

Description

The AP3436/A is a step-down DC-DC converter with integrated power stage capable of driving up to 3A continuous output current. It integrates 2 N-channel power MOSFETs with low on-resistance. Current mode control provides fast transient response and cycle-by-cycle current limit.

For AP3436, the regulator adopts current-mode in forced pulse-width modulation (PWM) mode with 1.25MHz switching frequency internally, which allows small-sized components, such as capacitors and inductors. This feature greatly simplifies the design of switch-mode power supplies. Under PWM mode, the device remains at the fixed PWM operation (typical at 1.25MHz), regardless of if the load current is high or low.

For AP3436A, the regulator operates in either fixed PWM mode or a pulse-skipping modulation (PSM) mode depending on the different load conditions. The device can operate at typical 1.25MHz fixed switching frequency under heavy load condition. At light load, the regulator enters a PSM mode to minimize the switching loss by reducing the switching frequency.

The AP3436/A provides EN function. Pulling this pin high statically enables the device while pulling the pin low statically for longer than 10µs will shut it down.

Under Voltage Lockout is internally set at 2.75V for V_{CC} detection. The output voltage startup ramp is controlled by the soft start. An open drain power good signal indicates the output is within 75% to 125% of its nominal voltage.

The AP3436/A is available in U-DFN3030-10 package.

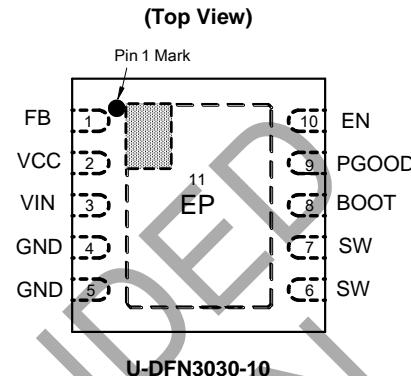
Applications

- Desktop & Notebook
- Low Voltage, High Density Power System
- Consumer Application Such as Set Top Box, LCD Display and CPE Equipment

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.

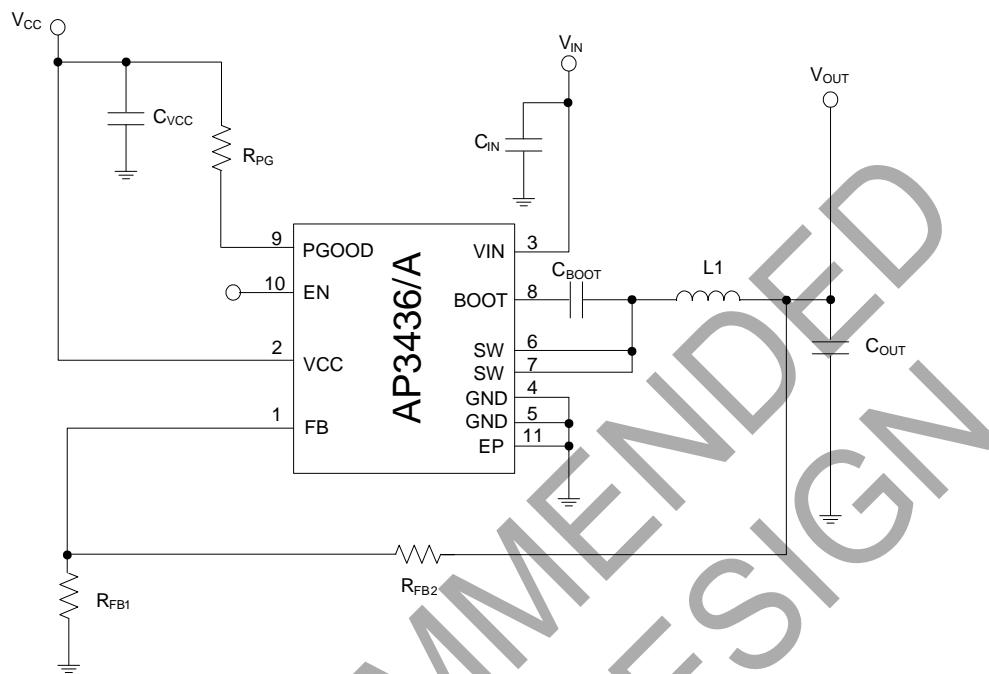
Pin Assignments



Features

- Analog Power Input V_{CC} Range: 3.0V to 5.5V
- Power Input V_{IN} Range: 1.3V to 5.5V
- 0.6V Reference Voltage with $\pm 1.5\%$ Precision
- 2 MOSFETs (Typ 50mΩ) for High Efficiency at 3A Loads
- High Efficiency: Up to 95%
- Output Current: 3A
- Current Mode Control
- Built-in Soft Start Function
- UV and OV Power Good Output
- Built-in UV and OV Protection Function
- Built-in Over Current Protection
- Built-in Thermal Shutdown Function
- Thermally Enhanced 3mmx3mm DFN Package
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Typical Applications Circuit



Note 4: When using a single power supply for V_{cc} and V_{IN}, a 4.7Ω resistor should be placed between them for noise isolation.

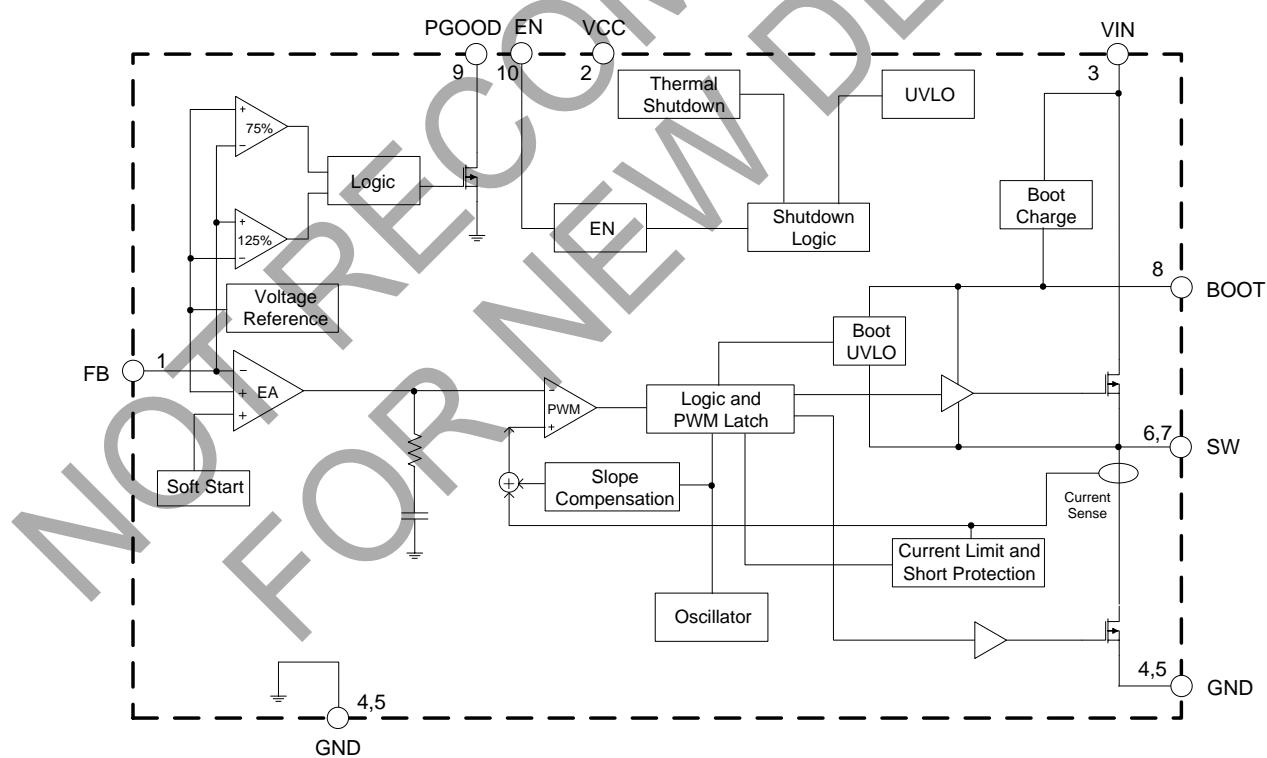
| Component | Value | Unit | Component | Value | Unit |
|------------------|-------|------|-------------------|-------|------|
| C _{VCC} | 1 | µF | C _{IN} | 44 | µF |
| R _{PG} | 10 | kΩ | C _{BOOT} | 0.1 | µF |
| R _{FB2} | TBD | kΩ | L ₁ | 1.5 | µH |
| R _{FB1} | TBD | kΩ | C _{OUT} | 88 | µF |

Table 1. Component Guide

Pin Descriptions

| Pin Number | Pin Name | Function |
|------------|-------------|--|
| 1 | FB | Voltage Feedback Input. Connect to V_{OUT} through a voltage divider to set the output voltage |
| 2 | VCC | Analog Power Input |
| 3 | VIN | Power Input |
| 4, 5 | GND | Ground. Must be Connected to GND on PCB |
| 6, 7 | SW | Power Switch Output |
| 8 | BOOT | High Side Switch Driver Supply |
| 9 | PGOOD | Open Drain Power Good Output |
| 10 | EN | Enable |
| 11 | Exposed Pad | Thermal Connection to the PCB. Must be connected to GND on PCB |

Functional Block Diagram



Absolute Maximum Ratings (Note 5)

| Symbol | Parameter | Rating | Unit |
|---------------------|--|----------------------|------|
| V_{CC}, V_{IN} | VCC, VIN Pin Voltage | -0.3 to 6 | V |
| V_{EN} | EN Pin Voltage | -0.3 to 6 | V |
| V_{SW} | SW Pin Voltage | -0.3 to $V_{IN}+0.3$ | V |
| $V_{SW_TRANSIENT}$ | SW Pin Transient Voltage (<50ns) | -5 to $V_{IN}+5$ | V |
| V_{FB} | FB Pin Voltage | -0.3 to 6 | V |
| V_{PGD} | PGOOD Pin Voltage | -0.3 to 6 | V |
| V_{BOOT_SW} | BOOT to SW Voltage | 0 to 6 | V |
| θ_{JA} | Thermal Resistance (Junction to Ambient, Simulation) | 33 | °C/W |
| θ_{JC} | Thermal Resistance (Junction to Case) | 3 | °C/W |
| T_J | Operating Junction Temperature | -40 to +150 | °C |
| T_{STG} | Storage Temperature | -65 to +150 | °C |
| T_{LEAD} | Lead Temperature (Soldering, 10sec) | +260 | °C |
| V_{HBM} | ESD (Human Body Model) | 2000 | V |
| V_{MM} | ESD (Machine Model) | 200 | 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_{CC} | Analog Input Voltage | 3.0 | 5.5 | V |
| V_{IN} | Power Input Voltage | 1.3 | 5.5 | V |
| $I_{OUT(MAX)}$ | Maximum Output Current | 3 | – | A |
| V_{OUT} | Output Voltage | 0.8 | V_{IN} | V |
| T_A | Operating Ambient Temperature | -40 | +85 | °C |

Electrical Characteristics ($V_{CC} = 5V$, $V_{IN} = 5V$, $T_A = +25^\circ C$, unless otherwise specified.)

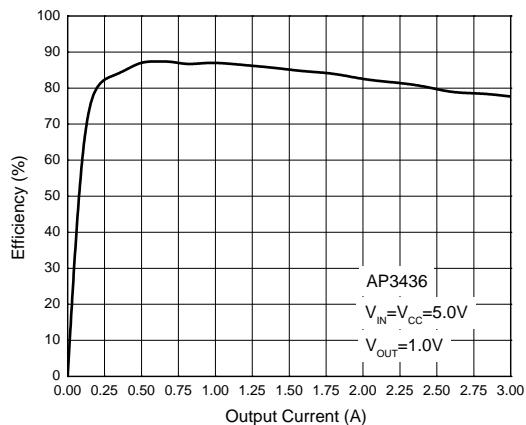
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|--------------------------------------|---|---|-------|-------|-------|-----------|
| SUPPLY VOLTAGE (VCC, VIN PIN) | | | | | | |
| V_{CC} | Analog Power Input Voltage | — | 3.0 | — | 5.5 | V |
| V_{IN} | Power Input Voltage | — | 1.3 | — | 5.5 | V |
| I_Q | Quiescent Current | $V_{FB} = 1.5V$, $V_{CC} = 5V$, $V_{IN} = 5V$ | — | 400 | — | μA |
| I_{SHDN} | Shutdown Supply Current | $V_{EN} = 0V$, $3.0V \leq V_{CC} \leq 5.5V$, $1.3V \leq V_{IN} \leq 5.5V$ | — | — | 1 | μA |
| POWER ON RESET | | | | | | |
| V_{UVLO} | Internal Under Voltage Lockout Threshold for V_{CC} | — | — | 2.75 | 2.85 | V |
| V_{HYS_VCC} | Internal Under Voltage Hysteresis for V_{CC} | — | — | 150 | — | mV |
| VOLTAGE REFERENCE (FB PIN) | | | | | | |
| V_{FB} | Voltage Reference | $3.0V \leq V_{CC} \leq 5.5V$ | 0.591 | 0.600 | 0.609 | V |
| INTERNAL PWM FREQUENCY | | | | | | |
| f | PWM Frequency | $3.0V \leq V_{CC} \leq 5.5V$ | 1.0 | 1.25 | 1.5 | MHz |
| MOSFET SPEC | | | | | | |
| R_{ON_H} | High Side Switch On-resistance | $V_{BOOT_SW} = 5.0V$ | — | 50 | 100 | $m\Omega$ |
| | | $V_{BOOT_SW} = 3.0V$ | — | 70 | 140 | $m\Omega$ |
| R_{ON_L} | Low Side Switch On-resistance | $V_{CC} = 5.0V$ | — | 50 | 100 | $m\Omega$ |
| | | $V_{CC} = 3.0V$ | — | 70 | 140 | $m\Omega$ |
| CURRENT LIMIT | | | | | | |
| I_{LIMIT} | Current Limit Threshold | — | 4.8 | 7.6 | — | A |
| THERMAL SHUTDOWN | | | | | | |
| T_{TSD} | Thermal Shutdown | — | — | +160 | — | °C |
| — | Hysteresis | — | — | +20 | — | °C |
| BOOT SPEC (BOOT PIN) | | | | | | |
| R_{BOOT} | BOOT Charge Resistor | $V_{CC} = 5.0V$ | — | 16 | — | Ω |
| — | BOOT to SW UVLO | $V_{CC} = 3.0V$ | — | 2.2 | — | V |
| SOFT START | | | | | | |
| t_{SS} | Soft Start Time | — | 0.8 | — | 2 | ms |

Electrical Characteristics (Cont. $V_{CC} = 5V$, $V_{IN} = 5V$, $T_A = +25^\circ C$, unless otherwise specified.)

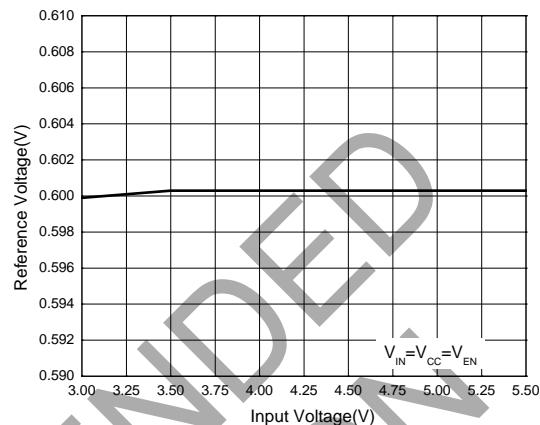
| Symbol | Parameter | Conditions | Min | Typ | Max | Unit |
|-------------------------------|---|---|----------------------|-----------|----------------------|----------------------|
| ENABLE (EN PIN) | | | | | | |
| V_{EN_L} | EN Pin Threshold | — | — | — | 0.8 | V |
| V_{EN_H} | | — | 1.6 | — | — | V |
| POWER GOOD (PGOOD PIN) | | | | | | |
| V_{FBTH} | Feedback Threshold | V_{FB} falling (Fault) | 70 | 75 | — | % V_{REF} |
| | | V_{FB} rising (Good) | 77 | 82 | — | |
| | | V_{FB} rising (Fault) | — | 125 | 130 | |
| | | V_{FB} falling (Good) | — | 118 | 123 | |
| t_{PG_DLY} | Delay Time for PGOOD from High to Low | — | — | 30 | — | μs |
| R_{PG} | Internal Power Good Pull Low Resistance | — | — | — | 150 | Ω |
| R_{PG_UP} | External Pull-up Resistance Range | — | 3000 | — | — | Ω |
| SYSTEM PERFORMANCE | | | | | | |
| V_{UVP} | Output Under Voltage Protection Threshold | $V_{IN} = 1.3$ to $5.5V$ | — | — | $0.5 \times V_{OUT}$ | V |
| t_{UVP} | Delay Time for UVP Triggered | $V_{IN} = 1.5$ to $5V$ | — | 65 | — | μs |
| V_{OVP} | Output Over Voltage Protection Threshold | $V_{IN} = 1.3$ to $5.5V$ | $1.5 \times V_{OUT}$ | — | — | V |
| t_{OVP} | Delay Time for OVP Triggered | $V_{IN} = 1.5$ to $5V$ | — | 65 | — | μs |
| I_{OUT} | Output Current | $V_{IN} = 1.5$ to $5V$, $V_{OUT} = 1.0V$ | 3 | — | — | A |
| — | Output Voltage Line Regulation | $V_{IN} = 1.5$ to $5V$, $I_{OUT} = 100mA$ | — | 0.4 | — | % $\times V_{OUT}/V$ |
| — | Output Voltage Load Regulation | $I_{OUT} = 0A$ to $3A$ | — | 0.3 | — | % $\times V_{OUT}/A$ |
| V_{TRAN} | Output Voltage Load Transient | $V_{IN} = 5V$, $V_{OUT} = 1.0V$, $di/dt = 400mA/\mu s$ | — | ± 2.5 | — | % $\times V_{OUT}/A$ |
| η | Efficiency | $V_{CC} = 5V$, $V_{IN} = 5V$, $I_{OUT} = 3A$, $V_{OUT} = 1.2V$ | — | 80 | — | % |

Performance Characteristics

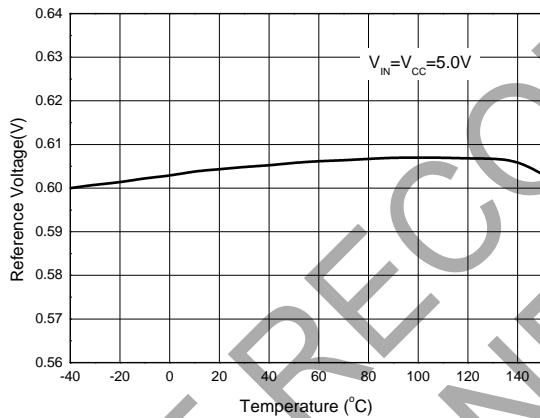
Efficiency vs. Output Current



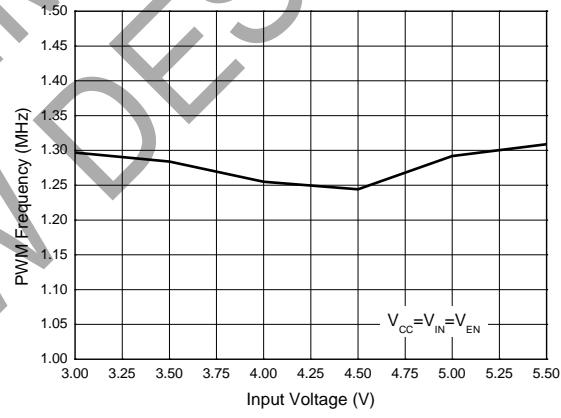
Reference Voltage vs. Input Voltage



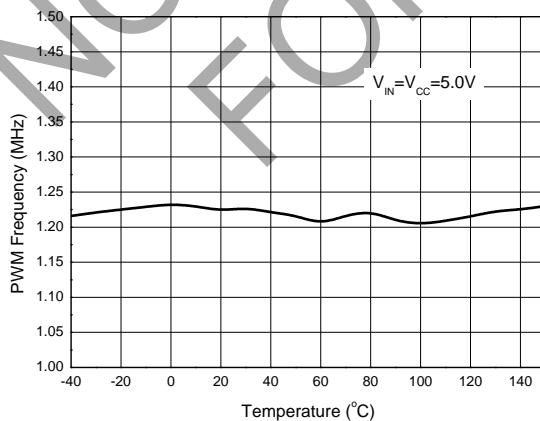
Reference Voltage vs. Temperature



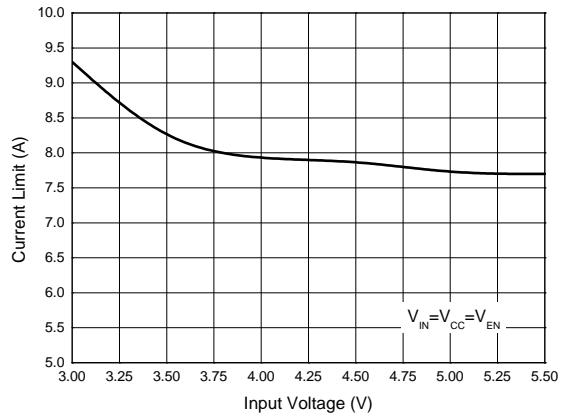
PWM Frequency vs. Input Voltage



PWM Frequency vs. Temperature

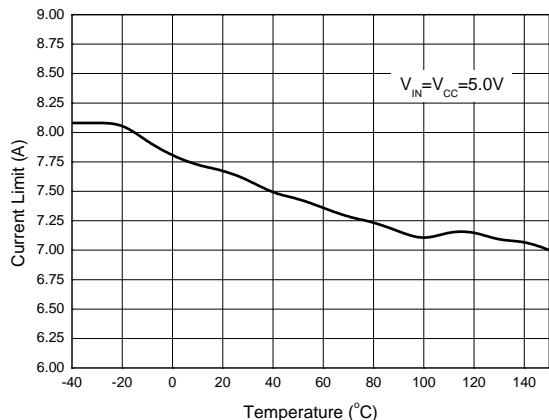


Current Limit vs. Input Voltage

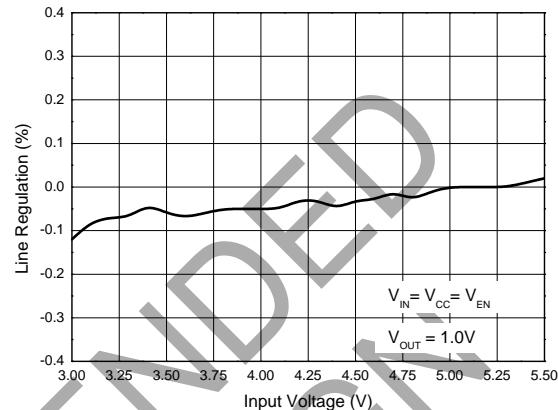


Performance Characteristics (Cont.)

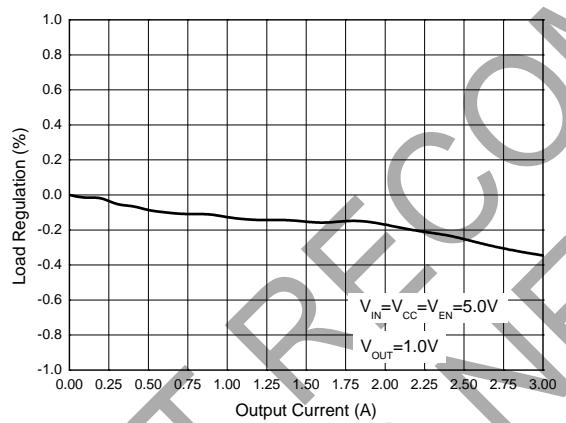
Current Limit vs. Temperature



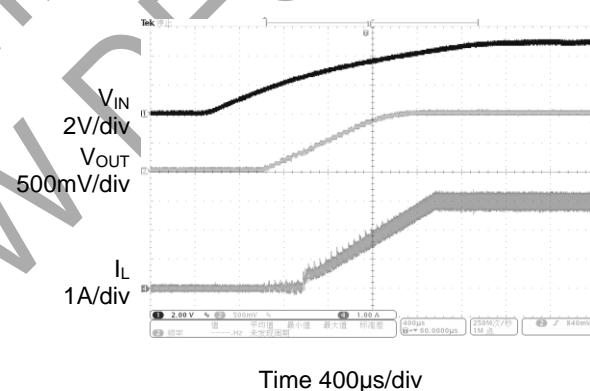
Line Regulation vs. Input Voltage



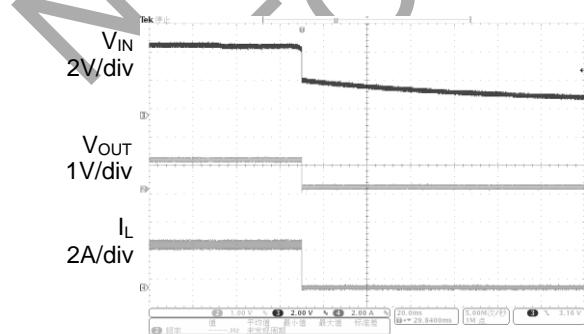
Load Regulation vs. Output Current



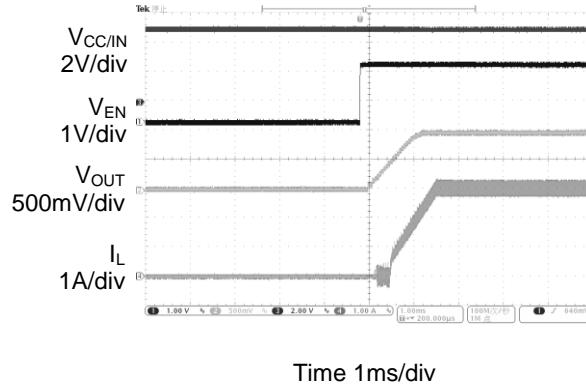
Power on Waveform
($V_{IN} = V_{CC} = 5V$, $V_{OUT} = 1V$, $I_{OUT} = 3A$)



Power off Waveform
($V_{IN} = V_{CC} = 5V$, $V_{OUT} = 1V$, $I_{OUT} = 3A$)

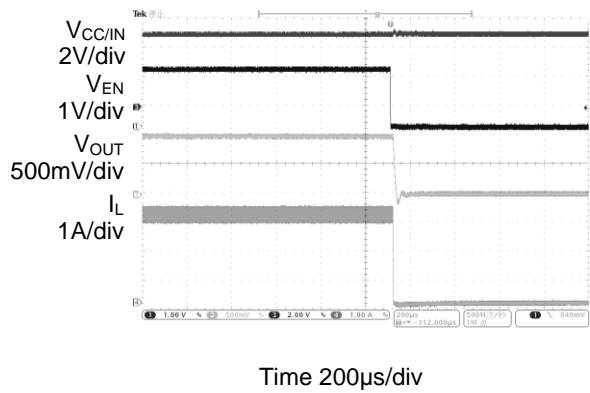


Enable Waveform
($V_{IN} = V_{CC} = 5V$, $V_{OUT} = 1V$, $I_{OUT} = 3A$)

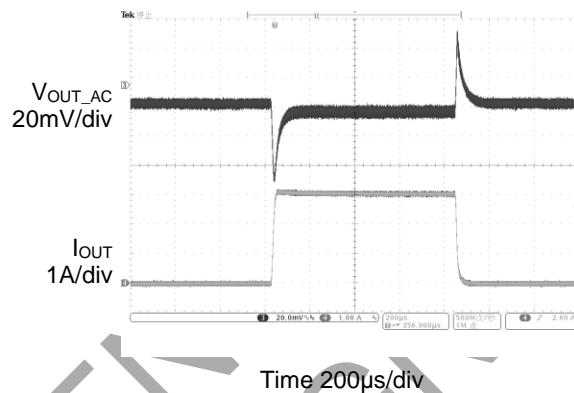


Performance Characteristics (Cont.)

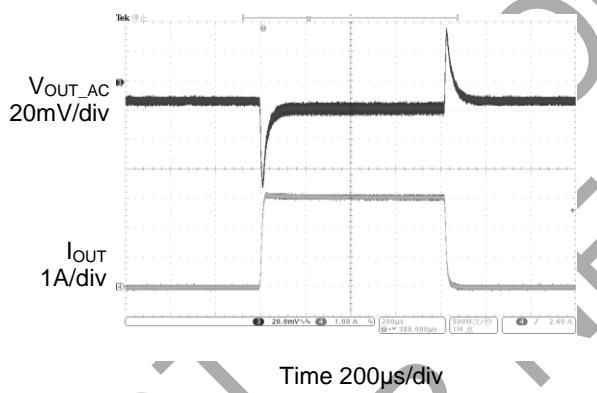
Disable Waveform
($V_{IN}=V_{CC}=5V$, $V_{OUT}=1V$, $I_{OUT}=3A$)



Load Transient Response
($V_{IN}=V_{CC}=5V$, $V_{OUT}=1V$, $I_{OUT}=0$ to $3A$)



Load Transient Response
($V_{IN}=V_{CC}=3.3V$, $V_{OUT}=1V$, $I_{OUT}=0$ to $3A$)



NOT FOR NEW DESIGN

Application Information

1. Overview

The AP3436/A is a 3A synchronous buck (step-down) converter with two integrated N-channel MOSFETs. For AP3436, the regulator operates in PWM mode with 1.25MHz switching frequency internally, regardless of if the load current is high or low. For AP3436A, when the load is very light, the regulator automatically operates in the PSM mode to minimize the switching loss, thus achieving high efficiency at light load. When the load increases, the regulator automatically switches over to a current-mode PWM operating at nominal 1.25MHz switching frequency.

2. Power On Reset

A Power On Reset (POR) circuitry continuously monitors the supply voltage at VCC pin. Once the rising POR threshold is exceeded, the AP3436/A sets itself to active state and is ready to accept chip enable command. The rising POR threshold is typically 2.75V.

3. Soft Start

A built-in soft-start is used to prevent surge current from power supply input V_{IN} during turn on (Referring to the Functional Block Diagram). The error amplifier is a three-input device. Reference voltage V_{REF} or the internal soft-start voltage V_{SS} whichever is smaller dominates the behavior of the non-inverting inputs of the error amplifier. V_{SS} internally ramps up to 0.6V after the soft-start cycle is initiated. The ramp is created digitally, so the output voltage will follow the V_{SS} signal and ramps up smoothly to its target level.

4. EN Function

The AP3436/A provides Enable Function. Pulling this pin higher than 1.6V statically enables the AP3436/A while pulling the pin lower than 0.8V statically for longer than 10µs will shutdown the IC.

5. Adjusting Output Voltage

The output voltage is set with a resistor divider from the FB pin. It is recommended to use divider resistors with 1% tolerance or better. Start with a 100kΩ for the resistor R1 and use the following equation to calculate R2. Consider using larger value resistors to improve efficiency at very light loads. If the values are too high, the regulator is more susceptible to noise and the voltage errors caused by FB input current are noticeable.

$$R2 = \frac{R1 \times 0.6}{V_{OUT} - 0.6}$$

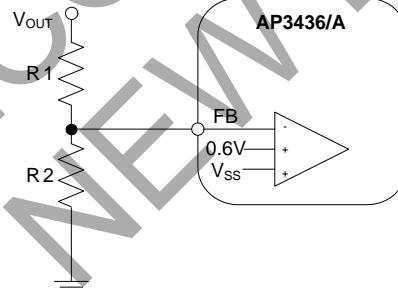


Figure 1. Voltage Divider Circuit

6. Short Circuit Protection (SCP)

The AP3436/A has Over Current Protection (OCP) and Under Voltage Protection (UVP) functions.

6.1 OCP Function

The high side switch current is detected during each cycle. During SCP conditions, the output voltage is pulled down and the switch current is increased. Once the increased high side switching current is detected to trigger the current limit of high side switch, the high side switch will be immediately turned off and will not be turned on again until the next switching cycle. When over current condition is removed, the AP3436/A will recover back to normal operation again.

6.2 UVP Function

The FB voltage is also monitored for Under Voltage Protection. The UV threshold is set at 0.2V. The under voltage protection has 65µs triggered delay. When UVP is triggered, both high side and low side are shutdown immediately. The UVP is a latched function, reset power supply or EN pin to restart AP3436/A again.

Application Information (Cont.)

7. Over Voltage Protection (OVP)

The output voltage is continuously monitored for Over Voltage Protection by FB pin. When it is larger than 1.67 times as setting, the OVP function is triggered. The Over Voltage Protection has 65µs triggered delay.

When OVP is triggered, both high side and low side are shutdown immediately and the output voltage is discharged by an internal 1kΩ resistor.

8. Power Good

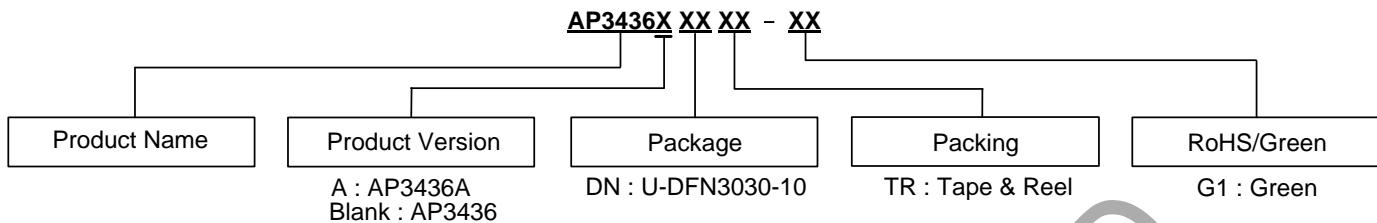
The PGOOD pin output connects an open drain MOSFET. The output is pulled low when the FB voltage enters the fault condition by falling below 75% or rising above 125% of the nominal internal reference voltage. There is a 7% hysteresis on the threshold voltage, so when the FB voltage rises to the good condition above 82% or falls below 118% of the internal voltage reference the PGOOD output MOSFET is turned off. It is recommended to use a pull-up resistor between the values of 3kΩ and 100kΩ to a voltage source that is 5V or less.

9. Thermal Shutdown

The device implements an internal thermal shutdown to protect itself if the junction temperature exceeds +160°C. Switching is stopped when the junction temperature exceeds the thermal trip threshold. Once the die temperature decreases below +140°C, the device reinitiates the soft start operation. The thermal shutdown hysteresis is +20°C.

NOT RECOMMENDED
FOR NEW DESIGN

Ordering Information

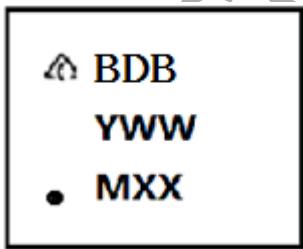


| Package | Temperature Range | Function | Part Number | Marking ID | Packing |
|--------------|-------------------|----------|----------------|------------|------------------|
| U-DFN3030-10 | -40 to +85°C | PWM | AP3436DNTR-G1 | BDB | 5000/Tape & Reel |
| | | PWM/PSM | AP3436ADNTR-G1 | BDF | 5000/Tape & Reel |

Marking Information

AP3436

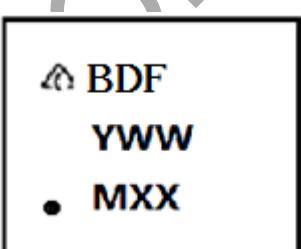
(Top View)



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

AP3436A

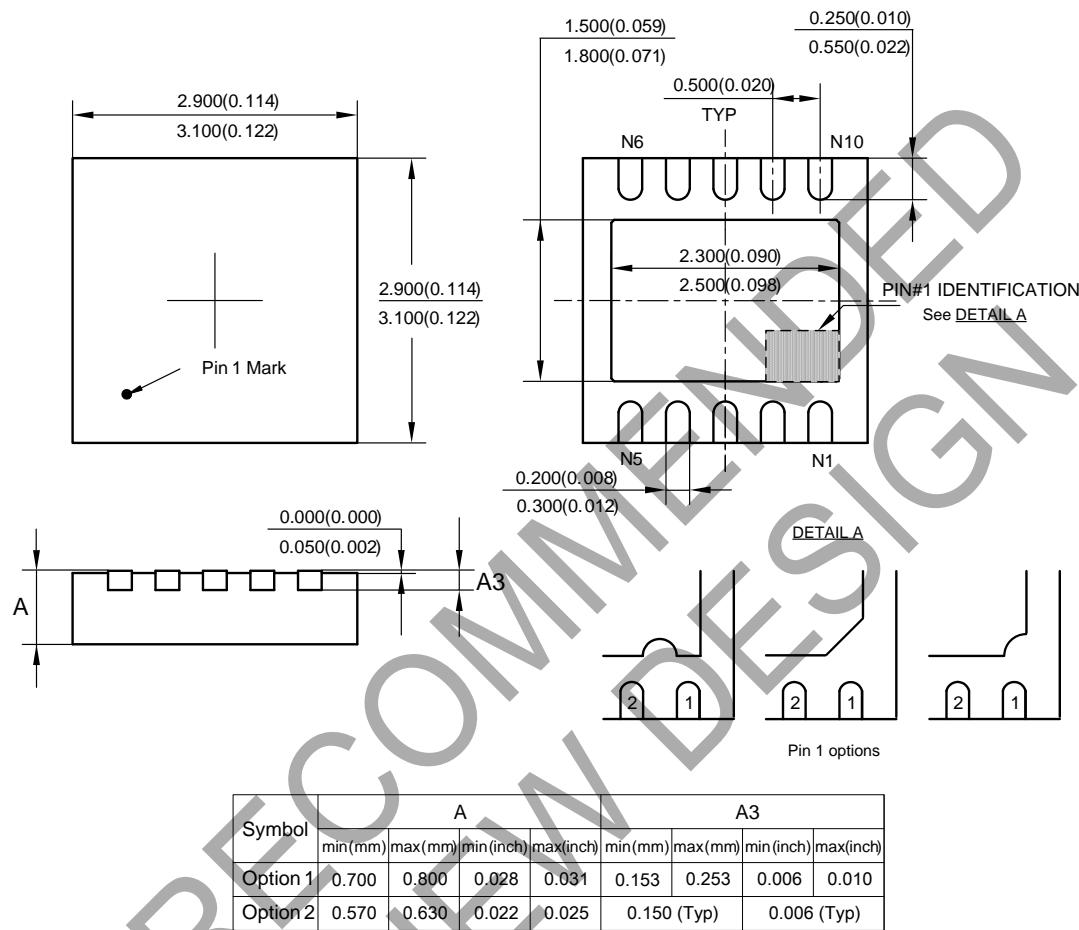
(Top View)



First Line: Logo and Marking ID
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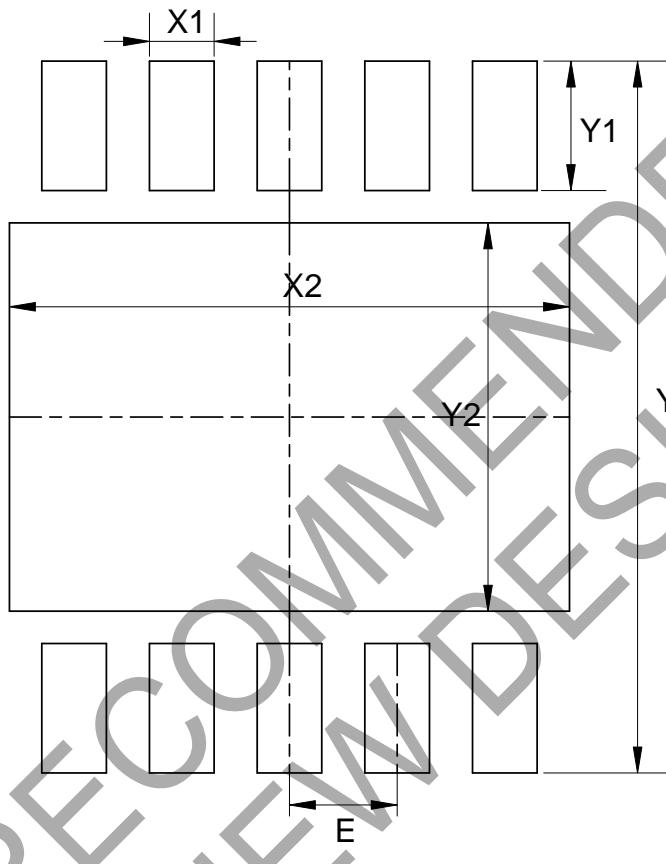
Package Outline Dimensions (All dimensions in mm(inch).)

(1) Package Type: U-DFN3030-10



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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