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AP1161

300mA LDO Regulator with Over/Under Voltage Detection Function

1. General Description

The AP1161 is an integrated circuit having bipolar silicon monolithic architecture. It is a low dropout regulator with ON/OFF control and capable of supplying an output current of 300mA constantly. The AP1161 has regulator output voltage monitoring function, enabling to detect overvoltage and undervoltage. Self-diagnose function can detect a fault operation of overvoltage and undervoltage detections. In addition, overcurrent protection and thermal shutdown circuits are integrated.

2. Features

- Low Noise: 180nV/√Hz at 10kHz
- Overvoltage/Undervoltage Detection Function
- Self-Diagnose Function for Overvoltage/Undervoltage Detection
- Operating Temperature: -40 ~ 125 °C
- High Accurate Output Voltage: 3.38V ± 65mV
- Dropout Voltage: 300mV at Iout=300mA
- Great RSRR: 76dB at 1kHz
- Low Power Consumption: 550μA at Iout=0mA
- ON/OFF Control of Regulator Output (Active High)
- Overcurrent Protection and Thermal Shutdown Circuits
- Small Package: 16-pin HQFN

3. Applications

- Automotive Equipment
- Industrial Equipment

4. Table of Contents

5. Block Diagram and Functions

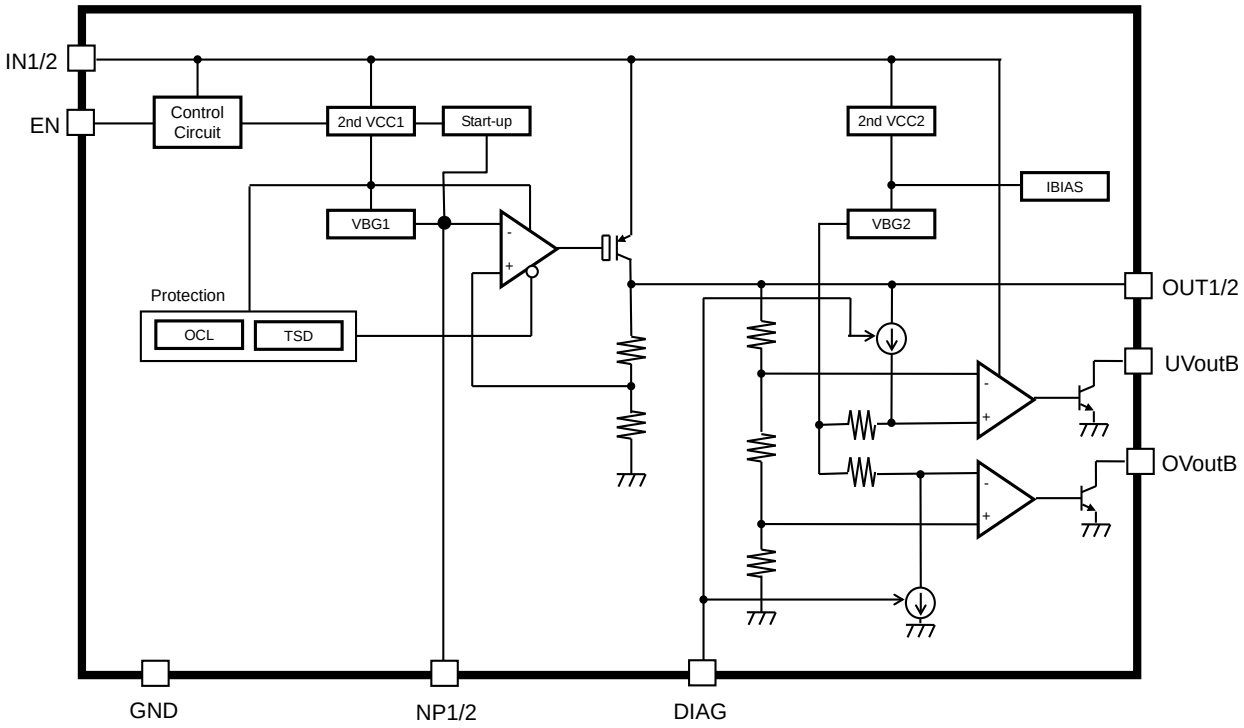
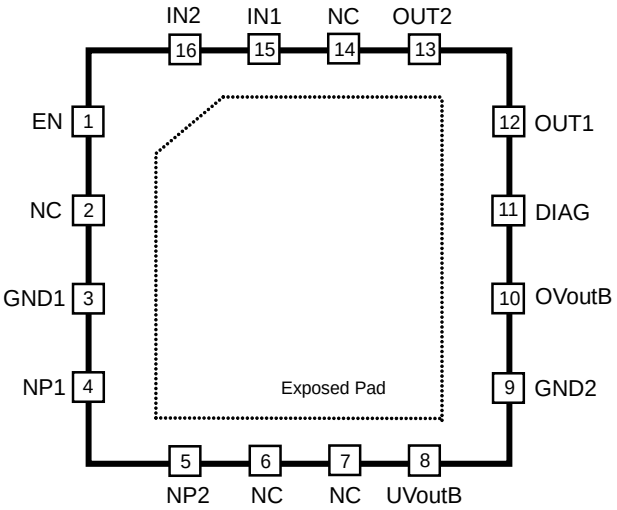


Figure 1. Block Diagram

6. Pin Configurations and Functions

6.1 Pin Layout



6.2 Pin Function

No.	Name	I/O	Description
1	EN	I	ON/OFF Control of Regulator Regulator output monitoring function is not turned OFF by this setting. This pin is internally pulled down by 100kΩ.
2	NC	-	No Connection Pin
3	GND1	-	Ground Pin No.3 pin and No.9 pin are internally connected.
4	NP1	O	Noise Path Pin Connect a capacitor between these pins and the GND.
5	NP2	O	
6	NC	-	No Connection Pin
7	NC	-	No Connection Pin
8	UVoutB	O	Undervoltage Detection Output (Open Collector Output)
9	GND2	-	Ground Pin No.3 pin and No.9 pin are internally connected.
10	OVoutB	O	Overvoltage Detection Output (Open Collector Output)
11	DIAG	I	Self-diagnose Function Control (Active High) This pin is internally pulled down by 100kΩ.
12	OUT1	O	Regulator Output Connect OUT1/2 on board.
13	OUT2	O	
14	NC	-	No Connection Pin
15	IN1	P	Regulator Input Connect IN1/2 on board.
16	IN2	P	
-	Exposed Pad	-	Ground Pin, Heat Dissipation Pad (Note 2)

Note 1. I (Input terminal), O (Output terminal), P (Power terminal)
Note 2. The exposed pad must be connected to the GND1/2.

7. Absolute Maximum Ratings

Parameter	Symbol	Min.	Max.	Unit	Condition
IN1/2 Terminal Voltage	V_{IN}	-0.3	16	V	
OUT1/2 Terminal Voltage	V_{OUT}	-0.3	10	V	
NP Terminal Voltage	V_{NP}	-0.3	6	V	
EN Terminal Voltage	V_{EN}	-0.3	16	V	
OVoutB Terminal Voltage	V_{OVO}	-0.3	16	V	
UVoutB Terminal Voltage	V_{UVO}	-0.3	16	V	
DIAG Terminal Voltage	V_{DIAG}	-0.3	16	V	
Junction Temperature	Tj	-	150	°C	
Storage Temperature	Tstg	-55	150	°C	
Power Dissipation	P_D	-	3.125	W	Ta=25°C (Note 3)

Note 3. It should be derated by –25mW if the temperature is higher than 25°C.
Thermal Resistance θJA=40°C /W

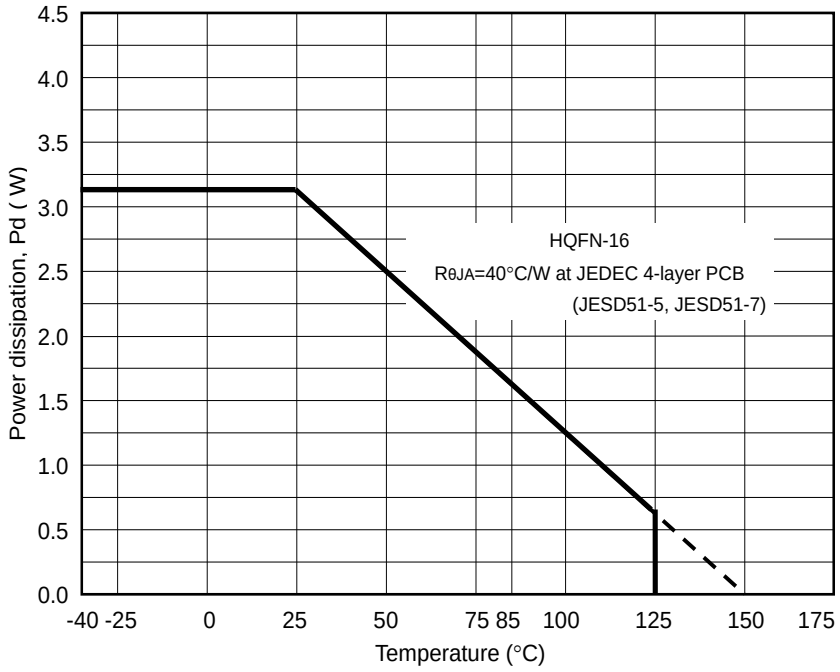


Figure 2. Maximum Power Dissipation

WARNING: Operation at or beyond these limits may result in permanent damage to the device.
Normal operation is not guaranteed at these extremes.

8. Recommended Operating Conditions

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Operational Temperature Range	Ta	-40	-	125	°C	
IN1/2 Voltage Range	V_{INA}	3.8	-	7.0	V	

9. Electrical Characteristics

($3.8V \le V_{IN} \le 7.0V$, $V_{EN} = 3.3V$, $-40°C \le T_j \le 150°C$, unless otherwise specified)

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Regulator						
Output Voltage	V_{OUTA}	$1mA \le I_{OUT} \le 1000mA$	3.275	3.380	3.445	V
	V_{OUTB}	$1mA \le I_{OUT} \le 1000mA$ $2.5V \le V_{IN} < 3.8V$	V_{IN}-V_{DROP}	-	3.6	
Dropout Voltage	V_{DROP}	$V_{IN} = 2.5V$, $I_{OUT} = 300mA$ $T_a \le 25°C$	-	-	0.30	V
		$V_{IN} = 2.5V$, $I_{OUT} = 300mA$ $25°C < T_a$	-	-	0.35	
Over Current Detection Level (Note 4)	$I_{OCPTRIP}$	$V_{OUT} \le 3V$ $2.5V \le V_{IN} \le 7.0V$	360	550	900	mA
Reverse Current	I_{REV}	$V_{IN}=0V$, $V_{OUT}=5V$	-	-	1.0	mA
Power Dissipation						
IN Terminal Power Dissipation 1	I_Q	$I_{OUT}=0mA$, EN= "H"				mA
		$T_a \le 25°C$	0.25	1.0	1.5	
		$25°C < T_a$			10	
IN Terminal Power Dissipation 2	I_S	$I_{OUT}=0mA$, EN= "L"	75	200	500	μA
EN Terminal						
EN Terminal Voltage "H" Detection Level	V_{ENH}		2.1	-	-	V
EN Terminal Voltage "L" Detection Level	V_{ENL}		-	-	1.1	V
EN Pin Pull-down Resistance	R_{EN}		50	100	200	kΩ
NP Terminal						
NP Terminal Voltage	V_{NP}		1.0	1.25	1.5	V
Output Voltage Monitoring Function : 2.5V ≤ VIN ≤ 7V						
Output Level of Undervoltage	V_{UV}	$V_{IN}=1.0V$	0	-	0.66	V
Undervoltage Detection Threshold	V_{THUV}	DIAG pin = "L"	3.135	3.190	3.245	V
Output Voltage – Undervoltage Detecting Level	dV1	DIAG pin = "L"	80	190	310	mV
Overvoltage Detection Threshold	V_{THOV}	DIAG pin = "L"	3.465	3.530	3.595	V
Overvoltage Detecting Level – Output Voltage	dV2	DIAG pin = "L"	70	150	280	mV
Delay Time of Undervoltage Detection	t_{UVON}	"L" Detection Level: 0.66V (Note 5)	-	0.3	1	μs
Delay Time of Releasing Undervoltage Detection	t_{UVOFF}	"H" Detection Level: 2.64V (Note 5)	-	0.3	2	μs
Delay Time of Overvoltage Detection	t_{OVON}	"L" Detection Level: 0.66V (Note 5)	-	0.3	2	μs

Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit
Delay Time of Releasing Overvoltage Detection	t_{OVOFF}	"H" Detection Level: 2.64V (Note 5)	-	0.3	2	μs
UVoutB Output Low Level	V_{UVOL}	IUVOUTB=+1mA	-	0.1	0.4	V
OVoutB Output Low Level	V_{OVOL}	IOVOUTB=+1mA	-	0.1	0.4	V
UVoutB Output Leak Current	I_{UVOL}	UVOUTB =5V	-	-	1	μA
OVoutB Output Leak Current	I_{OVOL}	OVOUTB =5V	-	-	1	μA
Thermal Shutdown Function						
Thermal Shutdown Temperature (Note 6)	T_{SD}	Temperature Rising	151	165	180	°C
Temperature Hysteresis of Thermal Shutdown (Note 6)	T_{SDH}	Temperature Falling	5	15	20	°C
DIAG Terminal						
DIAG Terminal Voltage "H" Detection Level	V_{DGH}		2.1	-	-	V
DIAG Terminal Voltage "L" Detection Level	V_{DGL}		-	-	1.1	V
DIAG Terminal Pull-down Resistance	R_{DIAG}		50	100	200	kΩ
Noise: IOUT=1mA~300mA, CNP=1000pF						
Output Noise (Note 6)	V_{NOISE}	100Hz	-	-	1400	nV/√Hz
		500Hz	-	-	1000	
		1kHz	-	-	900	
		10kHz	-	-	180	
		100kHz	-	-	60	
		1MHz	-	-	50	
		10MHz	-	-	10	
		20MHz	-	-	3	
Ripple Rejection: V_{IN}=4.2V, I_{OUT}=1mA						
Ripple Rejection (Note 7)	PSRR	100Hz	-	79	-	dB
		1kHz	-	76	-	dB
		10kHz	-	57	-	dB
		100kHz	-	62	-	dB
		1MHz	-	58	-	dB
		2MHz	-	43	-	dB
		5MHz	-	38	-	dB
Power-up						
Power-up Time	t_{STRT}	Time until UVoutB pin starts outputting after EN pin = "L" CNP=2000pF, COUT=10μF	-	-	500	μs

Note 4. The maximum current is limited by power dissipation.
Note 5. Pulled up by 100kΩ, 3.3V.
Note 6. Guaranteed by design. Not all of products are tested on shipping.
Note 7. Design reference values

10. Functional Descriptions

10.1 ON/OFF Control of Regulator Output

Regulator output is enabled by setting the voltage level of the EN pin higher than V_{ENH}. Regulator output is disabled by setting the EN pin voltage lower than V_{ENL}.

10.2 Protection Functions

1) Over Current Limit Protection
The AP1161 controls output transistor to prevent that the OUT pin output current exceeds a defined value ($I_{OCPTRIP1\sim3}$). V_{OUT} level returns to normal value when the output current becomes a rated value.

2) Thermal Shutdown
The output transistor is turned OFF when T_j exceeds a defined value (T_{SD}). It returns to normal operation when T_j becomes less than a defined value (T_{SD} - T_{SDH}).

3) Undervoltage Detection
The open collector output of the UVoutB pin is turned ON when V_{OUT} becomes less than a defined value (V_{THUV}). It becomes high impedance when V_{OUT} becomes more than the defined value (V_{THUV}).

4) Overvoltage Detection
The open collector output of the OVoutB pin is turned ON when V_{OUT} exceeds a defined value (V_{THOV}). It becomes high impedance when V_{OUT} becomes less than the defined value.

- Example 1: The EN pin voltage is supplied externally and the UVoutB and OVoutB pins are pulled up by the IN pins.

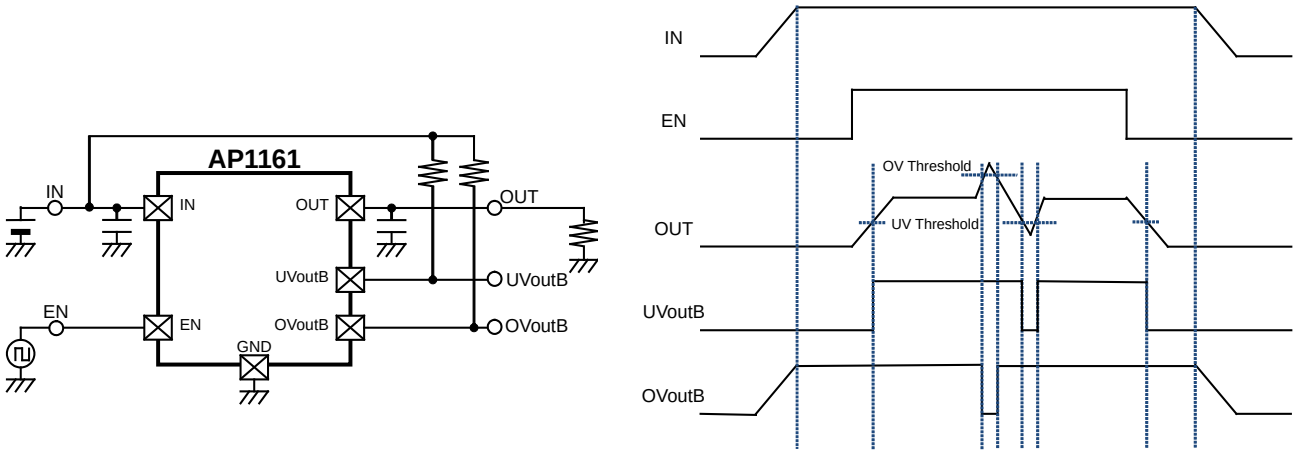


Figure 3. Example 1

- Example 2: The EN pin voltage is supplied by the IN pin, and the UVoutB and OVoutB pins are pulled up by the OUT pins.

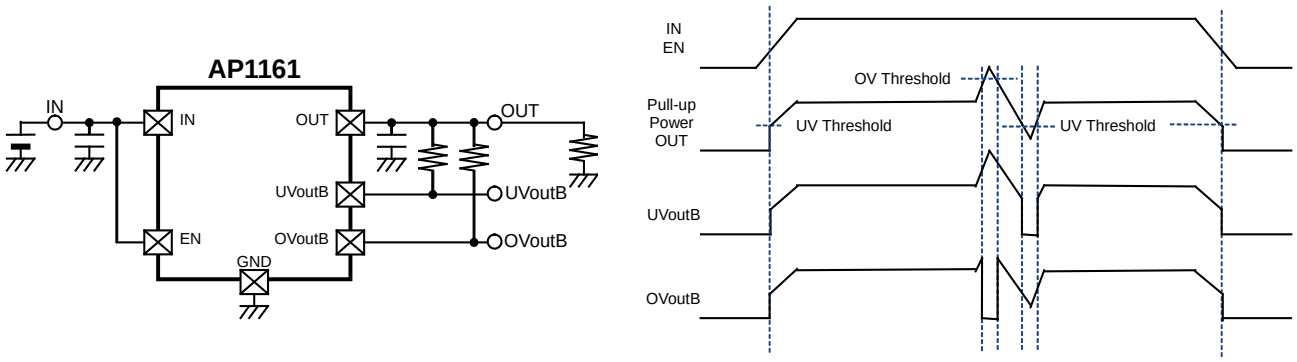
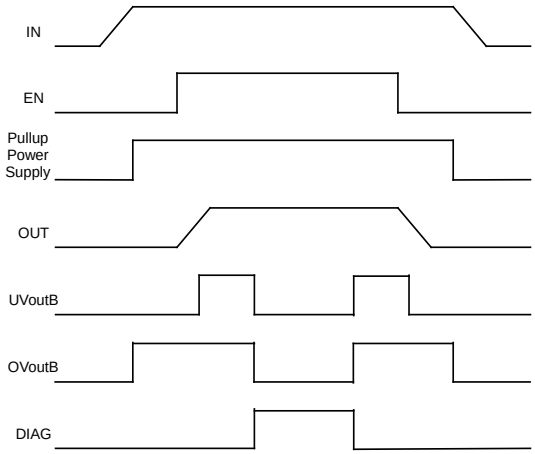


Figure 4. Example 2

10.3 Self-Diagnose Function

Self-diagnose function for Undervoltage and Overvoltage detections is enabled by setting the DIAG pin to “H”. Each open collector output of the UVoutB and OVoutB pins is tuned ON if Undervoltage and Overvoltage detections are operated normally. The UVoutB and the OVoutB pin outputs will be high impedance if these functions are not operated correctly.

- Undervoltage/Overvoltage Detection Function Normal Operation



- Undervoltage/Overvoltage Detection Function Error

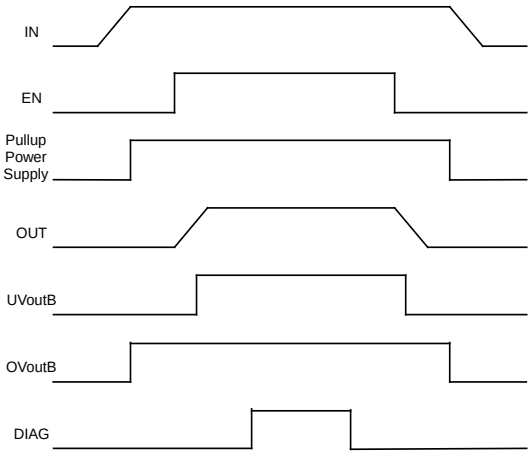


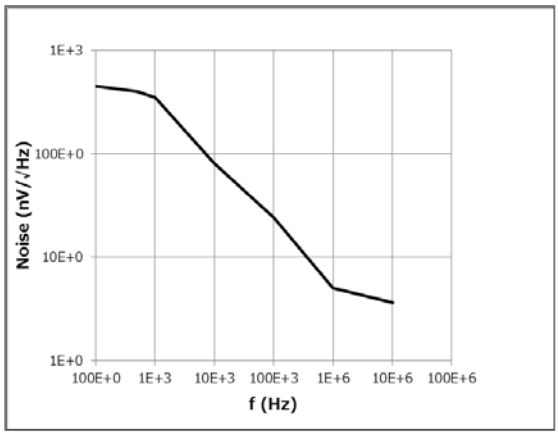
Figure 5. Self-Diagnose Timing Chart

11. Characteristics Example

It is measurement result by our recommended constant.

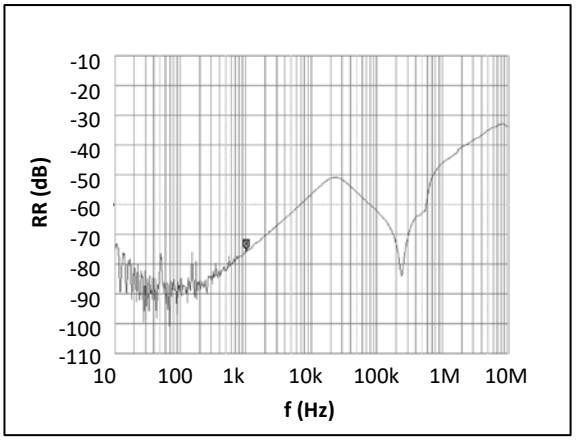
■Output Noise

VIN=3.8V, IOUT=300mA, Ta=25°C



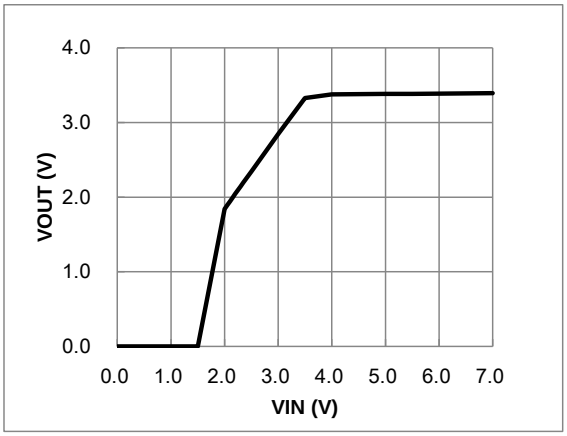
■Ripple Rejection Ratio

VIN=4.2V, IOUT=1mA, Ta=25ºC



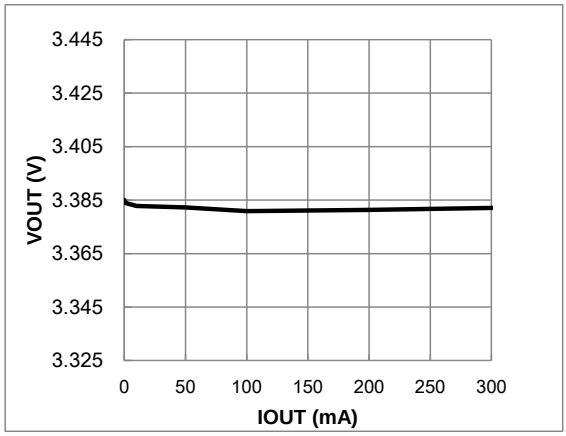
■Input / Output Voltage Characteristics

IOUT=300mA, Ta=25°C



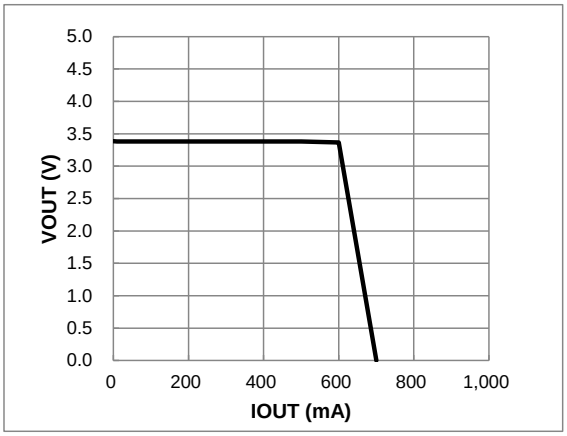
■Load Regulation

VIN=4.2V, Ta=25ºC



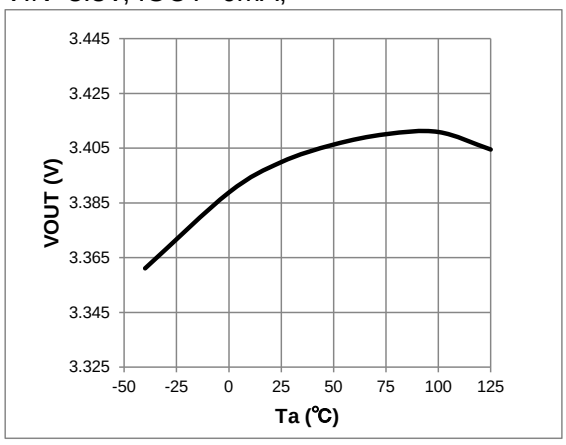
■Overcurrent Protect Characteristics

VIN=4.2V, Ta=25°C



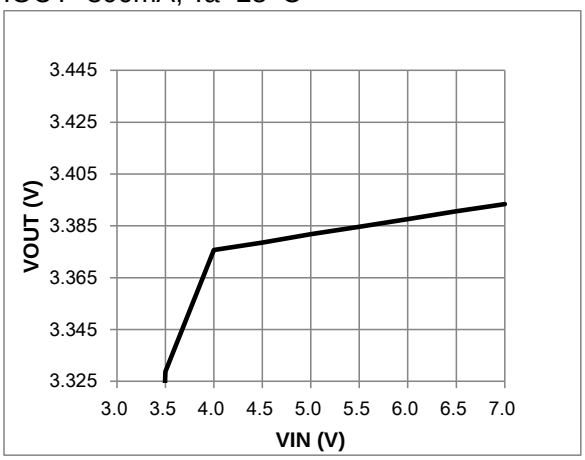
■Temperature Characteristic of Output Voltage

VIN=3.8V, IOUT=0mA,



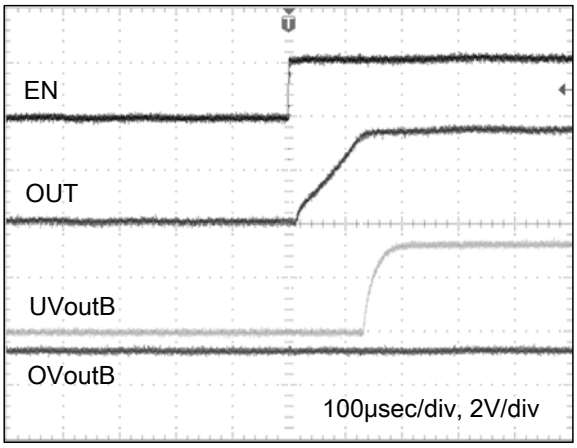
■**Line Regulation**

IOUT=300mA, Ta=25°C



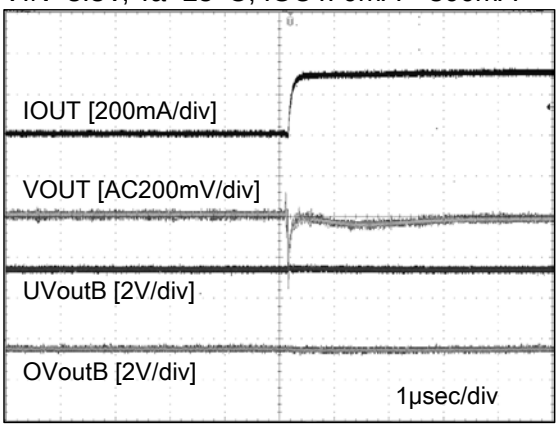
■**Startup Time**

VIN=4.2V, IOUT=0mA, Ta=25°C

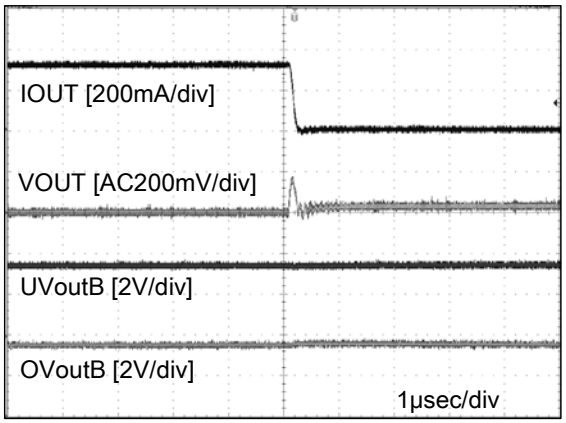


■**Load Transient**

VIN=3.8V, Ta=25°C, IOUT: 0mA→300mA



IOUT: 300mA→0mA



12. Recommended External Circuits

12.1. External Circuit Example

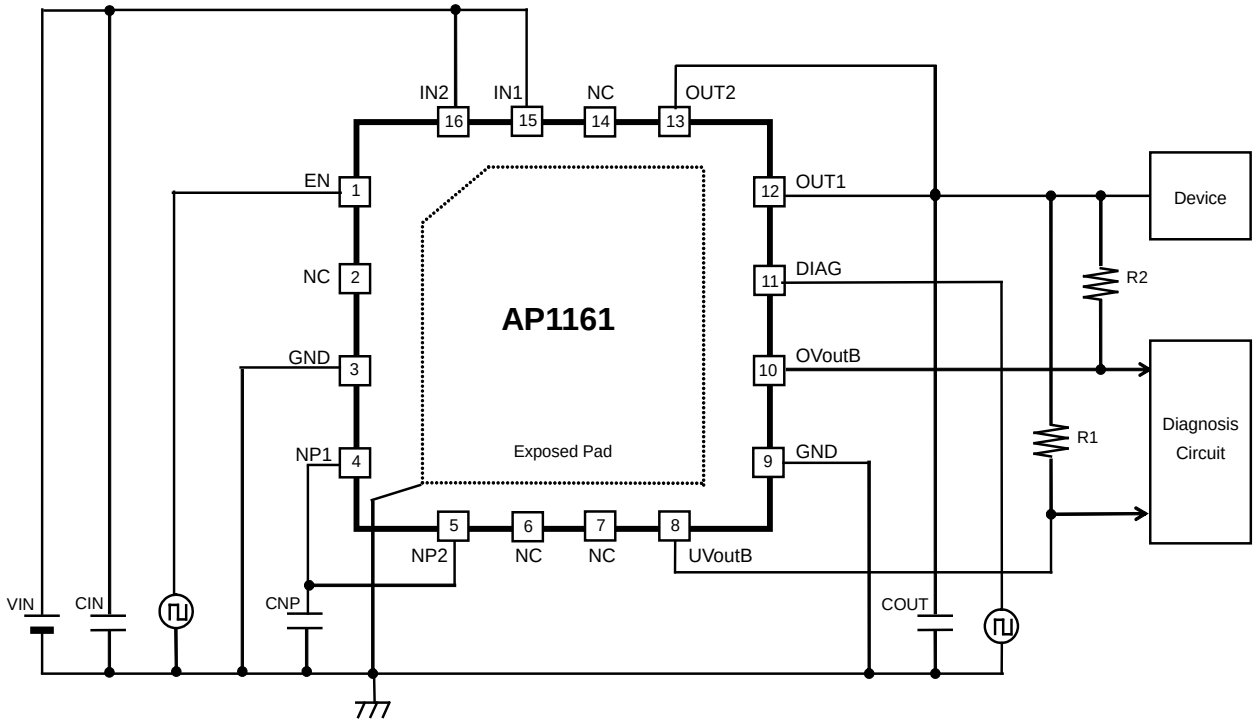


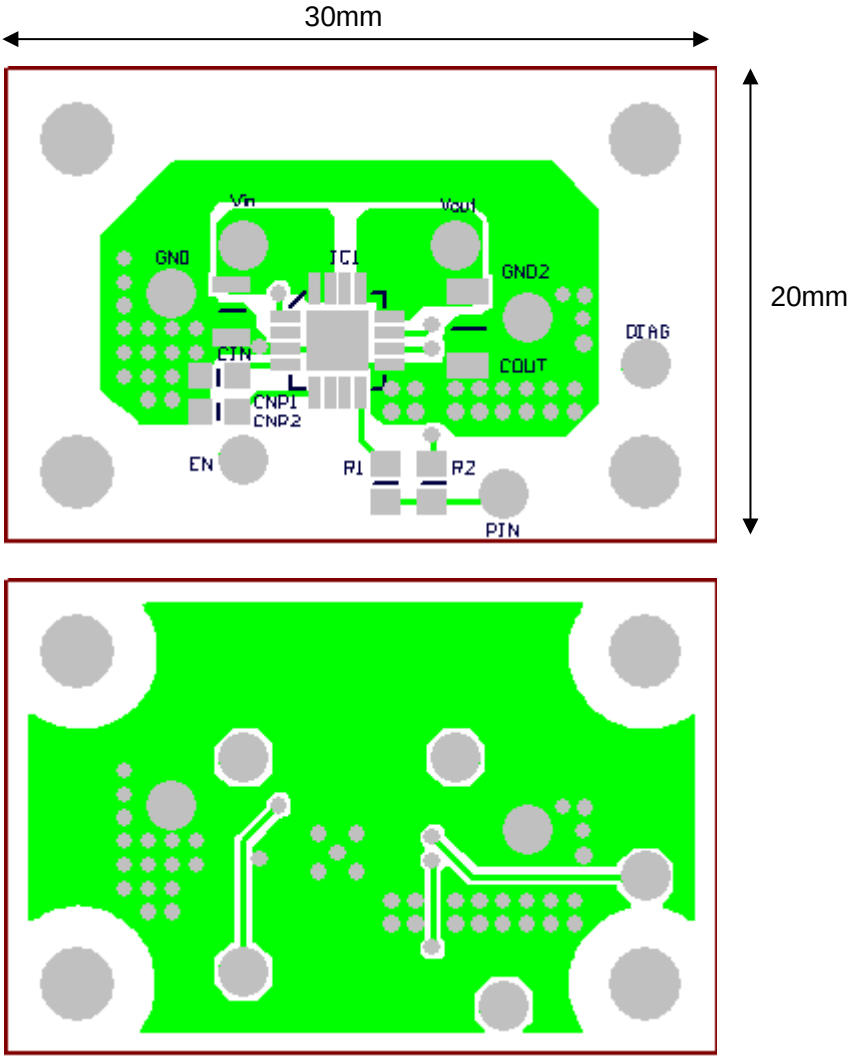
Figure 6. External Circuit Example

Table 1. Recommended External Parts

Parts	Min.	Typ.	UNIT	Note
CIN	4.7	10	μF	Ceramic Capacitor
COUT	4.7	10	μF	Ceramic Capacitor
CNP	1000	2000	pF	Ceramic Capacitor
R1	10	100	kΩ	
R2	10	100	kΩ	

Note 8. Above values are recommended examples (effective capacitance value). Before using the AP1161, please check and choose optimal values on your system board.

12.2 Recommended board layout example

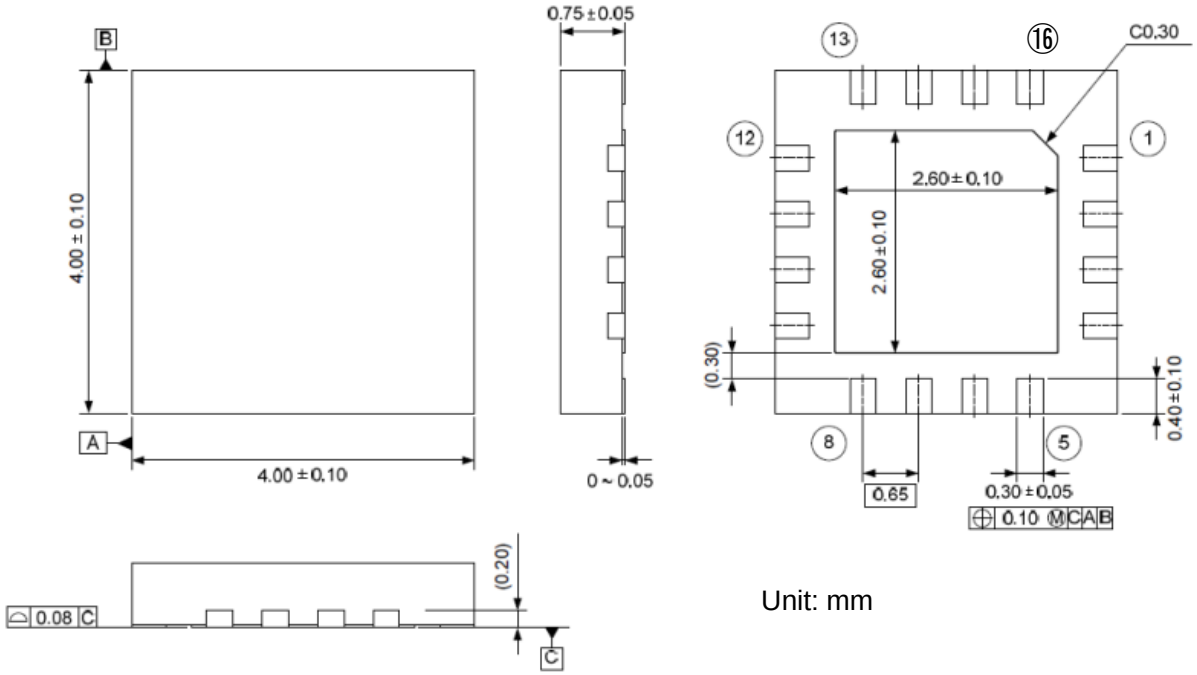


1. Place the input capacitor, CIN, as close as possible to the VIN and GND pins.
2. Place the output capacitor, COUT, as close as possible to the OUT and GND pins.
3. GND area should be consolidated in wiring on the PCB.
4. The exposed pad must be connected to PCB ground since it shares ground with the IC. Vias (heat dissipation holes) are effective for dissipating heat to each layer of the PCB.

13. Package

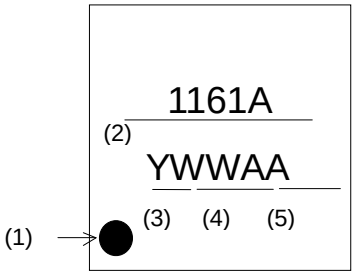
13.1 Outline Dimensions

・16-pin HQFN (Lead Terminals are plated)



Unit: mm

13.2 Marking



(1) 1pin Indication
(2) Product Number
(3) Manufacturing Date Year (last 1 digits)
(4) Manufacturing Date Week
(5) Administration Number

14. Ordering Guide

AP1161ABN	-40 ~125°C	16-pin HQFN

15. Revision History

Date (Y/M/D)	Revision	Reason	Page	Contents
18/05/30	0.0	First Edition		

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