Functional Block Diagram of AP3409

Functional Block Diagram (Cont.)



Functional Block Diagram of AP3409A

Absolute Maximum Ratings (Note 5)

| Symbol | Parameter | Rating | Unit |
|-------------------|--|------------------------------|------|
| V _{DD} | VDD Pin Voltage | -0.3 to 6 | V |
| V _{PVDD} | PVDD Pin Voltage | -0.3 to 6 | V |
| V _{FB} | FB Pin Voltage | -0.3 to 6 | V |
| V _{COMP} | COMP Pin Voltage | -0.3 to 6 | V |
| V _{SW} | SW Pin Voltage | -0.3 to V _{IN} +0.3 | V |
| V _{RT} | SHDN/RT Pin Voltage | -0.3 to 6 | V |
| θ _{JA} | Thermal Resistance (Junction to Ambient) | 110 | °C/W |
| θ _{JC} | Thermal Resistance (Junction to Case) | 3 | °C/W |
| T _J | Operating Junction Temperature | +150 | °C |
| T _{STG} | Storage Temperature | -65 to +150 | °C |
| T _{LEAD} | Lead Temperature (Soldering, 10 sec) | +260 | °C |
| - | ESD (Machine Model) | 200 | V |
| - | ESD (Human Body Model) | 2000 | V |

Note 5: 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

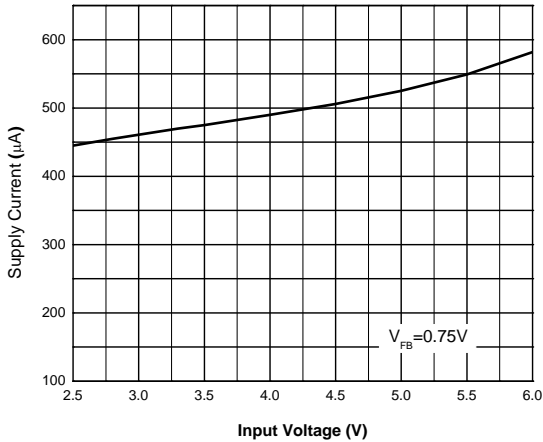
| Symbol | Parameter | Min | Max | Unit |
|-----------------|--------------------------------|-----|------|------|
| V_{IN} | Input Voltage | 2.6 | 5.5 | V |
| $I_{OUT (MAX)}$ | Maximum Output Current | 3 | – | A |
| T_J | Operating Junction Temperature | -40 | +125 | °C |

Electrical Characteristics ($V_{IN}=V_{DD}=V_{PVDD}=3.3V$, $T_A=+25^{\circ}C$, unless otherwise specified.)

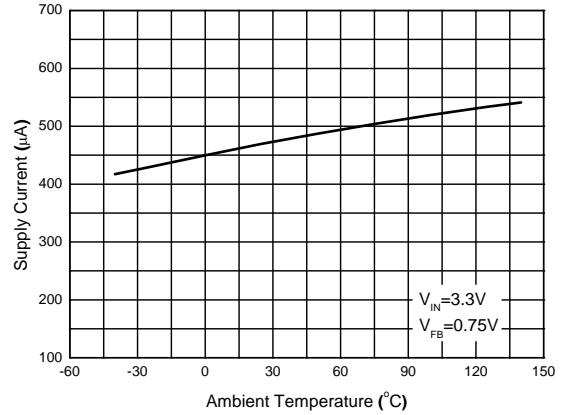
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit | |
|---|---|--|----------------|--------------|--------------|-----------|---|
| INPUT SECTION | | | | | | | |
| V_{DD} | Input Voltage Range | | 2.6 | – | 5.5 | V | |
| I_Q | Supply Current | $V_{FB}=0.75V$, No Switching | – | 460 | – | μA | |
| I_{SHDN} | Shutdown Supply Current | Shutdown, $V_{IN}=5.5V$ | – | – | 1 | μA | |
| V_{UVLO} | Under Voltage Threshold Lockout | V_{DD} Rising | – | 2.2 | – | V | |
| V_{HUVLO} | Under Voltage Hysteresis Lockout | – | – | 300 | – | mV | |
| FEEDBACK SECTION | | | | | | | |
| V_{FB} | Feedback Voltage | – | 0.784 | 0.8 | 0.816 | V | |
| I_{FB} | FB Pin Bias Current | – | – | 0.1 | 0.4 | μA | |
| R_T | Current Sense Trans-resistance | – | – | 0.2 | – | Ω | |
| – | Switching Leakage Current | $V_{SHDN/RT}=V_{IN}=5.5V$ | – | – | 1 | μA | |
| G_V | Error Gain Amplifier Voltage | – | – | 800 | – | – | |
| G_S | Error Amplifier Trans-conductance | – | – | 800 | – | $\mu A/V$ | |
| OSCILLATOR SECTION | | | | | | | |
| V_{RT} | RT Pin Voltage | – | 0.76 | 0.8 | 0.84 | V | |
| f_{OSC} | Switching Frequency | $R_{OSC}=330k\Omega$ | 0.8 | 1 | 1.2 | MHz | |
| | | ADJ Frequency | 0.3 | – | 4 | MHz | |
| D_{MAX} | Maximum Duty Cycle | $V_{FB}=0.75V$ | 100 | – | – | % | |
| POWER SWITCH SECTION | | | | | | | |
| I_{LIMIT} | Switch Current Limit | AP3409 | $V_{FB}=0.75V$ | 3.2 | 4.2 | – | A |
| | | AP3409A | | 3.5 | 4.2 | – | A |
| R_{PDSON} | Internal P-FET On Resistance | $I_{SW}=500mA$ | – | 0.11 | 0.16 | Ω | |
| R_{NDSON} | Internal N-FET On Resistance | $I_{SW}=-500mA$ | – | 0.11 | 0.17 | Ω | |
| SHDN/RT SECTION | | | | | | | |
| – | Shutdown Threshold | – | – | $V_{DD}-0.7$ | $V_{DD}-0.4$ | V | |
| PGOOD SECTION (Only for AP3409A) | | | | | | | |
| – | PGOOD Voltage Range | – | – | ± 12.5 | ± 15 | % | |
| – | PGOOD Pull Down Resistance | – | – | – | 120 | Ω | |
| TOTAL DEVICE | | | | | | | |
| I_{OUT} | Output Current | $V_{DD}=2.6V$ to $5.5V$, $V_{OUT}=2.5V$ | 3 | – | – | A | |
| LNR | Output Voltage Line Regulation | $V_{DD}=2.7V$ to $5.5V$, $I_{OUT}=100mA$ | – | 0.4 | – | %/V | |
| LOD | Output Voltage Load Regulation | $I_{OUT}=0.01A$ to $3A$ | – | ± 0.2 | – | % | |
| t_{SS} | Soft-start Time | $I_{OUT}=10mA$ | – | 1.5 | – | ms | |
| T_{OTSD} | Thermal Shutdown Temperature | – | – | +160 | – | °C | |
| T_{HYS} | Thermal Shutdown Temperature Hysteresis | – | – | +20 | – | °C | |

Performance Characteristics ($V_{IN}=V_{DD}=V_{PVDD}=3.3V$, $T_A=+25^{\circ}C$, unless otherwise specified.)

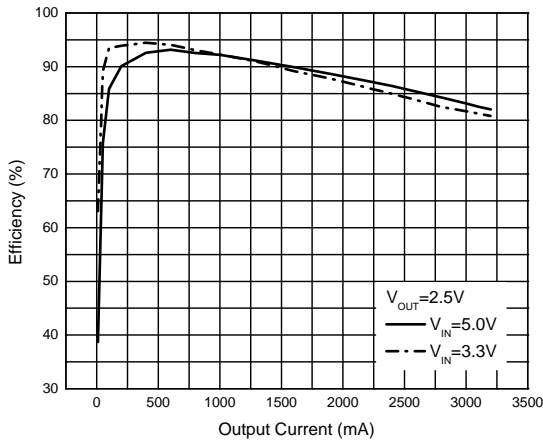
Supply Current vs. Input Voltage



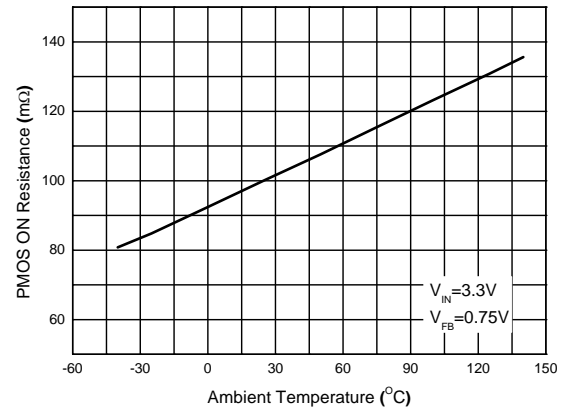
Supply Current vs. Ambient Temperature



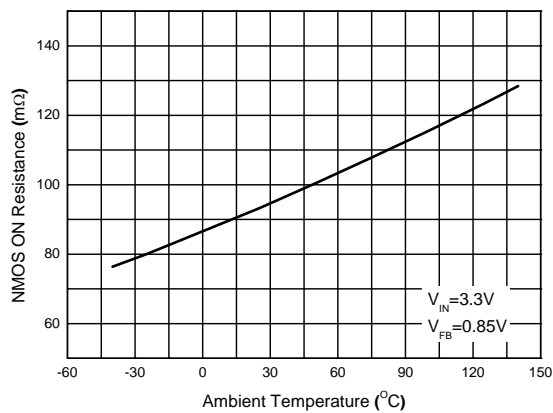
Efficiency vs. Output Current



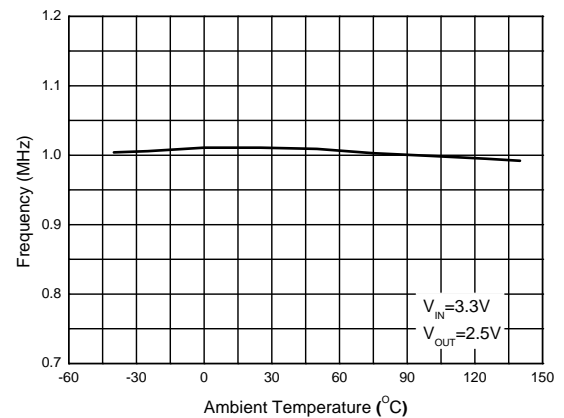
PMOS ON Resistance vs. Ambient Temperature



NMOS ON Resistance vs. Ambient Temperature

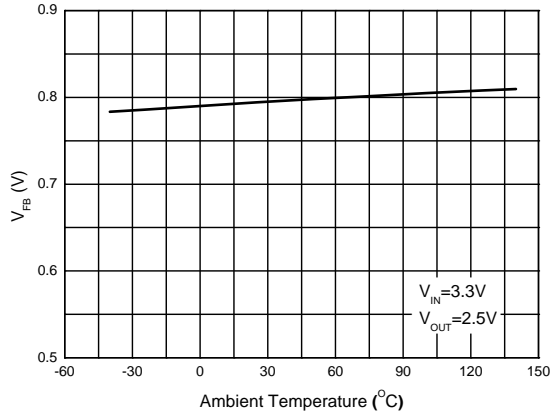


Frequency vs. Ambient Temperature

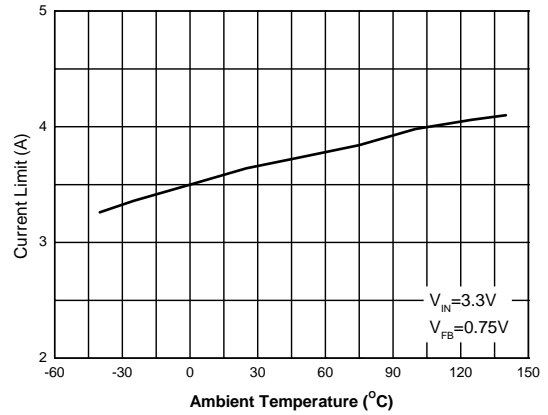


Performance Characteristics (Cont. $V_{IN}=V_{DD}=V_{PVDD}=3.3V$, $T_A=+25^{\circ}C$, unless otherwise specified.)

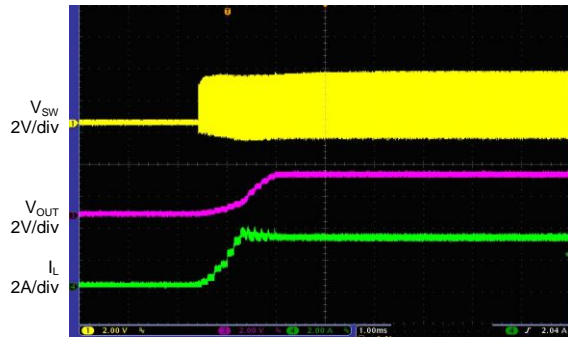
V_{FB} vs. Ambient Temperature



Current Limit vs. Ambient Temperature

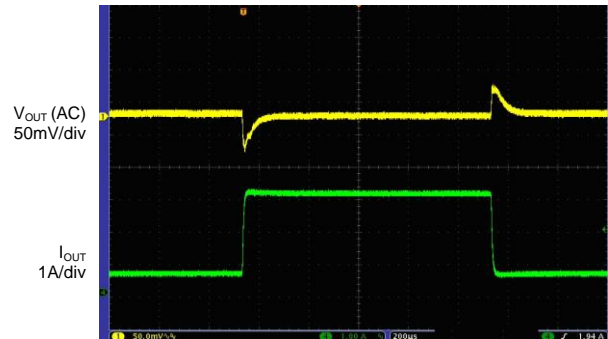


Start-up from V_{IN} ($V_{IN}=3.3V$, $V_{OUT}=2.5V$, $I_{OUT}=3A$)



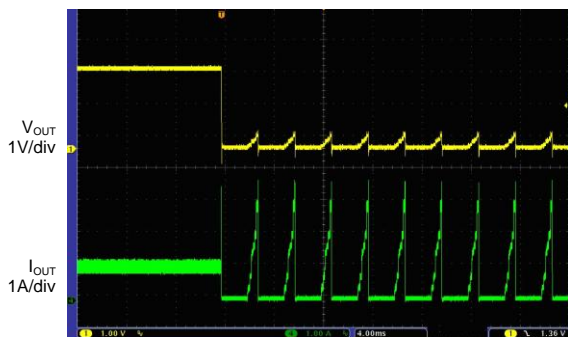
Time 1ms/div

Load Transient Response ($V_{IN}=3.3V$, $V_{OUT}=2.5V$, $I_{OUT}=0.5A$ to $3A$)



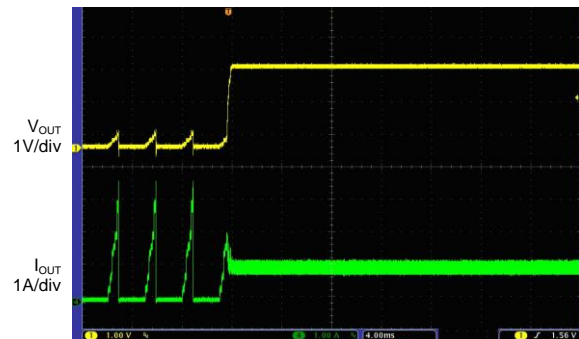
Time 200µs/div

Short Circuit Protection ($V_{IN}=3.3V$, $V_{OUT}=2.5V$)



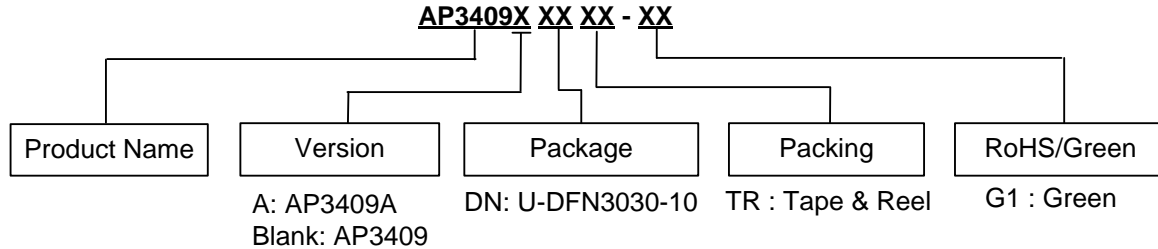
Time 4ms/div

Short Circuit Recovery ($V_{IN}=3.3V$, $V_{OUT}=2.5V$)



Time 4ms/div

Ordering Information

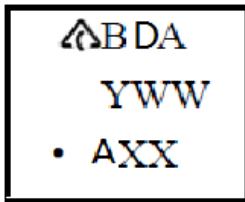


Diodes IC's Pb-free products with "G1" suffix in the part number, are RoHS compliant and green.

| Package | Temperature Range | Part Number | Marking ID | Packing |
|--------------|-------------------|----------------|------------|------------------|
| U-DFN3030-10 | -40 to +125°C | AP3409DNTR-G1 | BDA | 5000/Tape & Reel |
| | | AP3409ADNTR-G1 | BCA | 5000/Tape & Reel |

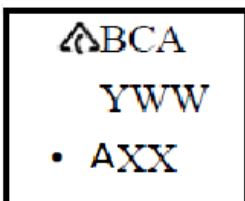
Marking Information

AP3409 (Top View)



First Line: Logo and Marking ID
 Second and Third Lines: Date Code
 Y: Year
 WW: Work Week of Molding
 A: Assembly House Code
 XX: 7th and 8th Digits of Batch No.

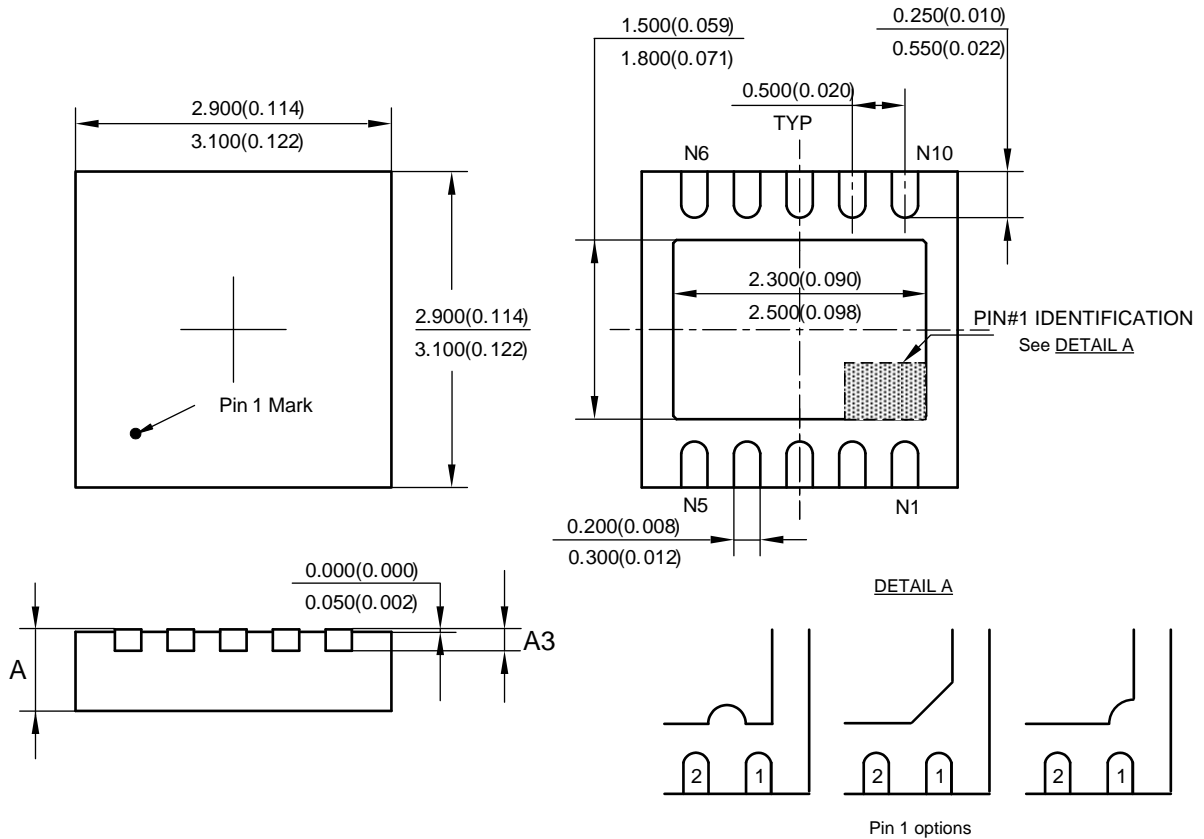
AP3409A (Top View)



First Line: Logo and Marking ID
 Second and Third Lines: Date Code
 Y: Year
 WW: Work Week of Molding
 A: Assembly House Code
 XX: 7th and 8th Digits of Batch No.

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

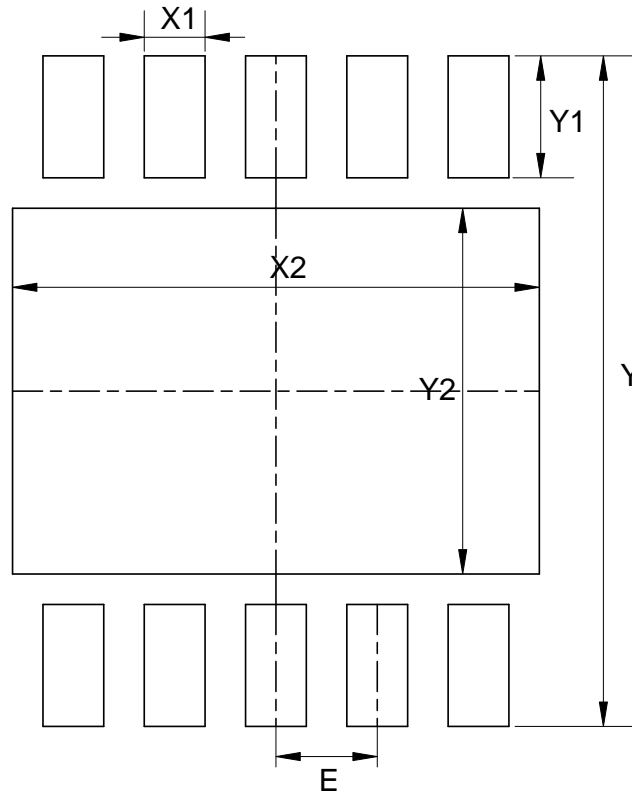
(1) Package Type: U-DFN3030-10



| Symbol | A | | | | A3 | | | |
|----------|---------|---------|-----------|-----------|-------------|---------|-------------|-----------|
| | min(mm) | max(mm) | min(inch) | max(inch) | min(mm) | max(mm) | min(inch) | max(inch) |
| Option 1 | 0.700 | 0.800 | 0.028 | 0.031 | 0.153 | 0.253 | 0.006 | 0.010 |
| Option 2 | 0.570 | 0.630 | 0.022 | 0.025 | 0.150 (Typ) | | 0.006 (Typ) | |

Suggested Pad Layout

(1) Package Type: U-DFN3030-10



| Dimensions | Y (mm)/(inch) | X1 (mm)/(inch) | Y1 (mm)/(inch) | X2 (mm)/(inch) | Y2 (mm)/(inch) | E (mm)/(inch) |
|------------|------------------|-------------------|-------------------|-------------------|-------------------|------------------|
| Value | 3.300/0.130 | 0.300/0.012 | 0.600/0.024 | 2.600/0.102 | 1.800/0.071 | 0.500/0.020 |

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