

## 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.

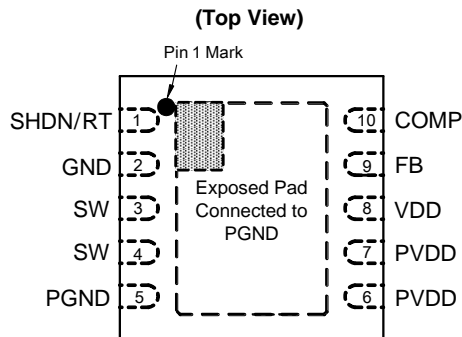
### Features

- 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)**

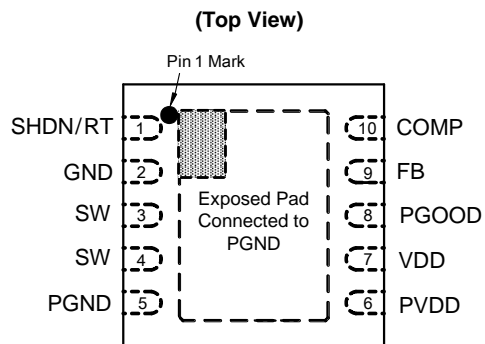
Notes:

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](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**

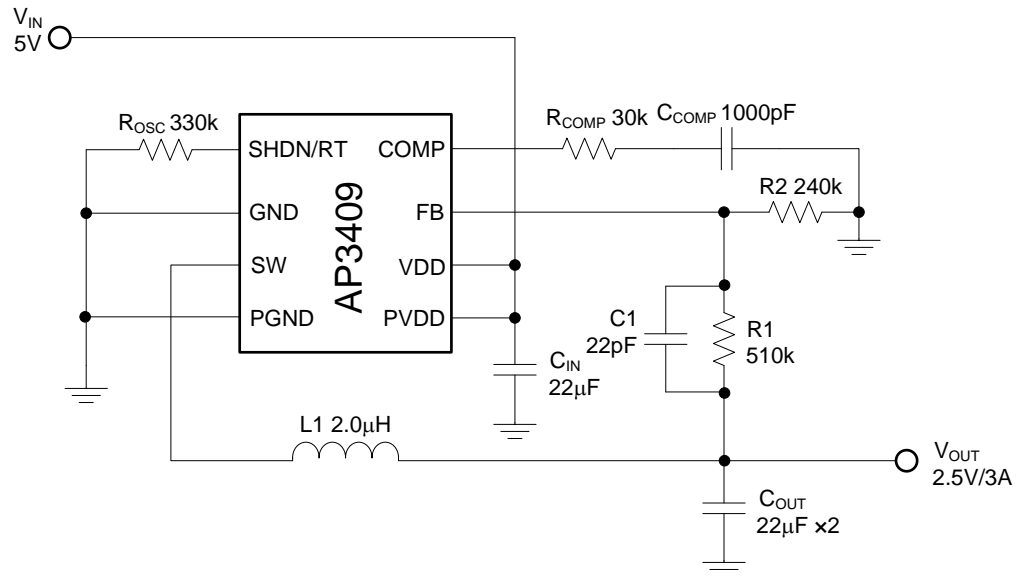


**U-DFN3030-10 (DN Package)  
For AP3409A**

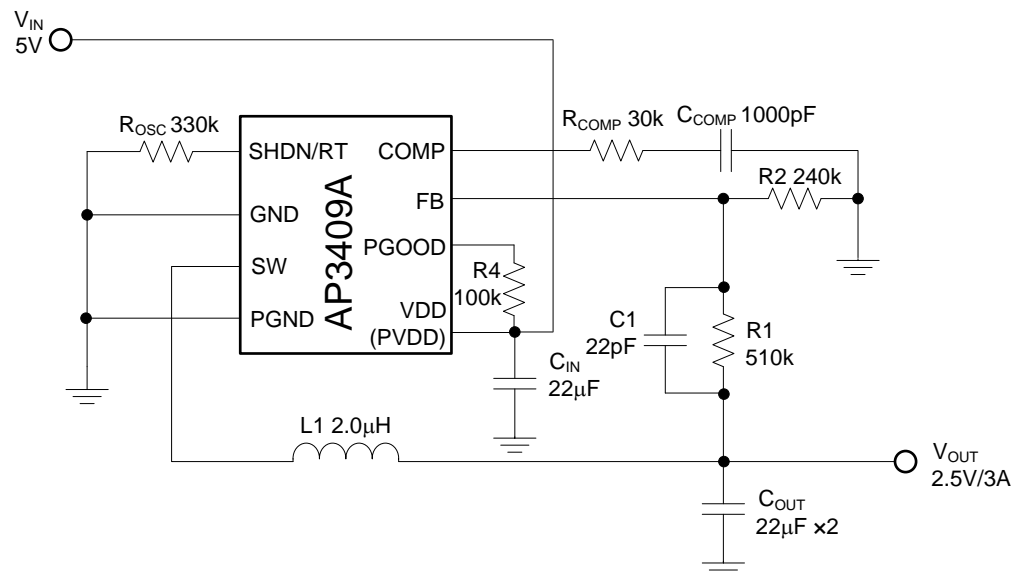
### Applications

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

## Typical Applications Circuit (Note 4)



Typical Application of AP3409



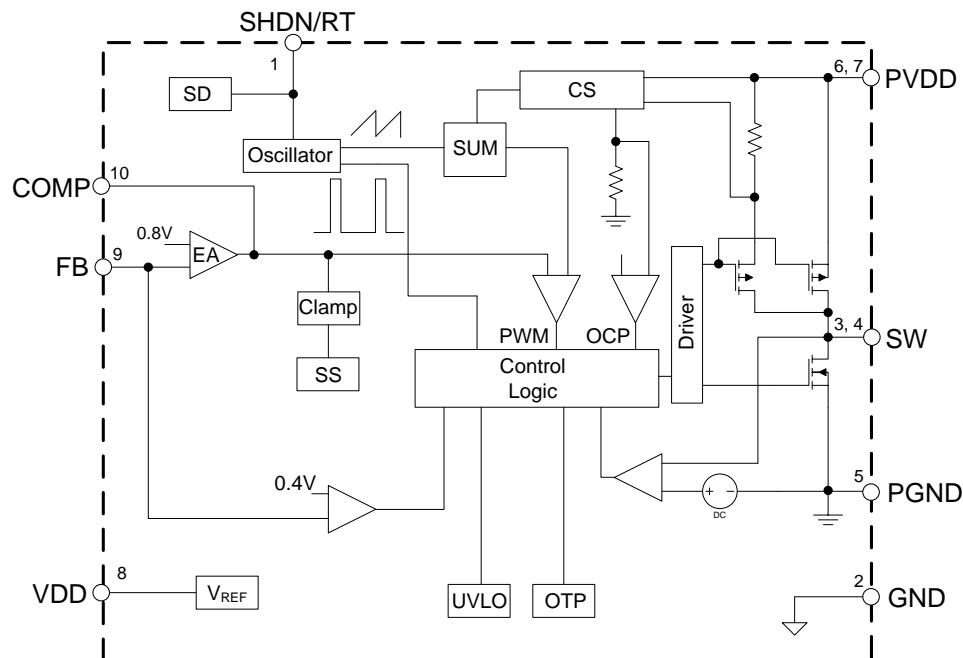
Typical Application of AP3409A

Notes 4:  $V_{OUT} = \frac{V_{FB} \times (R_1 + R_2)}{R_2}$

## Pin Descriptions

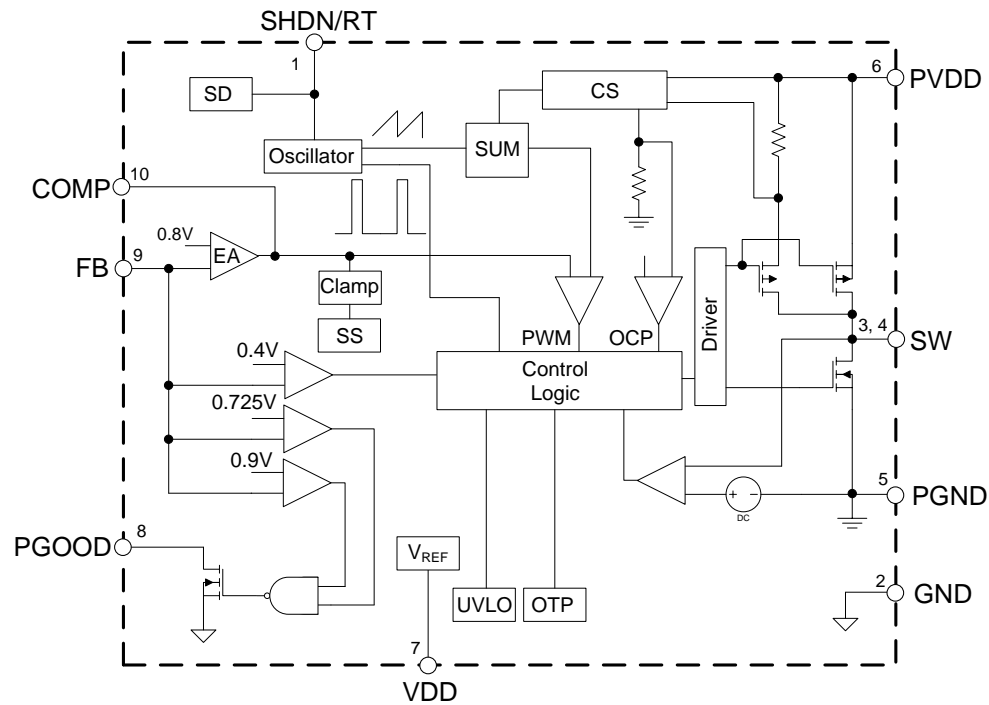
Pin Number		Pin Name	Function
AP3409	AP3409A		
1	1	SHDN/RT	Oscillator resistor input. Connect a resistor to GND from this pin to set the switching frequency. Forcing this pin to $V_{DD}$ to shutdown the device
2	2	GND	Signal ground. All small-signal ground, such as the compensation components and exposed 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
$\theta_{JA}$	Thermal Resistance (Junction to Ambient)	110	°C/W
$\theta_{JC}$	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

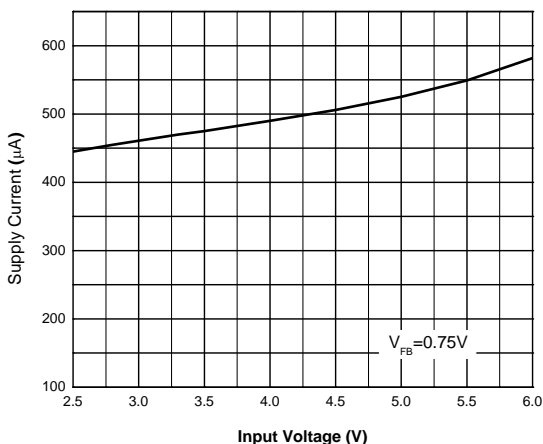
Symbol	Parameter	Min	Max	Unit
$V_{IN}$	Input Voltage	2.6	5.5	V
$I_{OUT (MAX)}$	Maximum Output Current	3	–	A
$T_J$	Operating Junction Temperature	-40	+125	°C

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

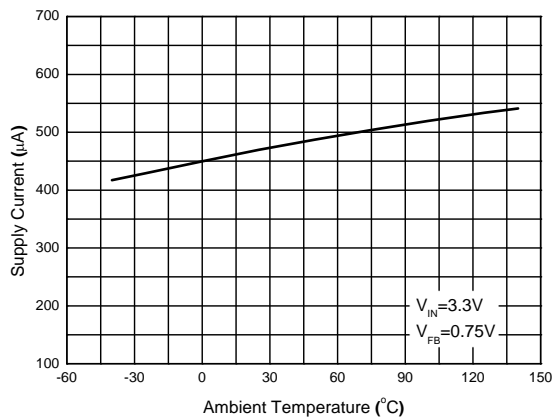
Symbol	Parameter	Conditions	Min	Typ	Max	Unit	
INPUT SECTION							
V <sub>DD</sub>	Input Voltage Range		2.6	–	5.5	V	
I <sub>Q</sub>	Supply Current	V <sub>FB</sub> =0.75V, No Switching	–	460	–	μA	
I <sub>SHDN</sub>	Shutdown Supply Current	Shutdown, V <sub>IN</sub> =5.5V	–	–	1	μA	
V <sub>UVLO</sub>	Under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

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

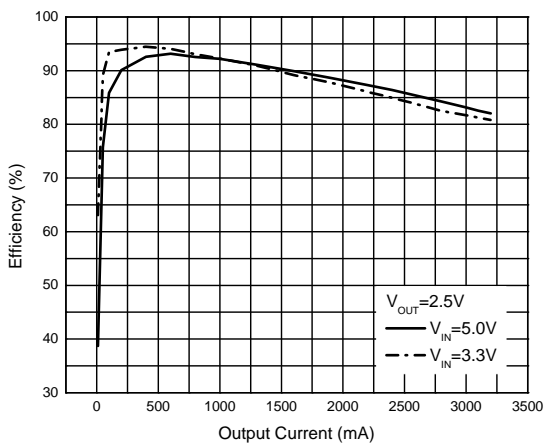
**Supply Current vs. Input Voltage**



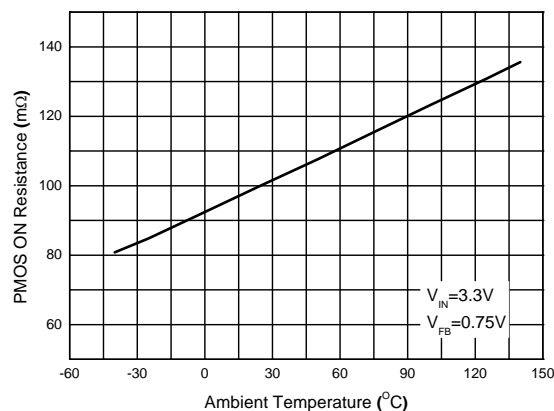
**Supply Current vs. Ambient Temperature**



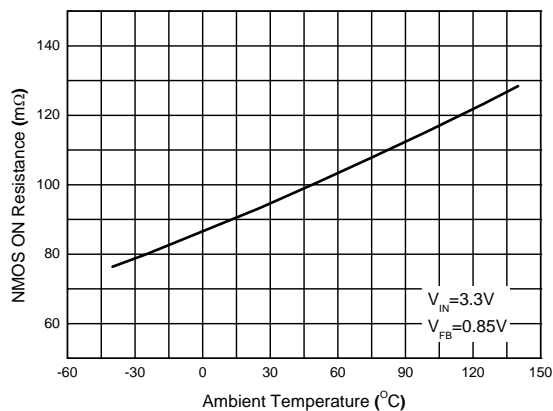
**Efficiency vs. Output Current**



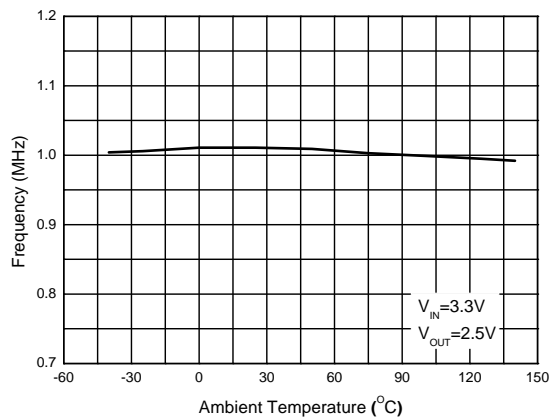
**PMOS ON Resistance vs. Ambient Temperature**



**NMOS ON Resistance vs. Ambient Temperature**

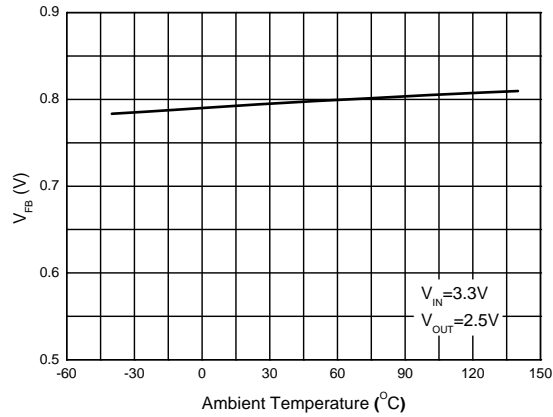


**Frequency vs. Ambient Temperature**

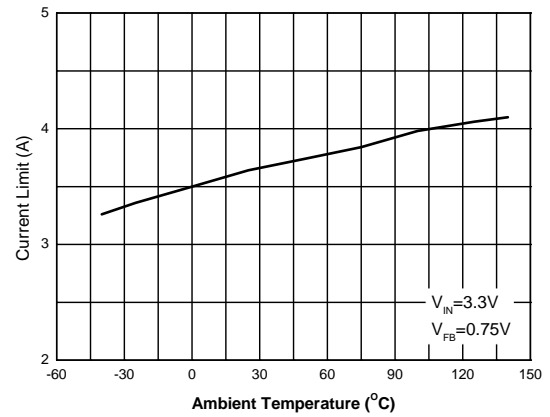


**Performance Characteristics** (Cont.  $V_{IN}=V_{DD}=V_{PVD}=3.3V$ ,  $T_A=+25^{\circ}C$ , unless otherwise specified.)

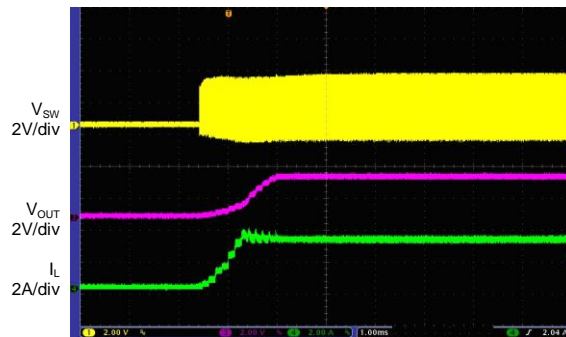
**$V_{FB}$  vs. Ambient Temperature**



**Current Limit vs. Ambient Temperature**



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



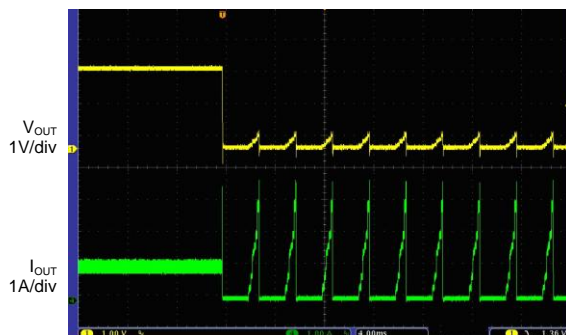
Time 1ms/div

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



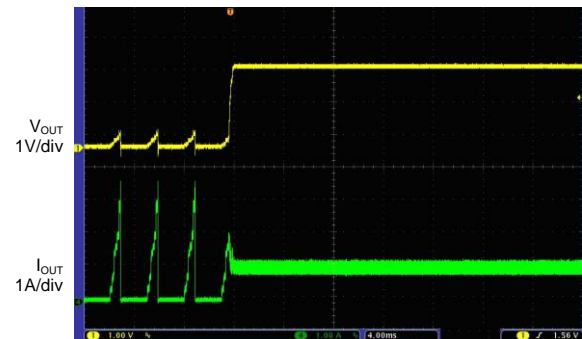
Time 200µs/div

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



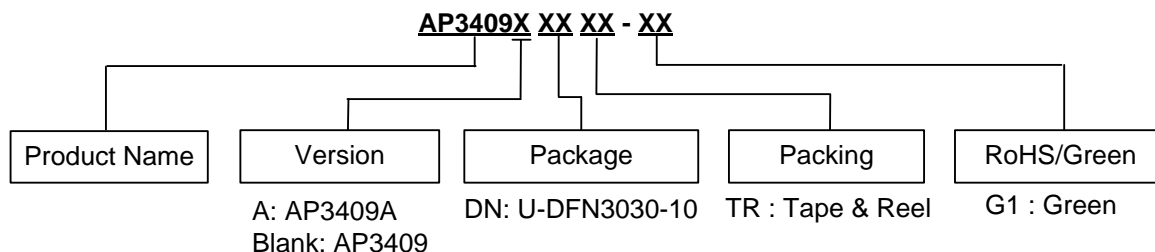
Time 4ms/div

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



Time 4ms/div

## Ordering Information

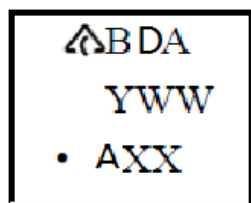


Diodes IC's Pb-free products with "G1" suffix in the part number, are RoHS compliant and green.

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

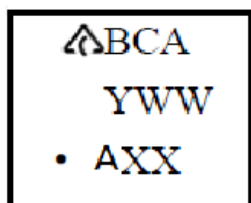
## Marking Information

### 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: 7<sup>th</sup> and 8<sup>th</sup> Digits of Batch No.

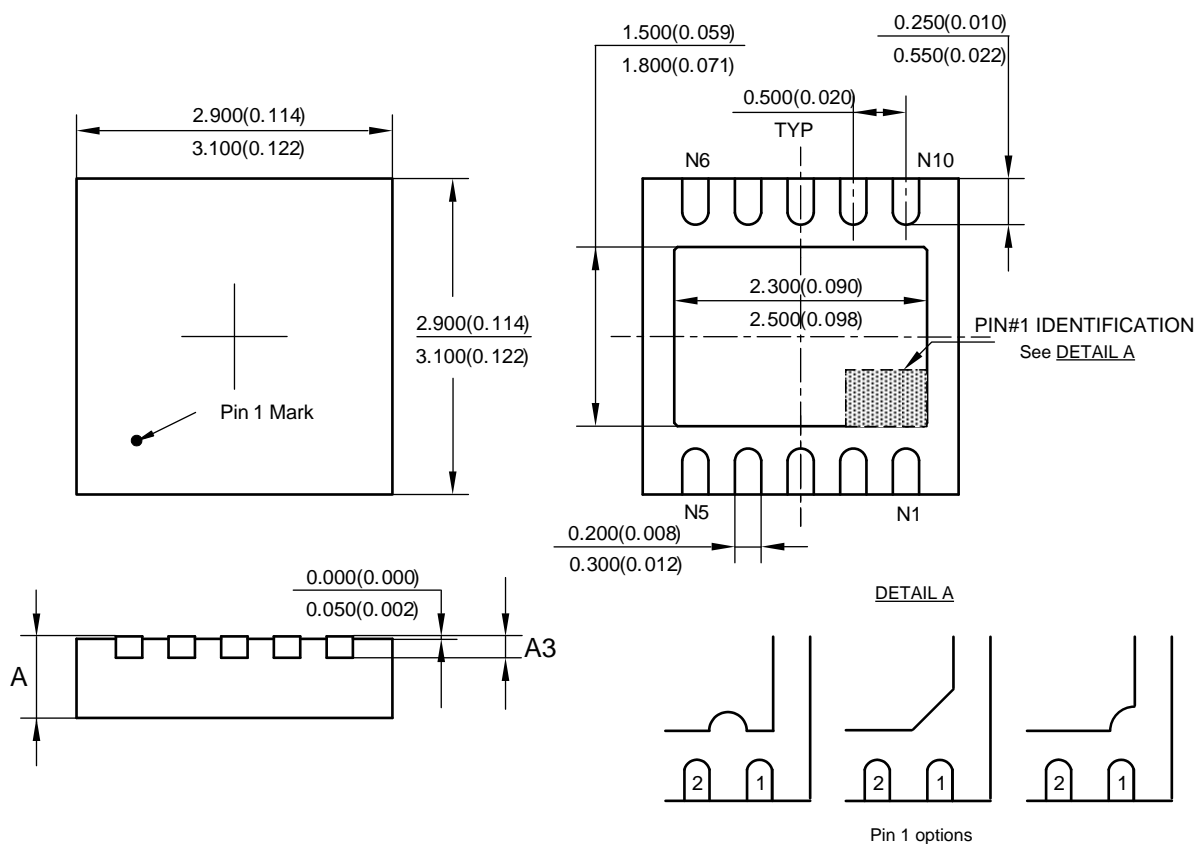
### AP3409A (Top View)



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

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

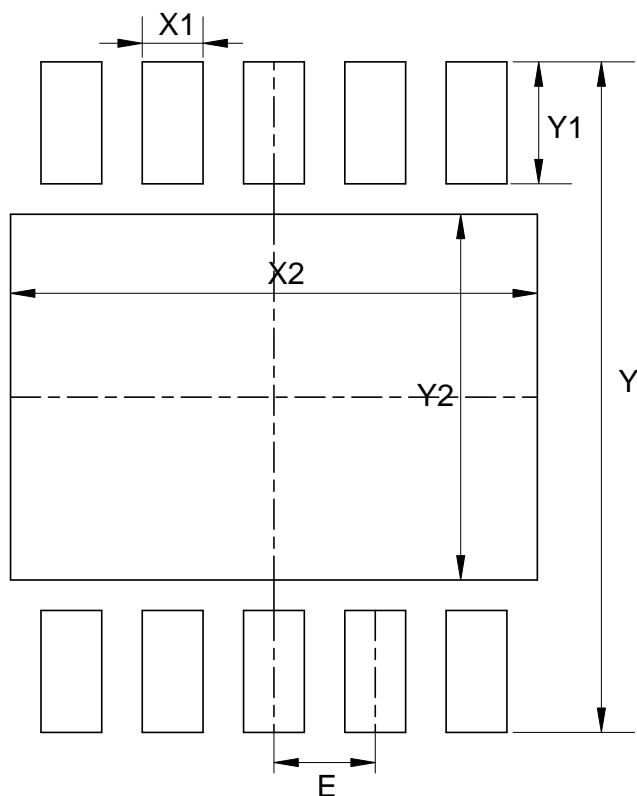
(1) Package Type: U-DFN3030-10



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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