3A, 1.25MHz High Performance Synchronous Buck Converter AP3436/A

General 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.

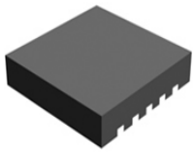
The AP3436/A is available in DFN-3×3-10 package.

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 ±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 3mm×3mm DFN Package

Applications

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



DFN-3×3-10

Figure 1. Package Type of AP3436/A

Pin Configuration

DN Package
(DFN-3×3-10)

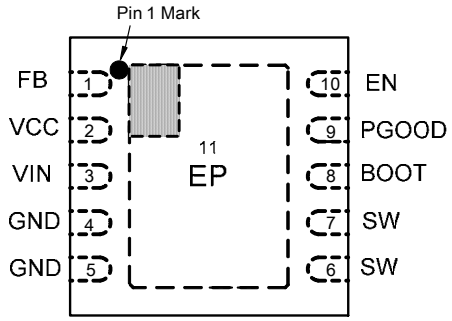


Figure 2. Pin Configuration of AP3436/A (Top View)

Pin Description

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

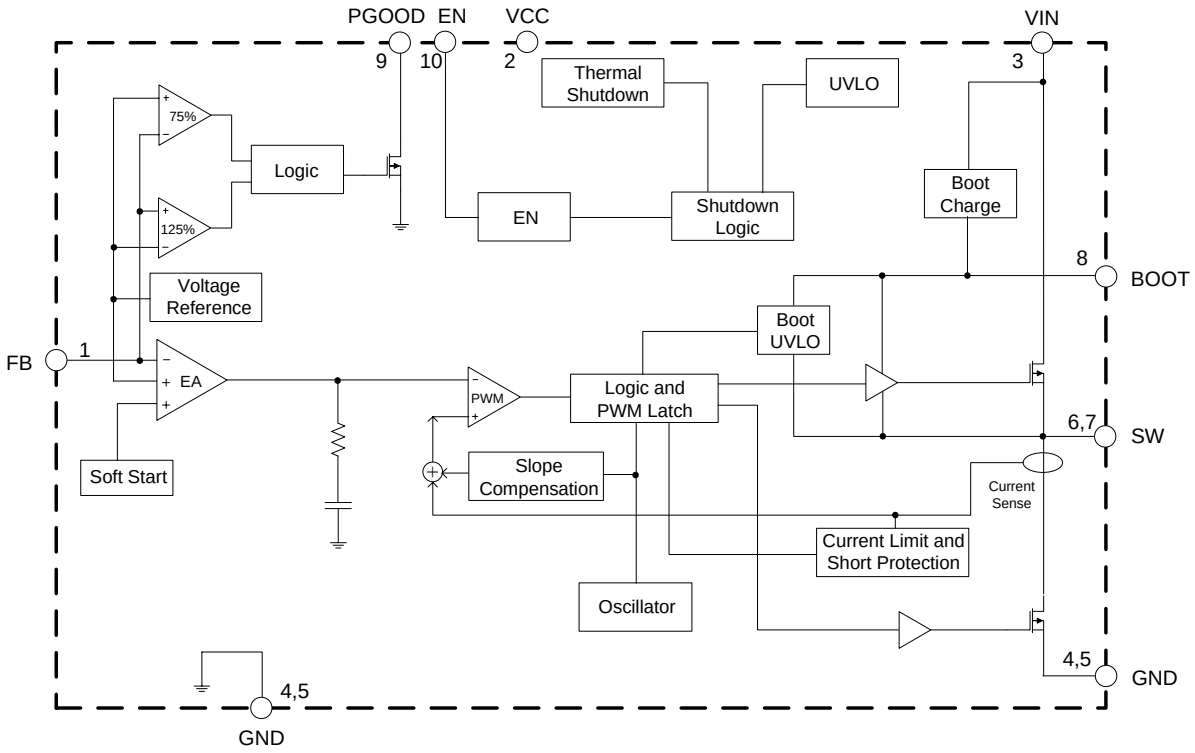
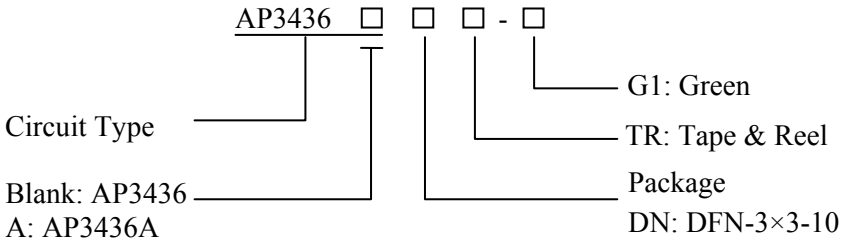


Figure 3. Functional Block Diagram of AP3436/A

Ordering Information



Package	Temperature Range	Function	Part Number	Marking ID	Packing Type
DFN-3×3-10	-40 to 85°C	PWM	AP3436DNTR-G1	BDB	Tape & Reel
		PWM/PSM	AP3436ADNTR-G1	BDF	

BCD Semiconductor's Pb-free products, as designated with "G1" in the part number, are RoHS compliant and green.

Absolute Maximum Ratings (Note 1)

Parameter	Symbol	Value	Unit
VCC, VIN Pin Voltage	V_{CC}, V_{IN}	-0.3 to 6	V
EN Pin Voltage	V_{EN}	-0.3 to 6	V
SW Pin Voltage	V_{SW}	-0.3 to V_{IN}+0.3	V
SW Pin Transient Voltage (<50ns)	$V_{SW\_TRANSIENT}$	-5 to V_{IN}+5	V
FB Pin Voltage	V_{FB}	-0.3 to 6	V
PGOOD Pin Voltage	V_{PGD}	-0.3 to 6	V
BOOT to SW Voltage	V_{BOOT_SW}	0 to 6	V
Thermal Resistance (Junction to Ambient, Simulation)	θ_{JA}	33	ºC/W
Operating Junction Temperature	T_J	-40 to 150	ºC
Storage Temperature	T_{STG}	-65 to 150	ºC
Lead Temperature (Soldering, 10sec)	T_{LEAD}	260	ºC
ESD (Human Body Model)	V_{HBM}	2000	V
ESD (Machine Model)	V_{MM}	200	V

Note 1: 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

Parameter	Symbol	Min	Max	Unit
Analog Input Voltage	V_{CC}	3.0	5.5	V
Power Input Voltage	V_{IN}	1.3	5.5	V
Maximum Output Current	$I_{OUT(MAX)}$	3		A
Output Voltage	V_{OUT}	0.8	V_{IN}	V
Operating Ambient Temperature	T_A	-40	85	ºC

Electrical Characteristics

V_{CC}=5V, V_{IN}=5V, T_A=25°C, unless otherwise specified.

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

Electrical Characteristics (Continued)

V_{CC}=5V, V_{IN}=5V, T_A=25°C, unless otherwise specified.

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
ENABLE (EN PIN)						
EN Pin Threshold	V_{EN_L}				0.8	V
	V_{EN_H}		1.6			V
POWER GOOD (PGOOD PIN)						
Feedback Threshold	V_{FBTH}	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	
Delay Time for PGOOD from High to Low	t_{PG_DLY}			30		μs
Internal Power Good Pull Low Resistance	R_{PG}				150	Ω
External Pull-up Resistance Range	R_{PG_UP}		3000			Ω
SYSTEM PERFORMANCE						
Output Under Voltage Protection Threshold	V_{UVP}	V_{IN}=1.3 to 5.5V			0.5× V_{OUT}	V
Delay Time for UVP Triggered	t_{UVP}	V_{IN}=1.5 to 5V		65		μs
Output Over Voltage Protection Threshold	V_{OVP}	V_{IN}=1.3 to 5.5V	1.5× V_{OUT}			V
Delay Time for OVP Triggered	t_{OVP}	V_{IN}=1.5 to 5V		65		μs
Output Current	I_{OUT}	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		%× V_{OUT}/V
Output Voltage Load Regulation		I_{OUT}=0A to 3A		0.3		%× V_{OUT}/A
Output Voltage Load Transient	V_{TRAN}	V_{IN}=5V, V_{OUT}=1.0V, dI/dt=400mA/μs		±2.5		%× V_{OUT}/A
Efficiency	η	V_{CC}=5V, V_{IN}=5V, I_{OUT}=3A, V_{OUT}=1.2V		80		%

Typical Performance Characteristics

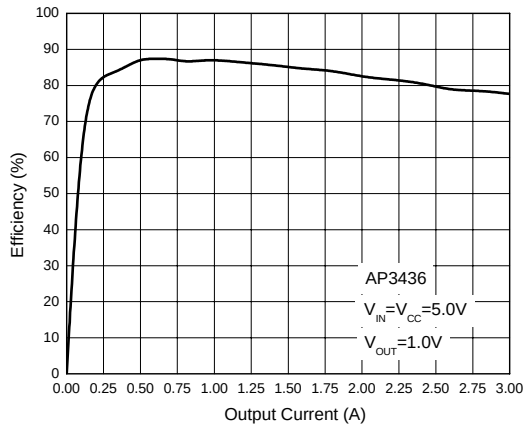


Figure 4. Efficiency vs. Output Current

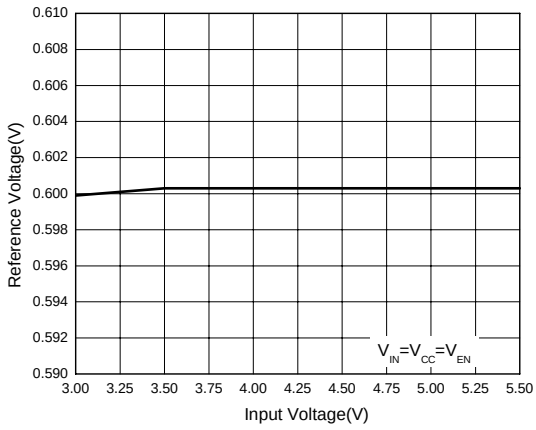


Figure 5. Reference Voltage vs. Input Voltage

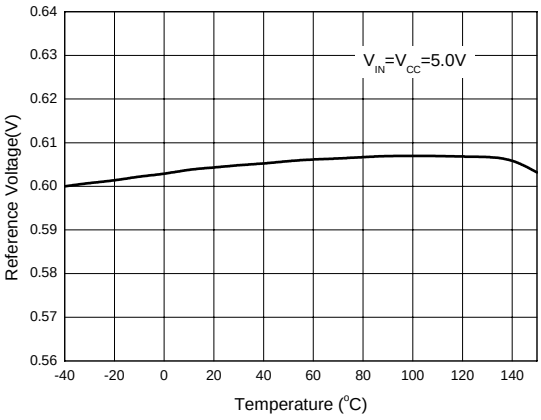


Figure 6. Reference Voltage vs. Temperature

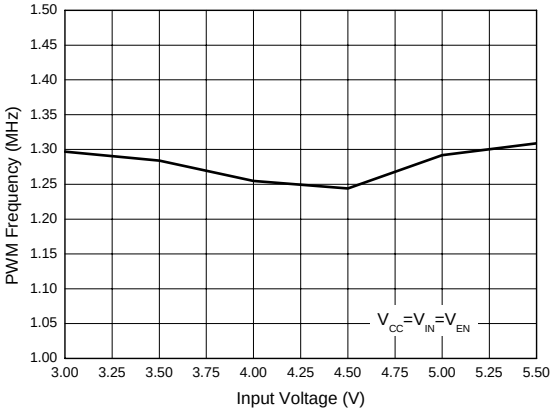


Figure 7. PWM Frequency vs. Input Voltage

Typical Performance Characteristics (Continued)

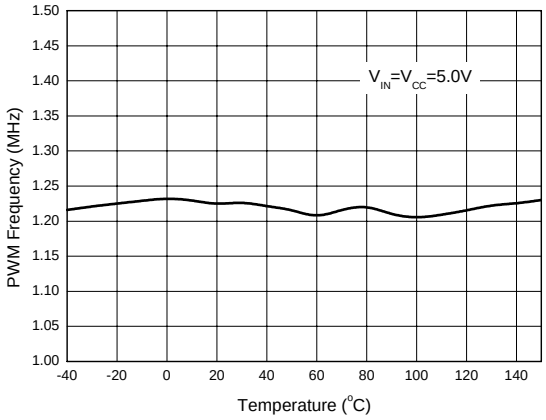


Figure 8. PWM Frequency vs. Temperature

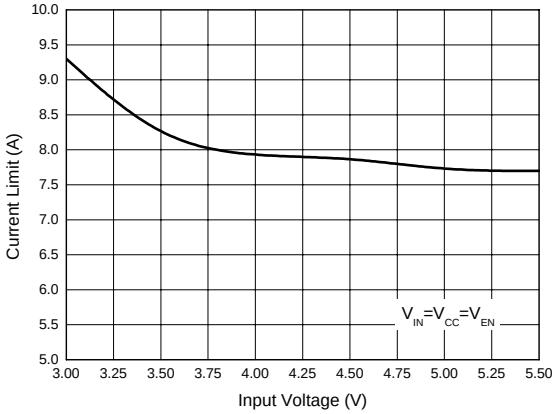


Figure 9. Current Limit vs. Input Voltage

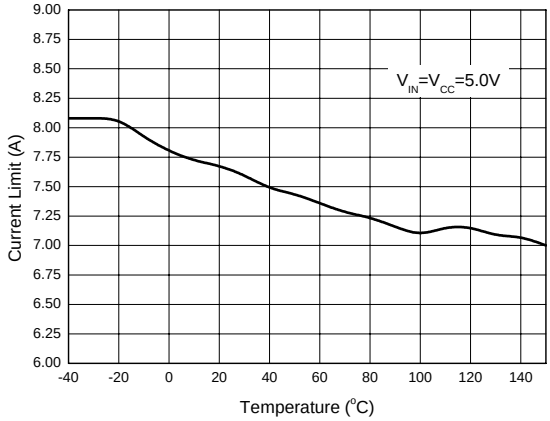


Figure 10. Current Limit vs. Temperature

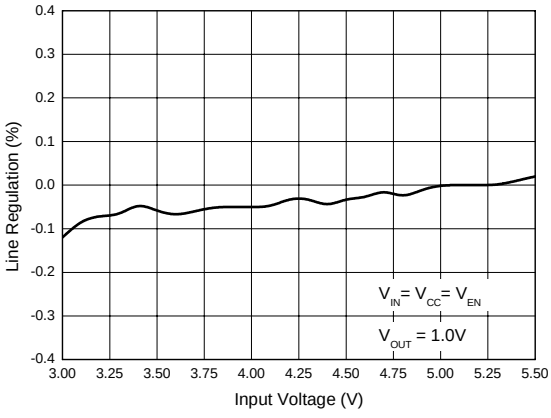


Figure 11. Line Regulation vs. Input Voltage

Typical Performance Characteristics (Continued)

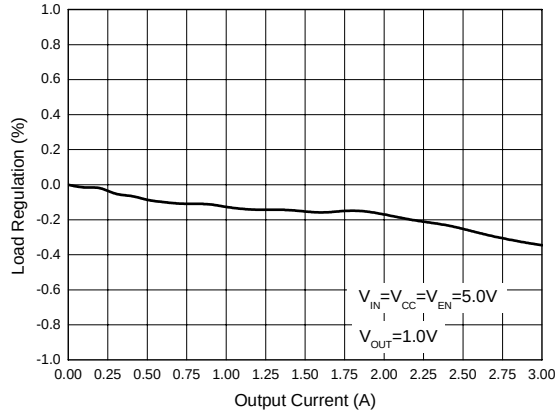


Figure 12. Load Regulation vs. Output Current

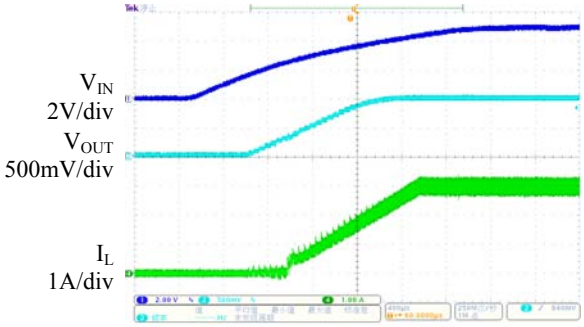


Figure 13. Power on Waveform
(V_{IN}=V_{CC}=5V, V_{OUT}=1V, I_{OUT}=3A)

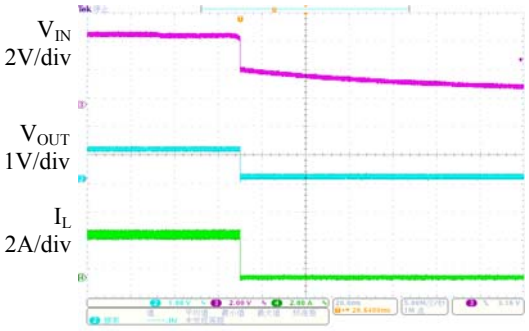


Figure 14. Power off Waveform
(V_{IN}=V_{CC}=5V, V_{OUT}=1V, I_{OUT}=3A)

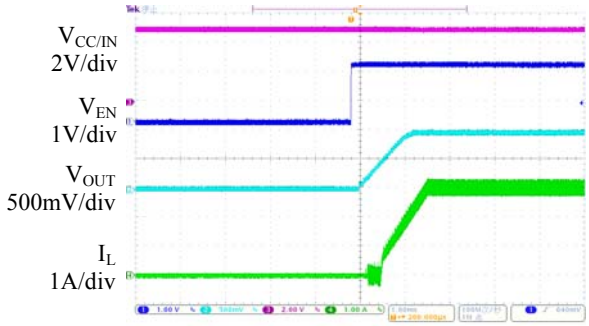


Figure 15. Enable Waveform
(V_{IN}=V_{CC}=5V, V_{OUT}=1V, I_{OUT}=3A)

Typical Performance Characteristics (Continued)

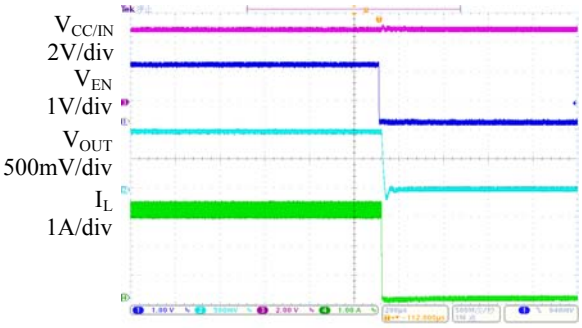


Figure 16. Disable Waveform
(V_{IN}=V_{CC}=5V, V_{OUT}=1V, I_{OUT}=3A)

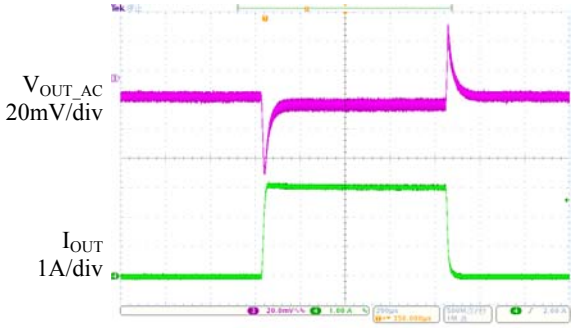


Figure 17. Load Transient Response
(V_{IN}=V_{CC}=5V, V_{OUT}=1V, I_{OUT}=0 to 3A)

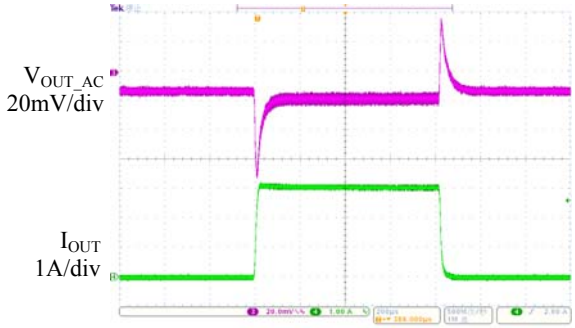
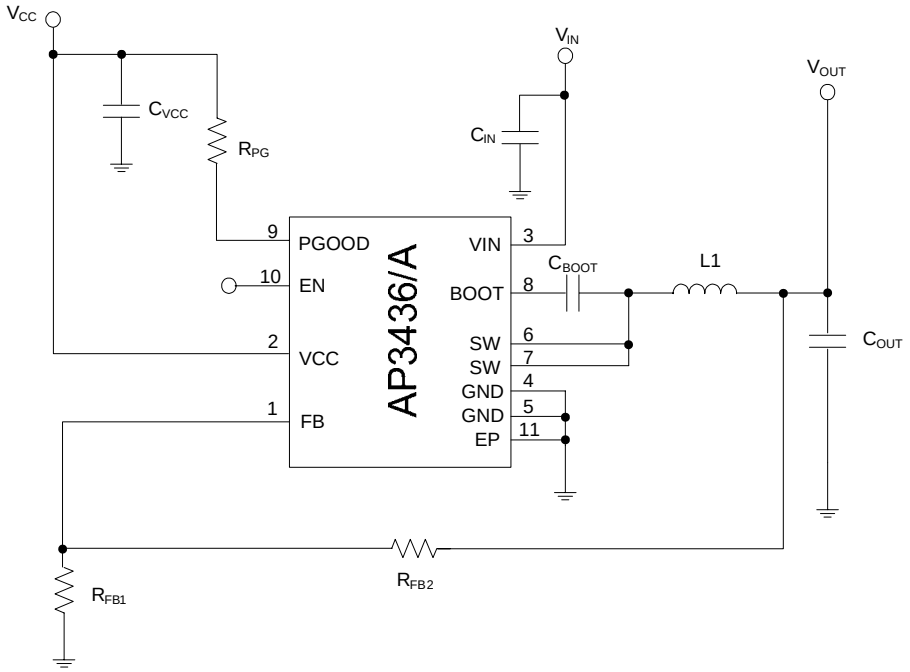


Figure 18. Load Transient Response
(V_{IN}=V_{CC}=3.3V, V_{OUT}=1V, I_{OUT}=0 to 3A)

Typical Application



Note 2: When using a single power supply for V_{CC} and V_{IN}, a 4.7Ω resistor should be placed between them for noise isolation.

Figure 19. Typical Application Circuit of AP3436/A

Table 1. Component Guide

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	L1	1.5	μH
R_{FB1}	TBD	kΩ	C_{OUT}	88	μF

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.

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

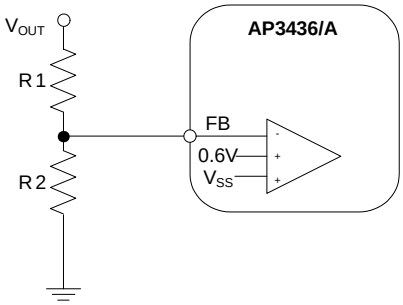


Figure 20. Voltage Divider Circuit

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.

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.

Application Information (Continued)

8. Power Good

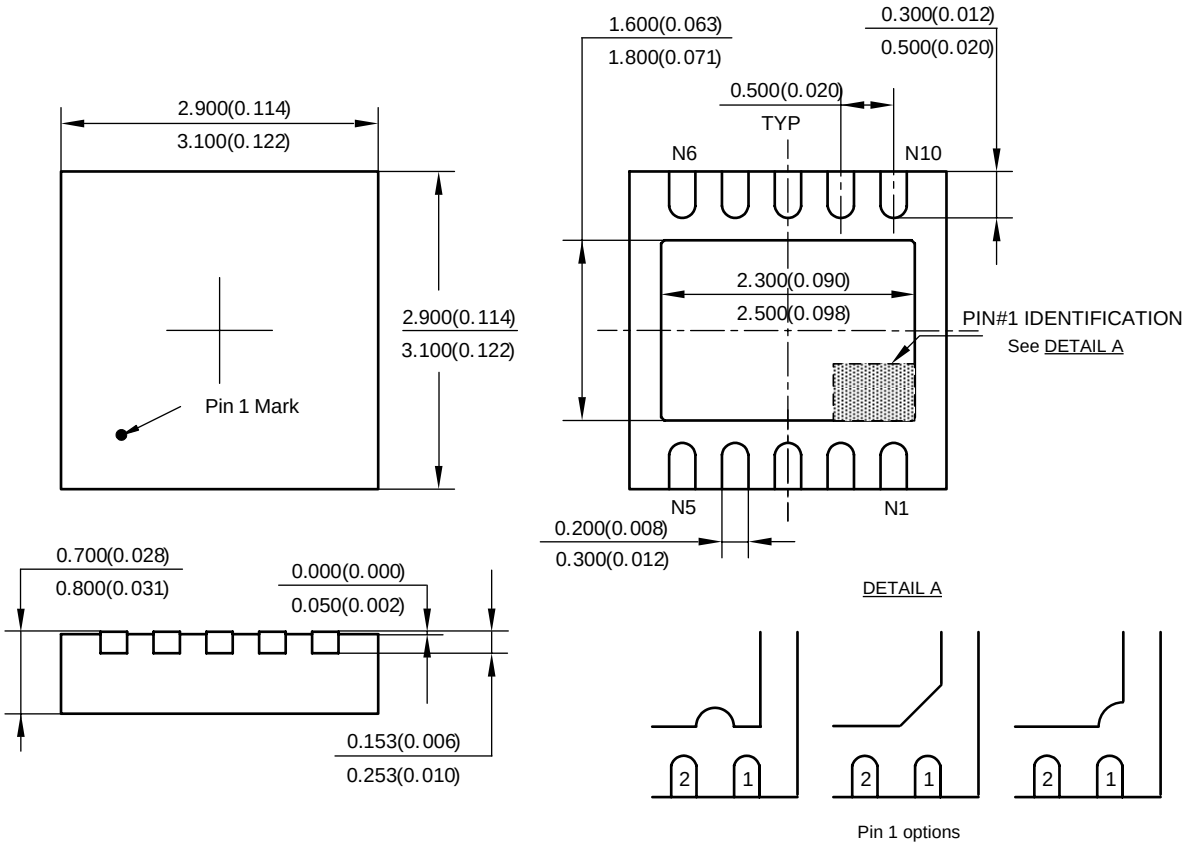
The PGOOD pin output connects an open drain MOSFET. The output is pulled low when the FB voltage enters the fault condition by falling below 75% or rising above 125% of the nominal internal reference voltage. There is a 7% hysteresis on the threshold voltage, so when the FB voltage rises to the good 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.

Mechanical Dimensions

DFN-3×3-10 **Unit: mm(inch)**



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