Description

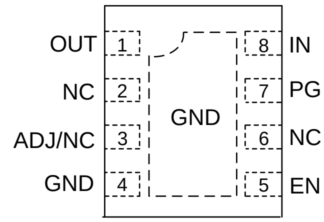
The AP7361E is a 1A, adjustable and fixed output voltage, ultra-low dropout linear regulator with enable. The device includes pass element, error amplifier, band-gap reference, current limit and thermal shutdown circuitry. The device is turned on when EN pin is set to logic high level.

The characteristics of the low dropout voltage and low quiescent current make it suitable for low to medium power applications, for example, laptop computers, audio and video applications and battery powered devices. The typical quiescent current is approximately 60µA. Built-in current-limit, thermal-shutdown and power good functions prevent IC from damage in fault conditions.

The AP7361E is available in U-DFN3030-8 (Type E) package.

Pin Assignments

(Top View)



U-DFN3030-8 (Type E)

Features

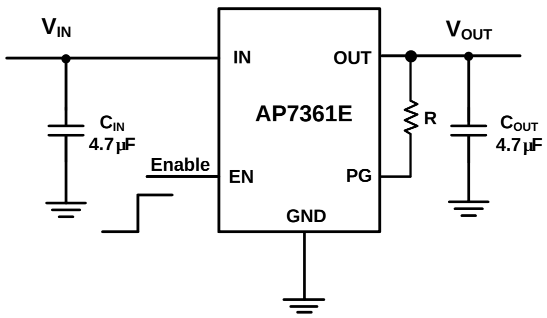
- Wide Input Voltage Range: 2.2V to 6.0V
- Output Voltage Accuracy: ±1%
- Very Low Dropout Voltage (3.3V): 360mV at 1A Typical
- Low Quiescent Current (I_Q): 60µA Typical
- Adjustable Output Voltage Range: 0.8V to 5.0V
- Fixed Output Options: 1.0V, 1.2V, 1.5V, 1.8V, 2.5V, 2.8V and 3.3V
- High PSRR: 75dB @ 1kHz
- Current Limit: 1.5A
- Fold-Back Short Circuit Protection: 400mA
- Power-Good (PG) Output for Supply Monitoring and for Sequencing of Other Supplies
- Thermal Shutdown Protection
- Stable with MLCC, E-Cap, Tan-Cap or Solid Capacitor ≥ 2.2µF
- Ambient Temperature Range: -40°C to +85°C
- Available in “Green” Molding Compound (No Br, Sb)
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. “Green” Device (Note 3)**
- **For automotive applications requiring specific change control (i.e. parts qualified to AEC-Q100/101/200, PPAP capable, and manufactured in IATF 16949 certified facilities), please contact us or your local Diodes representative. https://www.diodes.com/quality/product-definitions/**

Applications

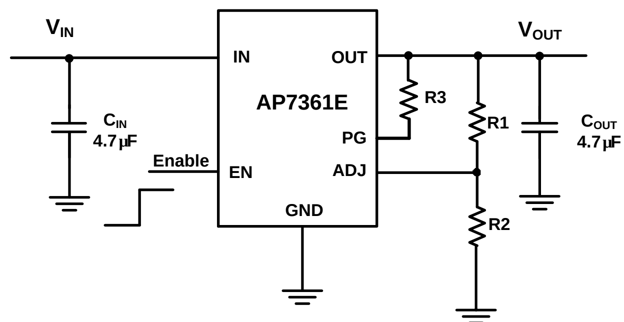
- LCD-TV, Monitor
- Set-Top-Box
- Home Electrical Appliances

Notes: 1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS), 2011/65/EU (RoHS 2) & 2015/863/EU (RoHS 3) compliant.
2. See https://www.diodes.com/quality/lead-free/ 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.

Typical Applications Circuit



Fixed Version with EN

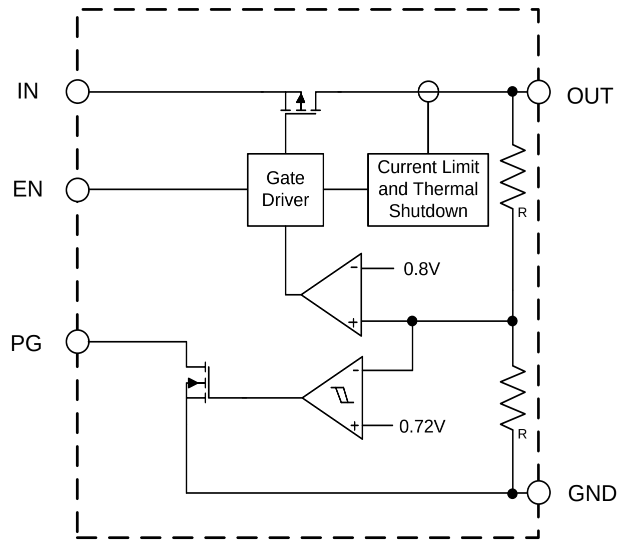


Adjustable Output

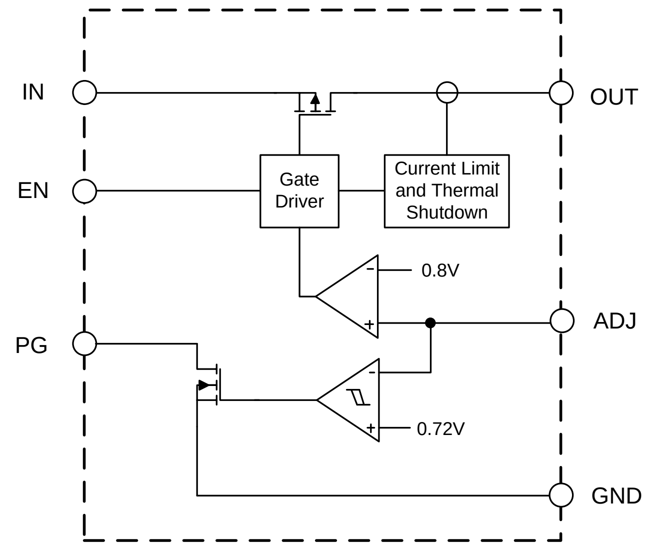
Pin Descriptions

Pin Number	Pin Name	Function
U-DFN3030-8 (Type E)		
1	OUT	The output of the regulator. Bypass to ground through at least 2.2µF ceramic capacitor. For improved AC load response a larger capacitor is recommended.
2, 6	NC	No connection
3	ADJ/NC	Adjustable voltage version only – a resistor divider from this pin to the OUT pin and ground sets the output voltage.
4	GND	Ground
5	EN	Enable input, active high
7	PG	Power-Good pin, open-drain output. When the V_{OUT} is below the PG threshold the PG pin is driven low; when the V_{OUT} exceeds the threshold, the PG pin goes into a high-impedance state. To use the PG pin, use a 10kΩ to 1MΩ pull-up resistor to pull it up to a supply of up to 6V, which can be higher than the input voltage.
8	IN	The input of the regulator. Bypass to ground through at least 1µF ceramic capacitor.

Functional Block Diagram



Fixed Version with EN



Adjustable Version with EN

Absolute Maximum Ratings (@T_A = +25°C, unless otherwise specified.) (Note 4)

Symbol	Parameter		Rating	Unit
V_{IN}	Input Voltage		6.5	V
—	OUT, ADJ, EN Voltage		V_{IN} + 0.3	V
T_J	Operating Junction Temperature Range		-40 to +150	°C
T_{STG}	Storage Temperature Range		-65 to +150	°C
P_D	Power Dissipation		Internally limited by maximum junction temperature of +150°C	—
P_D	Power Dissipation	U-DFN3030-8 (Type E)	1700	mW
ESD HBM	Human Body Model ESD Protection		> 2	kV
ESD CDM	Charge Device Model		±500	V

Note: 4. Stresses greater than the *Absolute Maximum Ratings* specified above can cause permanent damage to the device. These are stress ratings only; functional operation of the device at these or any other conditions exceeding those indicated in this specification is not implied. Device reliability can be affected by exposure to absolute maximum rating conditions for extended periods of time.

Recommended Operating Conditions (@T_A = +25°C, unless otherwise specified.)

Symbol	Parameter	Min	Max	Unit
V_{IN}	Input Voltage	2.2	6.0	V
V_{OUT}	Output Voltage	0.8	5.0	V
I_{OUT}	Output Current (Note 5)	0	1.0	A
T_A	Operating Ambient Temperature	-40	+85	°C

Note: 5. The device maintains a stable, regulated output voltage without a load current. When the output current is large, attention should be given to the limitation of the package power dissipation.

Electrical Characteristics (@T_A = +25°C, V_{IN} = V_{OUT} +1V, C_{IN} = 4.7µF, C_{OUT} = 4.7µF, V_{EN} = V_{IN}, unless otherwise specified.)

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
V_{REF}	FB Reference Voltage, ADJ Pin	I_{OUT} = 10mA, T_A = +25°C		0.792	0.8	0.808	V
I_{ADJ}	ADJ Pin Leakage Current	—		—	0.1	0.5	µA
I_Q	Input Quiescent Current	Enabled, I_{OUT} = 0A		—	68	91	µA
I_{SHDN}	Input Shutdown Current	V_{EN} = 0V, I_{OUT} = 0A		-1	0.05	1	µA
V_{OUT}	Output Voltage Accuracy	I_{OUT} = 100mA, T_A = +25°C	1.0V ≤ V_{OUT} < 1.5V	V_{OUT}(s)-0.015	V_{OUT}(s)	V_{OUT}(s)+0.015	V
			1.5V ≤ V_{OUT} ≤ 3.3V	V_{OUT}(s)*0.99	V_{OUT}(s)	V_{OUT}(s)*1.01	
$\frac{\Delta V_{OUT}}{\Delta V_{IN} \times V_{OUT}}$	Line Regulation	V_{IN} = V_{OUT} +1V to 5.5V, I_{OUT} = 100mA	T_A = +25°C	—	0.01	0.1	%/V
			-40°C ≤ T_A ≤ +85°C	—	—	0.2	
ΔV_{OUT} / V_{OUT}	Load Regulation	I_{OUT} from 1.0mA to 1A	1.2V < V_{OUT} ≤ 3.3V	-1.0	—	1.0	%
			1.0V ≤ V_{OUT} ≤ 1.2V	-1.5	—	1.5	%
$V_{DROPOUT}$	Dropout Voltage (Note 6)	I_{OUT} = 300mA	1.0V ≤ V_{OUT} < 1.1V	—	710	750	mV
			1.1V ≤ V_{OUT} < 1.2V	—	600	640	
			1.2V ≤ V_{OUT} < 1.3V	—	500	540	
			1.3V ≤ V_{OUT} < 1.4V	—	400	440	
			1.4V ≤ V_{OUT} < 1.5V	—	300	340	
			1.5V ≤ V_{OUT} < 2.6V	—	200	250	
			2.6V ≤ V_{OUT} ≤ 3.3V	—	90	140	
		I_{OUT} = 1A	1.0V ≤ V_{OUT} < 1.1V	—	840	—	
			1.1V ≤ V_{OUT} < 1.2V	—	780	—	
			1.2V ≤ V_{OUT} < 1.3V	—	710	—	
			1.3V ≤ V_{OUT} < 1.4V	—	660	—	
			1.4V ≤ V_{OUT} < 1.5V	—	610	—	
			1.5V ≤ V_{OUT} < 2.0V	—	570	—	
			2.0V ≤ V_{OUT} < 2.6V	—	440	—	
			2.6V ≤ V_{OUT} ≤ 3.3V	—	340	—	
t_D	Output Voltage Turn On Delay Time	V_{IN} = V_{OUT} + 1V, V_{EN} High to V_{OUT} Rising 10%		—	50	—	µs
t_{SS}	Output Voltage Ramp Up Time	V_{OUT} Rising 10% to 90%		—	200	—	µs
t_{PG}	PG React Time	V_{OUT} 90% to PG Active		—	30	—	µs
t_{PGF}	PG Off Deglitch Time	ADJ Falling to PG Low		—	3	—	µs
		EN Goes Low to PG Low					
V_{PGR}	PG Rising Threshold	ADJ Rising		89	92	95	%
V_{PGF}	PG Falling Threshold	ADJ Falling		79	82	85	%
V_{PGS}	PG Sinking Voltage	V_{IN} = 3.3V, Sinking Current = 5mA		—	—	0.4	V
V_{IL}	EN Input Logic Low Voltage	—		0	—	0.3	V
V_{IH}	EN Input Logic High Voltage	—		1.0	—	V_{IN}	V
R_{ENPD}	EN Pull-Down Resistor	—		—	3.0	—	MΩ
I_{EN}	EN Input Leakage Current	V_{IN} = 5.5V, V_{EN} = 0V		-0.1	—	0.1	µA
R_{PD}	Output Discharge Resistor	V_{OL} = 1V		—	100	—	Ω
I_{OUT}	Maximum Output Current	V_{IN} = V_{OUT} + 1V		1.0	—	—	A
I_{LIMIT}	Current Limit	V_{IN} = V_{OUT} + 1V ($V_{IN\ MINI}$ = 2.2V)		1.3	1.5	—	A
I_{SHORT}	Short-Circuit Current	V_{IN} = V_{OUT} + 1V, Output Voltage < 15% V_{OUT}		—	400	—	mA
PSRR	Power Supply Rejection Ratio (Note 7)	f = 1kHz, I_{OUT} = 100mA, V_{OUT} = 1.2V		—	75	—	dB
		f = 10kHz, I_{OUT} = 100mA, V_{OUT} = 1.2V		—	55	—	

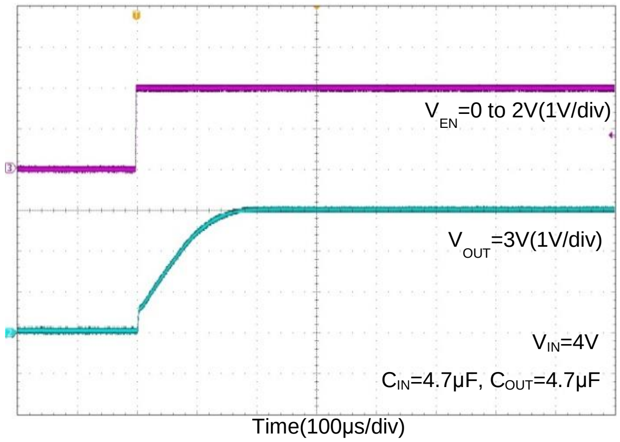
Electrical Characteristics (@T_A = +25°C, V_{IN} = V_{OUT} + 1V, C_{IN} = 4.7µF, C_{OUT} = 4.7µF, V_{EN} = V_{IN}, unless otherwise specified.) (continued)

Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
t_{ST}	Start-Up Time	V_{OUT} = 3V, C_{OUT} = 2.2µF, R_L = 30Ω	—	150	—	µs
$\frac{\Delta V_{OUT}}{\Delta T_A \times V_{OUT}}$	Output Voltage Temperature Coefficient	I_{OUT} = 100mA, -40°C ≤ T_A ≤ +85°C	—	±100	—	ppm/°C
T_{SHDN}	Thermal Shutdown Threshold	—	—	+150	—	°C
T_{HYS}	Thermal Shutdown Hysteresis	—	—	+20	—	°C
θ_{JA}	Thermal Resistance Junction-to-Ambient	U-DFN3030-8 (Type E) (Note 8)	—	70	—	°C/W

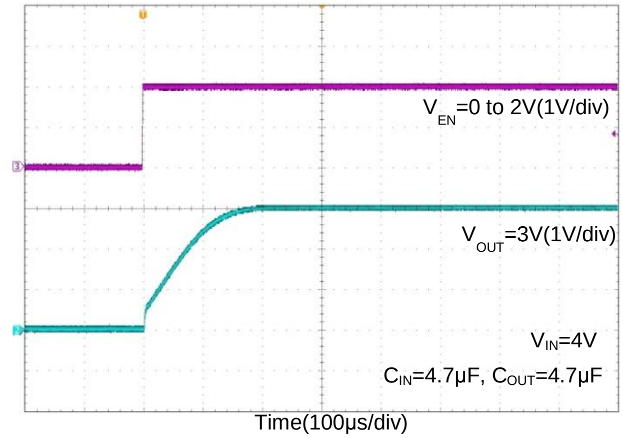
Notes: 6. Dropout voltage is the voltage difference between the input and the output at which the output voltage drops 2% below its nominal value. This parameter only applies to output voltages above 1.2V since minimum V_{IN} = 2.2V.
7. For V_{IN} ≥ 2.5V and V_{IN} = V_{OUT} +1V. For V_{IN} < 2.5V, the PSRR performance may be reduced.
8. Test condition: U-DFN3030-8 (Type E) device is mounted on 2" × 2", FR-4 substrate PCB, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane.

Typical Characteristics

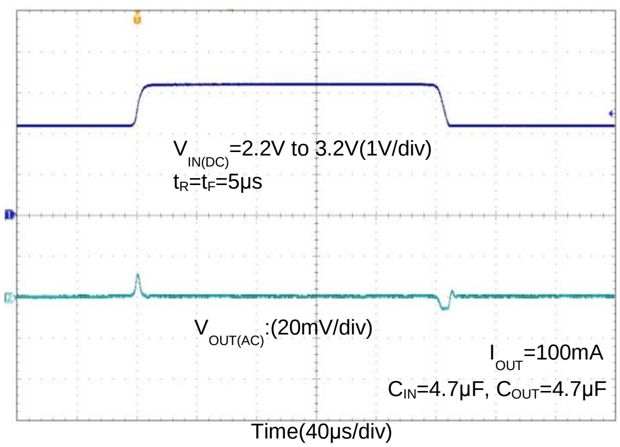
Start-up Time
V_{OUT}=3V@ I_{OUT}=50mA



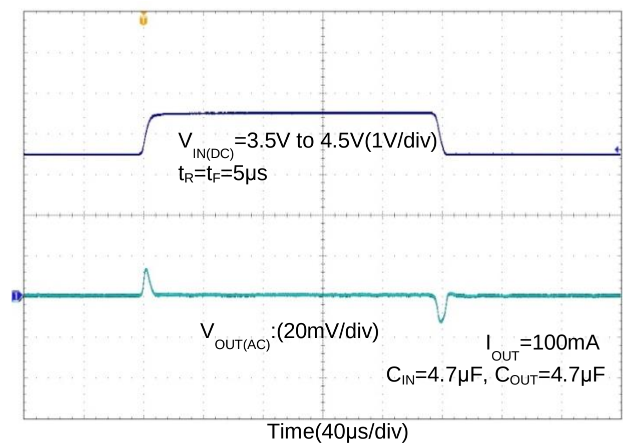
Start-up Time
V_{OUT}=3V@ I_{OUT}=100mA



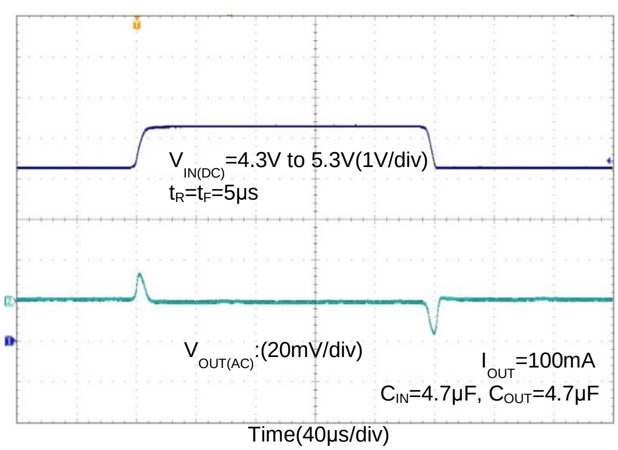
Line Transient Response
V_{OUT}=1.2V



Line Transient Response
V_{OUT}=2.5V

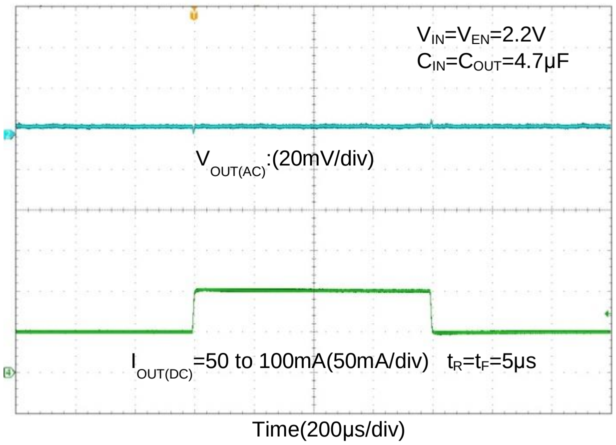


Line Transient Response
V_{OUT}=3.3V

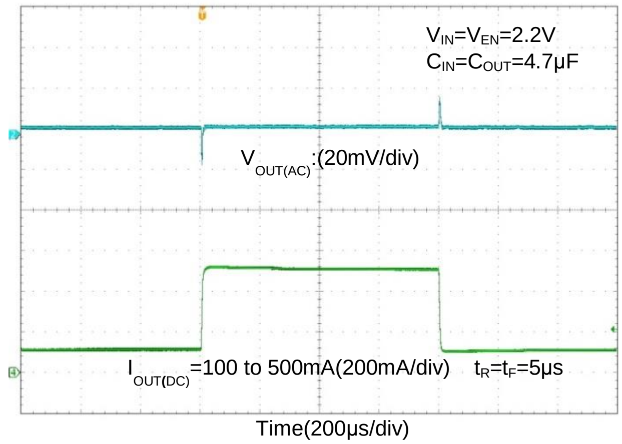


Typical Characteristics (continued)

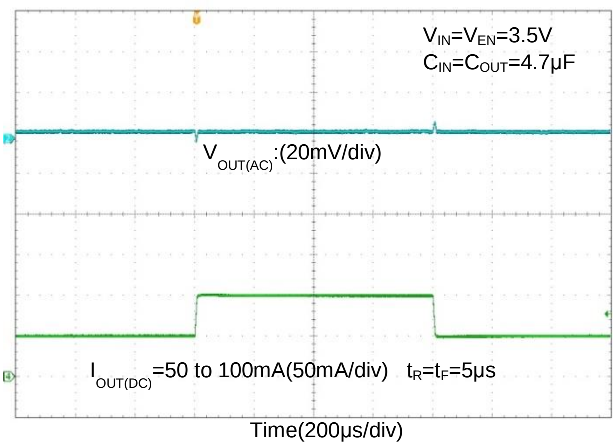
Load Transient Response
V_{OUT}=1.2V



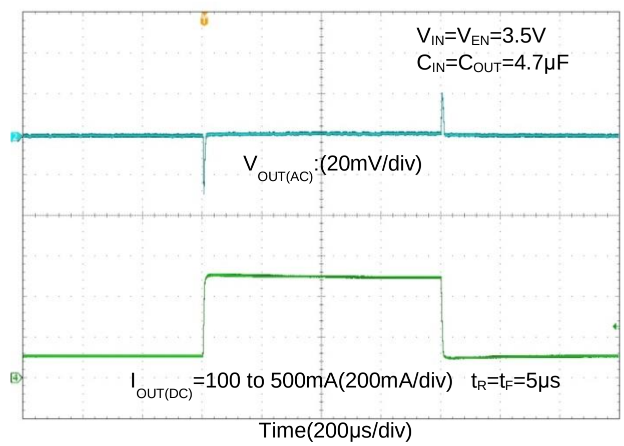
Load Transient Response
V_{OUT}=1.2V



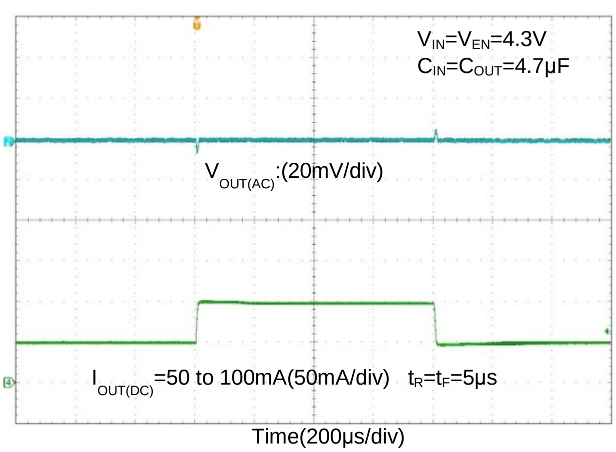
Load Transient Response
V_{OUT}=2.5V



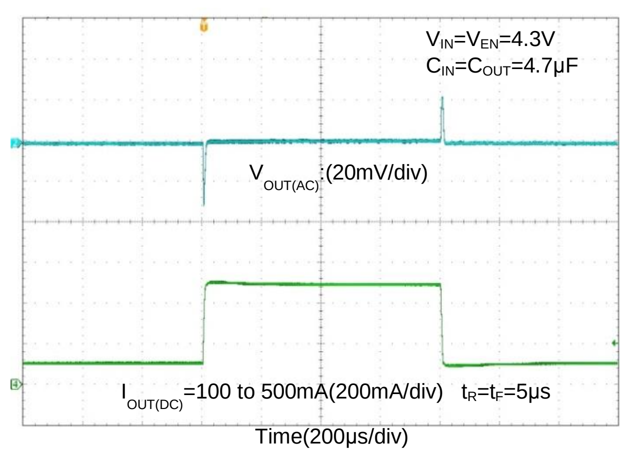
Load Transient Response
V_{OUT}=2.5V



Load Transient Response
V_{OUT}=3.3V



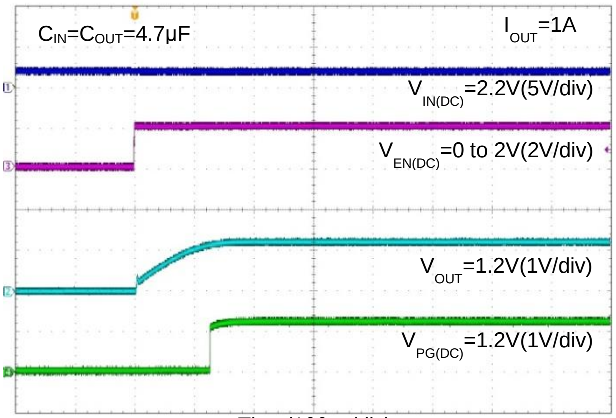
Load Transient Response
V_{OUT}=3.3V



Typical Characteristics (continued)

Enable Turn-On Response

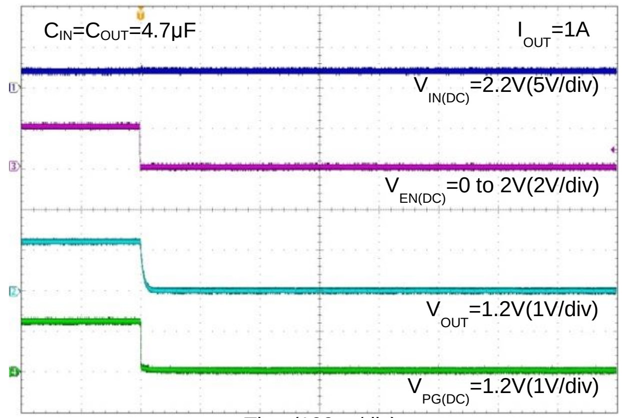
V_{OUT}=1.2V



Time(100µs/div)

Enable Turn-Off Response

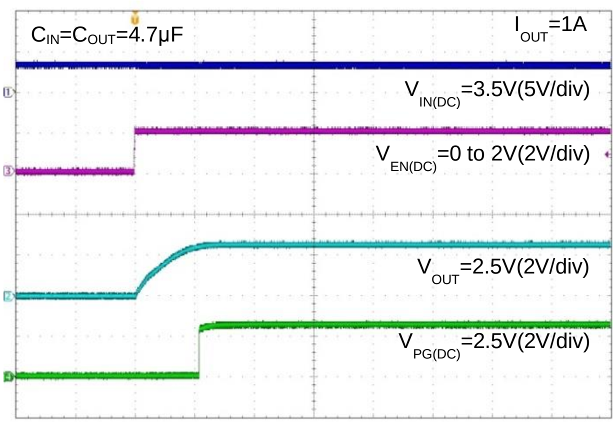
V_{OUT}=1.2V



Time(100µs/div)

Enable Turn-On Response

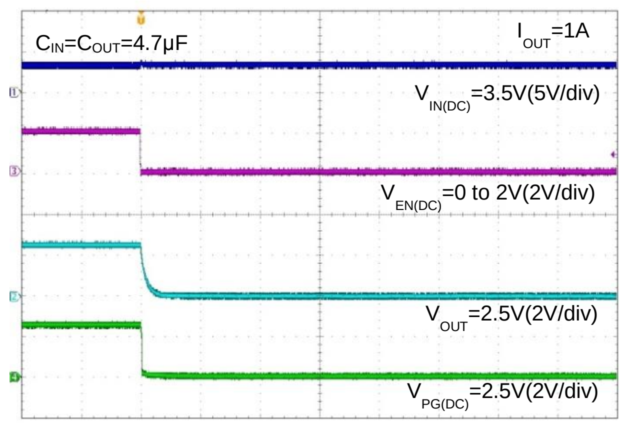
V_{OUT}=2.5V



Time(100µs/div)

Enable Turn-Off Response

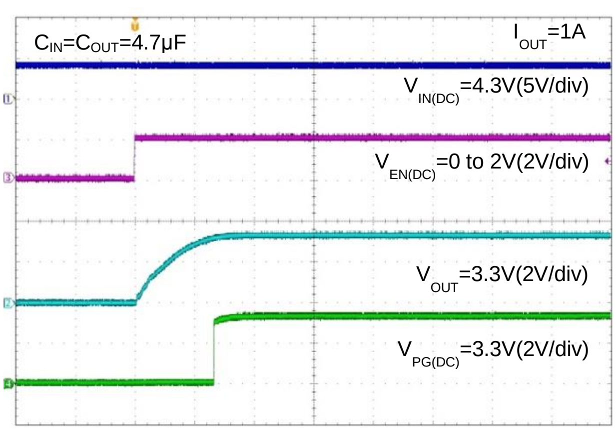
V_{OUT}=2.5V



Time(100µs/div)

Enable Turn-On Response

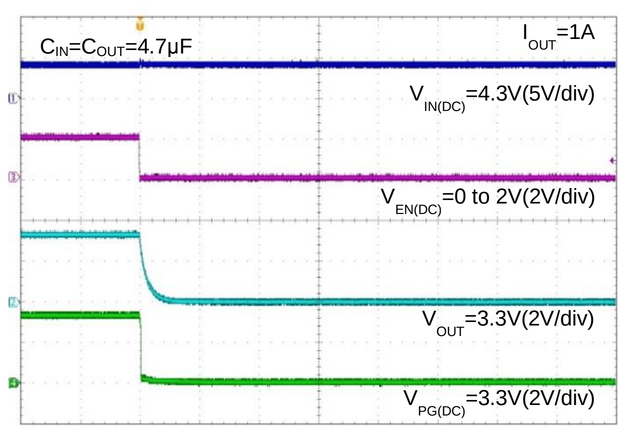
V_{OUT}=3.3V



Time(100µs/div)

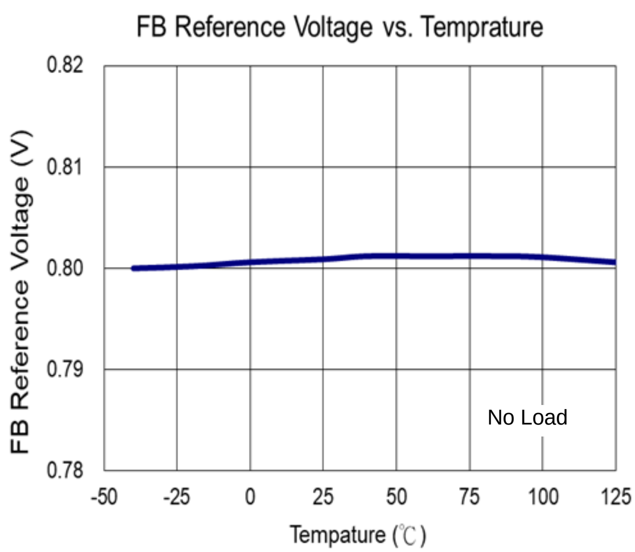
Enable Turn-Off Response

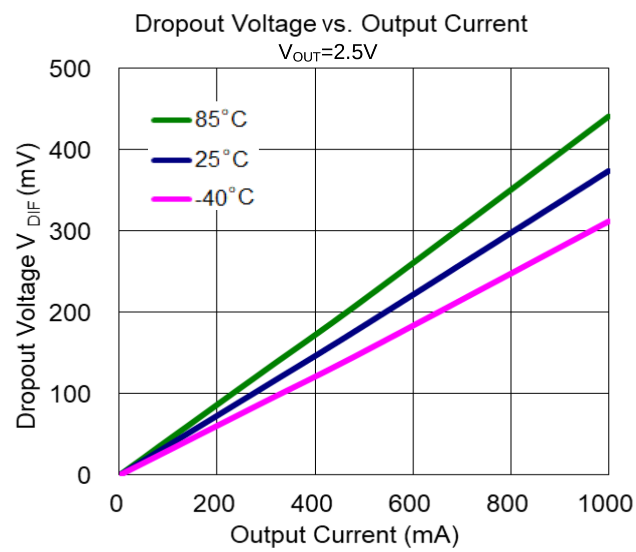
V_{OUT}=3.3V

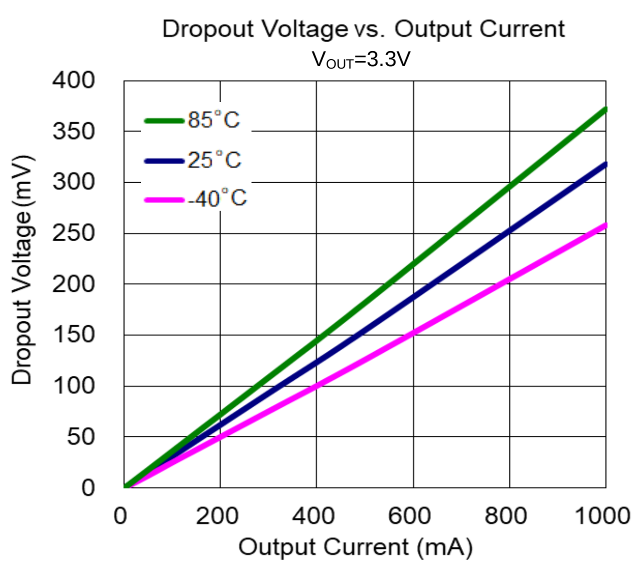


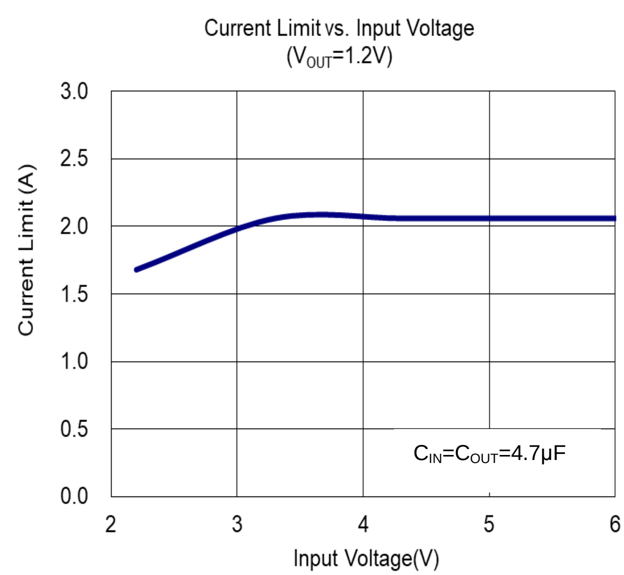
Time(100µs/div)

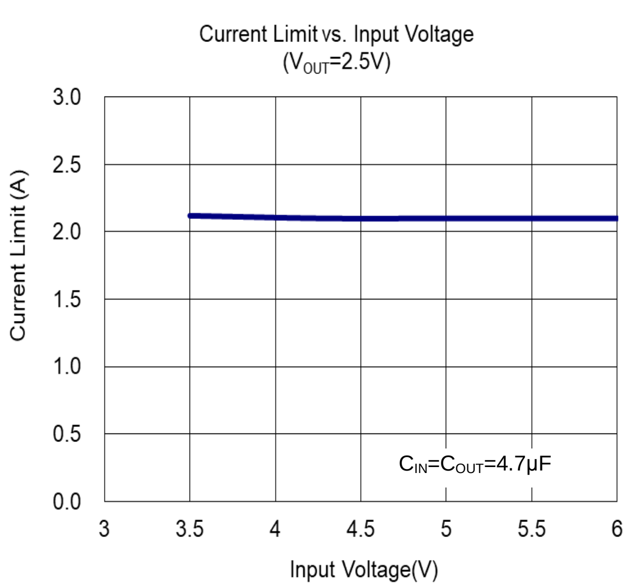
Typical Characteristics (continued)

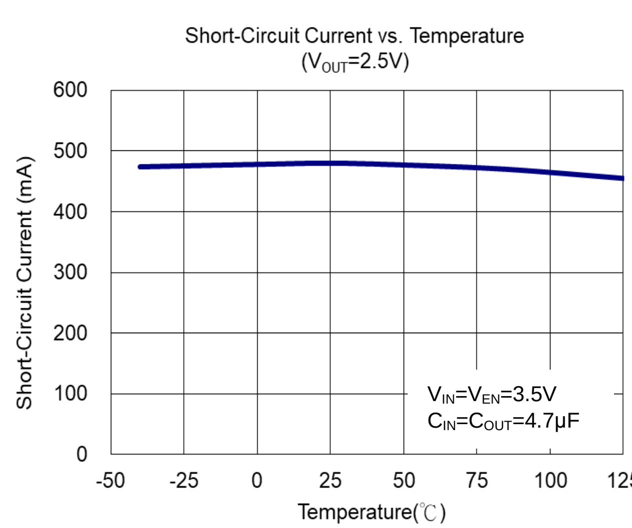






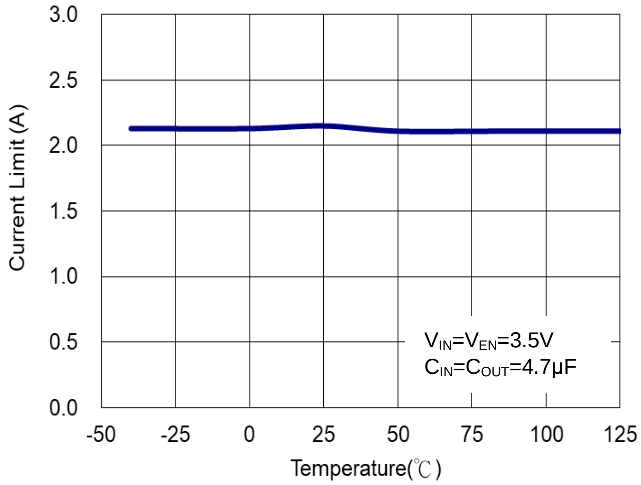




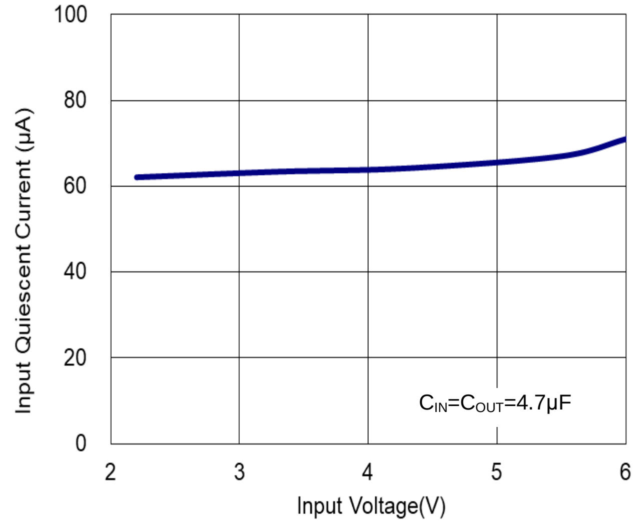


Typical Characteristics (continued)

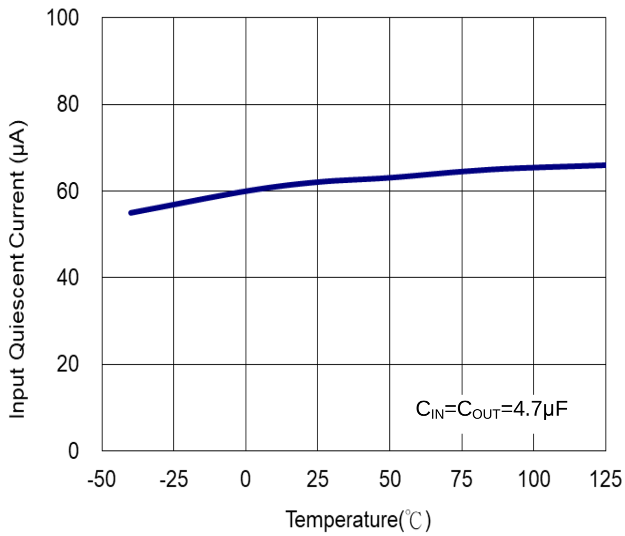
Current Limit vs. Temperature
(V_{OUT}=2.5V)



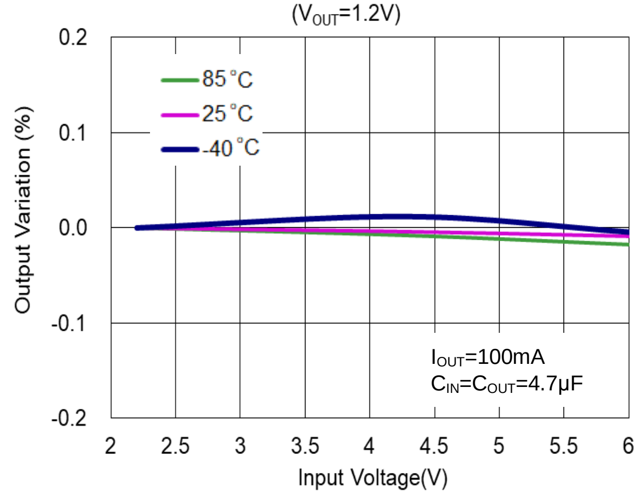
Input Quiescent Current vs. Input Voltage



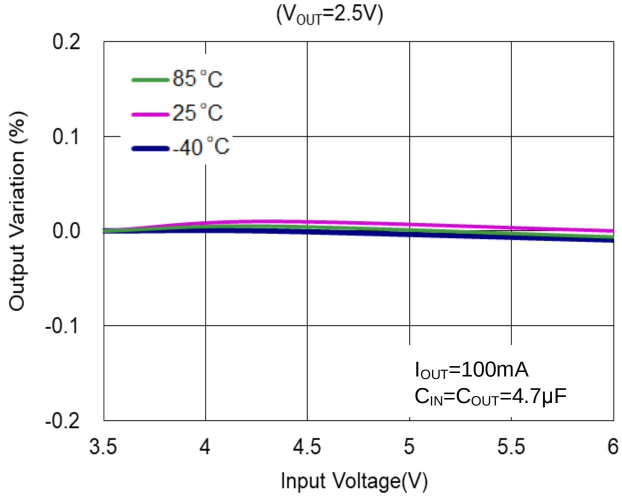
Input Quiescent Current vs. Temperature



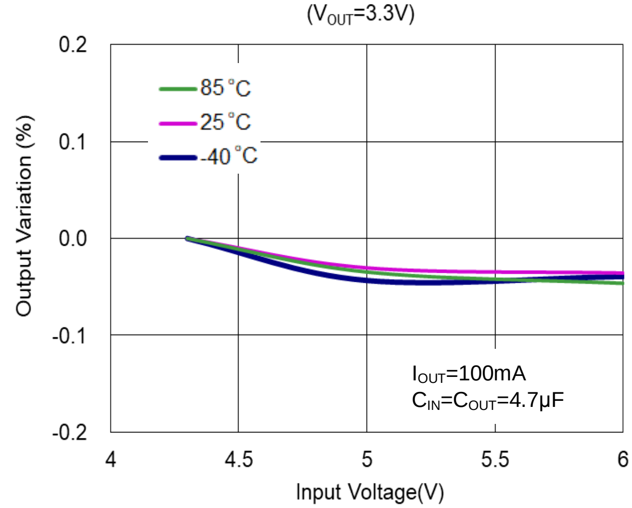
Line Regulation
(V_{OUT}=1.2V)



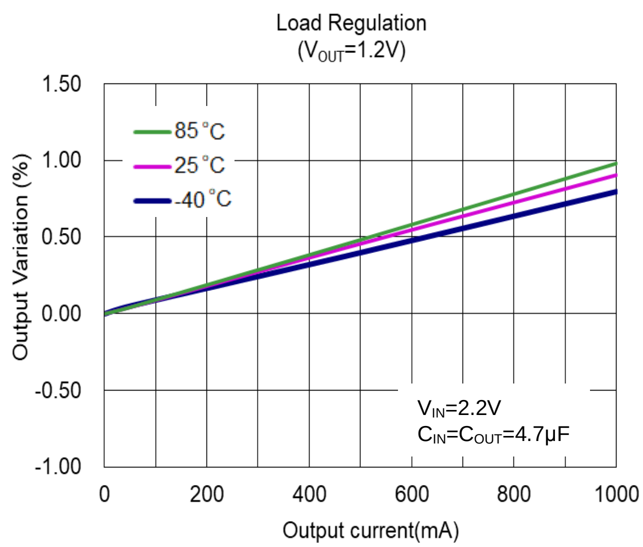
Line Regulation
(V_{OUT}=2.5V)

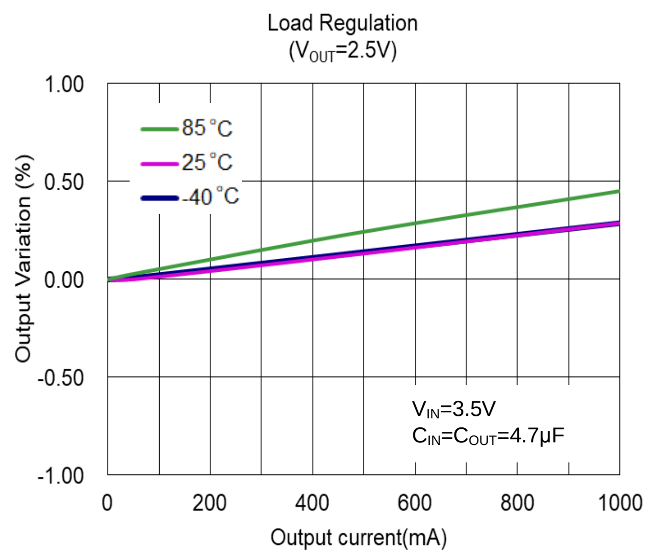


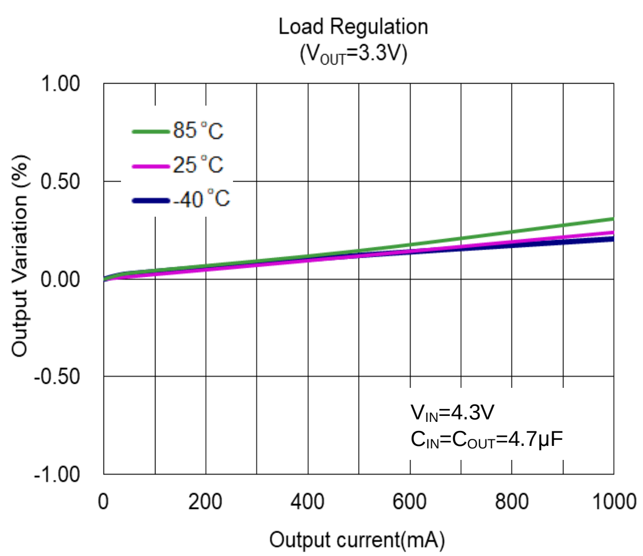
Line Regulation
(V_{OUT}=3.3V)

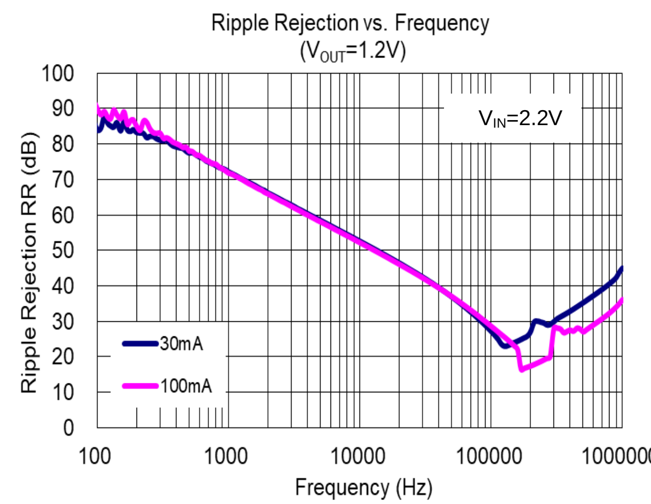


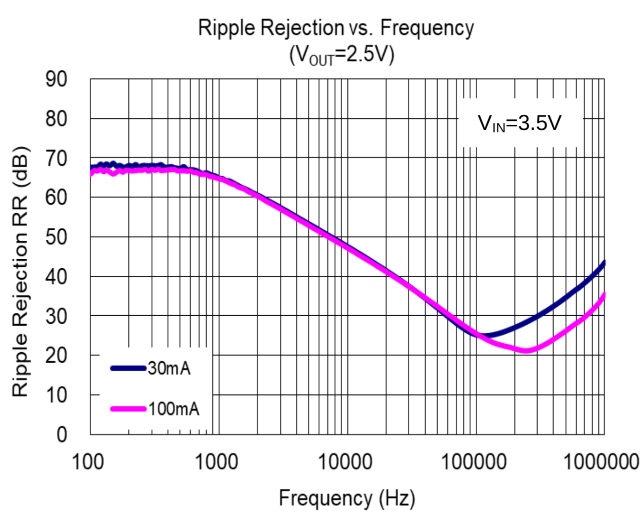
Typical Characteristics (continued)

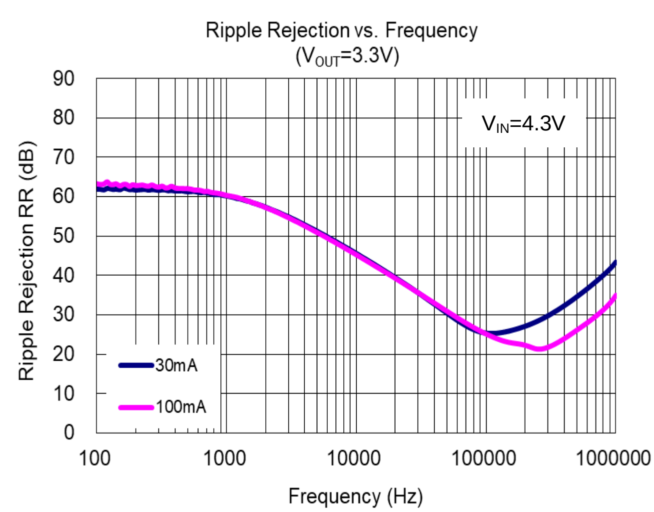












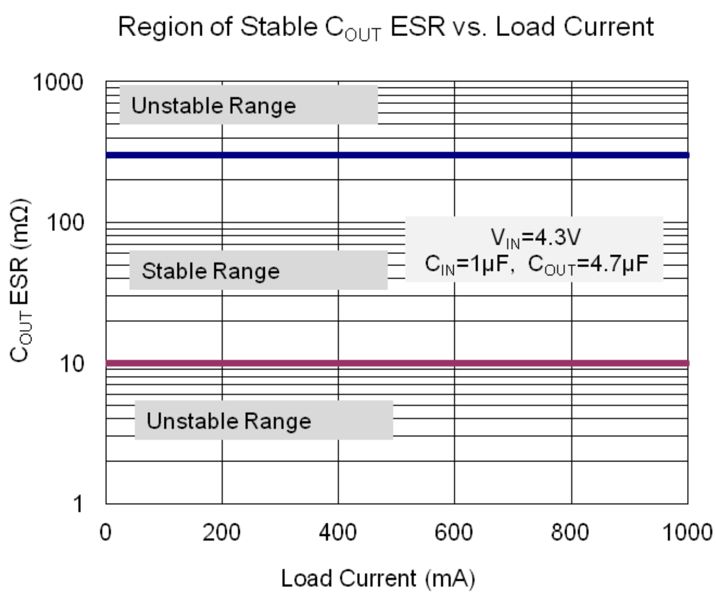
Application Information

Input Capacitor

A 1µF ceramic capacitor is recommended between IN and GND pins to decouple input power supply glitch and noise. The amount of the capacitance may be increased without limit. This input capacitor must be located as close as possible to the device to assure input stability and reduce noise. For PCB layout, a wide copper trace is required for both IN and GND pins. A lower ESR capacitor type allows the use of less capacitance, while higher ESR type requires more capacitance.

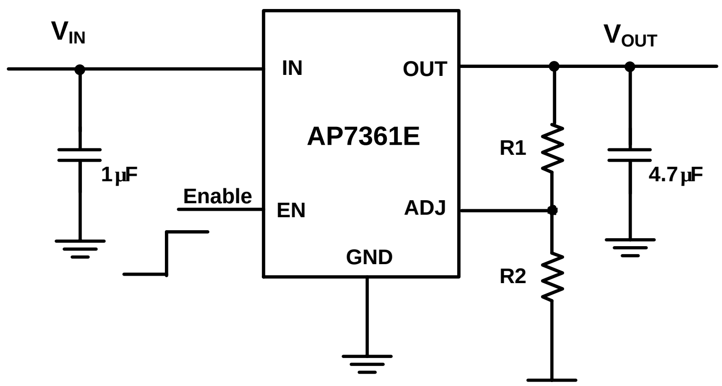
Output Capacitor

The output capacitor is required to stabilize and improve the transient response of the LDO. The AP7361E is stable with very small ceramic output capacitors. Using a ceramic capacitor value that is at least 2.2µF with 10mΩ ≦ ESR ≦ 300mΩ on the output ensures stability. Higher capacitance values help to improve line and load transient response. The output capacitance may be increased to keep low undershoot and overshoot. Output capacitor must be placed as close as possible to OUT and GND pins.



Adjustable Operation

The AP7361E provides output voltage from 0.8V to 5.0V through external resistor divider as shown below.



Adjustable Output

Application Information (continued)

The output voltage is calculated by:

$$V_{OUT} = V_{REF}\left(1 + \frac{R_1}{R_2}\right)$$

Where V_{REF} = 0.8V (the internal reference voltage).

Rearranging the equation will give the following that is used for adjusting the output to a particular voltage:

$$R1 = R2\left(\frac{V_{OUT}}{V_{REF}} - 1\right)$$

To maintain the stability of the internal reference voltage, R2 needs to be kept smaller than 80kΩ.

No Load Stability

Other than external resistor divider, no minimum load is required to keep the device stable. The device will remain stable and regulated in no load condition.

ON/OFF Input Operation

The AP7361E is turned on by setting the EN pin high, and is turned off by pulling it low. If this feature is not used, the EN pin should be tied to IN pin to keep the regulator output on at all time. To ensure proper operation, the signal source used to drive the EN pin must be able to swing above and below the specified turn-on/off voltage thresholds listed in the *Electrical Characteristics* section under V_{IL} and V_{IH}.

Current Limit Protection

When output current at OUT pin is higher than current limit threshold, the current limit protection will be triggered and clamp the output current to prevent over-current and to protect the regulator from damage due to overheating.

Short Circuit Protection

When OUT pin is short-circuit to GND, short circuit protection will be triggered and clamp the output current to approximately 400mA. Full current is restored when the output voltage exceeds 15% of V_{OUT}. This feature protects the regulator from over-current and damage due to overheating.

Power Good

The power-good (PG) pin is an open-drain output and can be pulled up through a resistor of 10kΩ to1MΩ to V_{IN}, V_{OUT} or any other rail that is 6V or lower. When the $V_{OUT} \geq V_{PGR}$, the PG output is high-impedance; if the V_{OUT} drops to below V_{PGF}, or the device is disabled, the PG pin is pulled to low by an internal MOSFET.

Thermal Shutdown Protection

Thermal protection disables the output when the junction temperature rises to approximately +150°C, allowing the device to cool down. When the junction temperature reduces to approximately +130°C the output circuitry is enabled again. Depending on power dissipation, thermal resistance, and ambient temperature, the thermal protection circuit may cycle on and off. This cycling limits the heat dissipation of the regulator, protecting it from damage due to overheating.

Ultra Fast Start-up

After enabled, the AP7361E is able to provide full power in as little as tens of microseconds, typically 200µs, without sacrificing low ground current. This feature will help load circuitry move in and out of standby mode in real time, eventually extend battery life for mobile phones and other portable devices.

Low Quiescent Current

The AP7361E, consuming only around 60µA for all input range, provides great power saving in portable and low power applications.

Application Information (continued)

Power Dissipation

The device power dissipation and proper sizing of the thermal plane that is connected to the thermal pad is critical to avoid thermal shutdown and ensure reliable operation. Power dissipation of the device depends on input voltage and load conditions and can be calculated by:

$P_D = (V_{IN} - V_{OUT}) \times I_{OUT}$

The maximum power dissipation, handled by the device, depends on the maximum junction to ambient thermal resistance, maximum ambient temperature, and maximum device junction temperature, which can be calculated by the equation in the following:

$$P_D(max@T_A) = \frac{(+150°C - T_A)}{R_{\theta JA}}$$

Ordering Information

AP7361E - X X - X

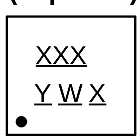
Output	Package	Packing
Blank : ADJ 10 : 1.0V 12 : 1.2V 15 : 1.5V 18 : 1.8V 25 : 2.5V 28 : 2.8V 33 : 3.3V	FGE : U-DFN3030-8 (Type E)	7 : 7" Tape & Reel

Part Number	Package Code	Packaging	7" Tape and Reel	
			Quantity	Part Number Suffix
AP7361E-XFGE-7	FGE	U-DFN3030-8 (Type E)	3000/Tape & Reel	-7

Marking Information

(1) U-DFN3030-8 (Type E)

(Top View)



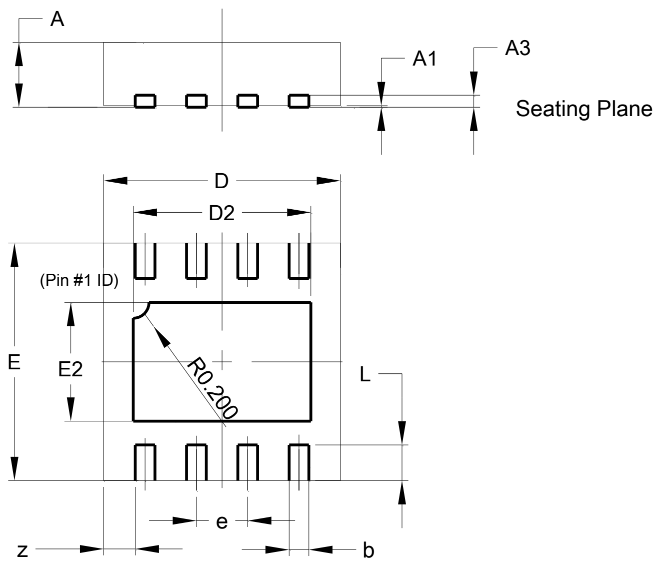
XXX : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : Internal Code

Part Number	Package	Identification Code
AP7361E-FGE-7	U-DFN3030-8 (Type E)	C9A
AP7361E-10FGE-7	U-DFN3030-8 (Type E)	C9B
AP7361E-12FGE-7	U-DFN3030-8 (Type E)	C9C
AP7361E-15FGE-7	U-DFN3030-8 (Type E)	C9D
AP7361E-18FGE-7	U-DFN3030-8 (Type E)	C9E
AP7361E-25FGE-7	U-DFN3030-8 (Type E)	C9F
AP7361E-28FGE-7	U-DFN3030-8 (Type E)	C9G
AP7361E-33FGE-7	U-DFN3030-8 (Type E)	C9H

Package Outline Dimensions

Please see http://www.diodes.com/package-outlines.html for the latest version.

U-DFN3030-8 (Type E)

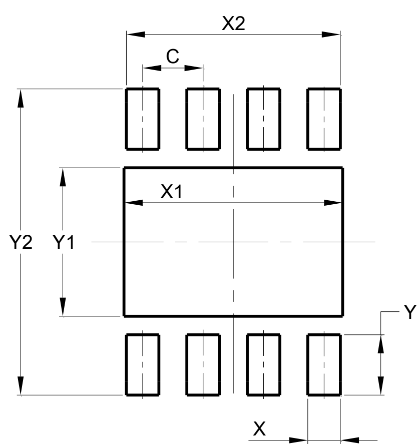


U-DFN3030-8 (Type E)			
Dim	**Min**	**Max**	**Typ**
A	0.57	0.63	0.60
A1	0.00	0.05	0.02
A3	-	-	0.15
b	0.20	0.30	0.25
D	2.95	3.05	3.00
D2	2.15	2.35	2.25
E	2.95	3.05	3.00
E2	1.40	1.60	1.50
e	-	-	0.65
L	0.30	0.60	0.45
z	-	-	0.40
All Dimensions in mm			

Suggested Pad Layout

Please see http://www.diodes.com/package-outlines.html for the latest version.

U-DFN3030-8 (Type E)



Dimensions	Value (in mm)
C	0.650
X	0.350
X1	2.350
X2	2.300
Y	0.650
Y1	1.600
Y2	3.300

Mechanical Data

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: NiPdAu over Copper Leads, Solderable per MIL-STD-202, Method 208 (e4)
- Weight: 0.0164 grams (Approximate)