

1A LOW DROPOUT ADJUSTABLE AND FIXED-MODE REGULATOR WITH ENABLE

Description

The AP7361 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.

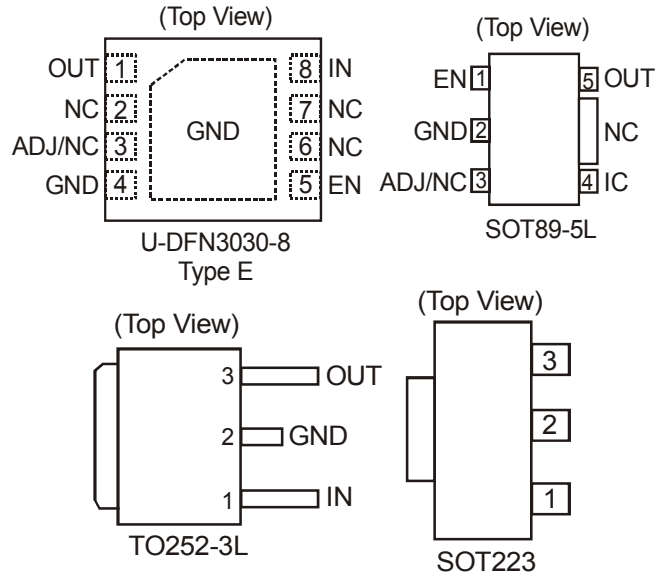
The characteristics of the low dropout voltage and low quiescent current make it suitable for low to medium power applications, for example, laptop computers, audio and video applications, and battery powered devices. The typical quiescent current is approximately 70 μ A. Built-in current-limit and thermal-shutdown functions prevent IC from damage in fault conditions.

The AP7361 is available in U-DFN3030-8 Type E, SOT89-5L, SOT223-3L and TO252-3L package.

Features

- Wide input voltage range: 2.2V – 6V
- 150mV very low dropout at 300mA load
- 500mV very low dropout at 1A load
- Low quiescent current (I_Q): 70 μ A typical
- Adjustable output voltage range: 1V to 5.0V
- Fixed output options: 1V to 3.3V
- Very fast transient response
- High PSRR
- Accurate voltage regulation
- Current limiting and short circuit protection
- Thermal shutdown protection
- Stable with ceramic output capacitor $\geq 2.2\mu$ F
- Ambient temperature range -40°C to 85°C
- DFN3030E-8, SOT89-5L, SOT223-3L and TO252-3L:
Available in "Green" Molding Compound (No Br, Sb)
- Lead Free Finish/ RoHS Compliant (Note 1)

Pin Assignments

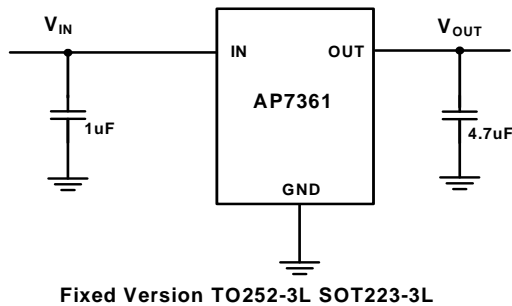
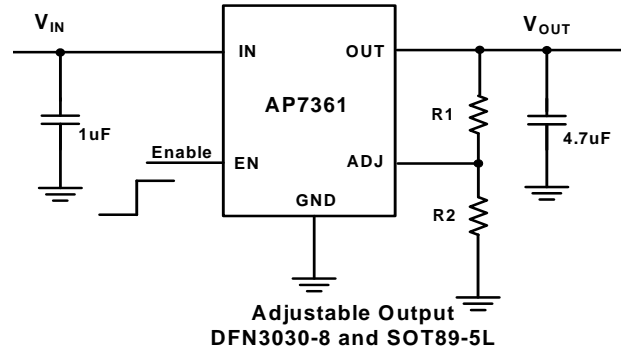
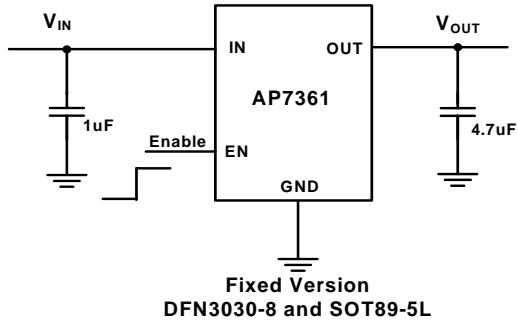


Applications

- Servers and laptops
- FPGA and DSP core or I/O power
- TV, and home electrical appliances
- Battery-powered devices

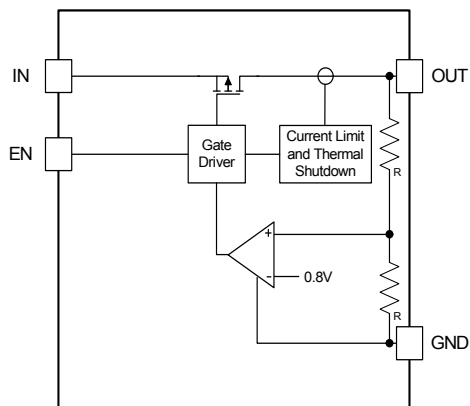
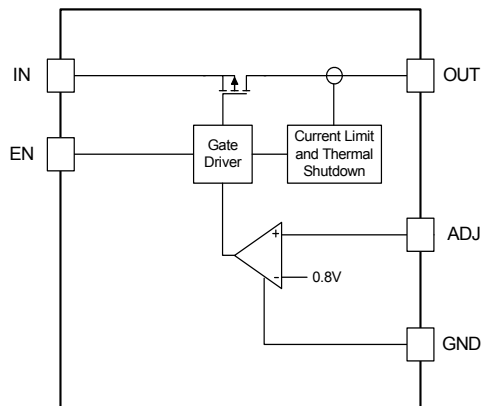
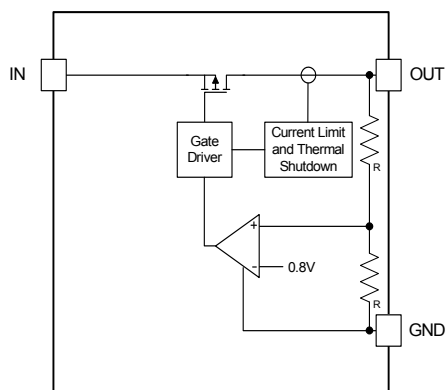
Note: 1. EU Directive 2002/95/EC (RoHS). All applicable RoHS exemptions applied. Please visit our website at http://www.diodes.com/products/lead_free.html

Typical Application Circuit



Pin Descriptions

| Pin Name | Pin Number | | | | | Description |
|----------|--------------------|----------|----------|-----------|------------|--|
| | U-DFN3030-8 Type E | SOT89-3L | TO252-3L | SOT223-3L | SOT223R-3L | |
| IN | 8 | 4 | 1 | 1 | 3 | The input of the regulator. Bypass to ground through at least 1μF ceramic capacitor. |
| OUT | 1 | 5 | 3 | 3 | 2 | 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. |
| GND | 4 | 2 | 2 | 2 | 1 | Ground. |
| ADJ | 3 | 3 | NA | NA | NA | Adjustable voltage version only – a resistor divider from this pin to the OUT pin and ground sets the output voltage. |
| EN | 5 | 1 | NA | NA | NA | Enable input, active high. |
| NC | 2, 6, 7 | NA | NA | NA | NA | No connection. |

Functional Block Diagram

Fixed Version DFN3030-8 and SOT89-5L

Adjustable Version DFN3030-8 and SOT89-5L

Fixed Version TO252-3L SOT223-3L

Absolute Maximum Ratings

| Symbol | Parameter | Ratings | Unit |
|----------|--------------------------------------|---|------|
| ESD HBM | Human Body Model ESD Protection | > 2 | KV |
| ESD MM | Machine Model ESD Protection | > 200 | V |
| V_{IN} | Input Voltage | 6.5 | V |
| | OUT, ADJ, EN Voltage | $V_{IN} + 0.3$ | V |
| T_J | Operating Junction Temperature Range | -40 ~ 150 | °C |
| T_{ST} | Storage Temperature Range | -65 ~ 150 | °C |
| P_D | Power Dissipation (Note 2) | Internally limited by maximum junction temperature of 150°C | |
| P_D | Power Dissipation (Note 2) | U-DFN3030-8 Type E | 1700 |
| | | TO252 | 1250 |
| | | SOT223-3L | 1100 |
| | | SOT89-5L | 800 |

Note: 2. Ratings apply to ambient temperature at 25°C

Stresses greater than the 'Absolute Maximum Ratings' specified above, may 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 may be affected by exposure to absolute maximum rating conditions for extended periods of time.

Recommended Operating Conditions

| Symbol | Parameter | Min | Max | Unit |
|-----------|-------------------------------|-----|-----|------|
| V_{IN} | Input voltage | 2.2 | 6.0 | V |
| I_{OUT} | Output Current (Note 3) | 0 | 1.0 | A |
| T_A | Operating Ambient Temperature | -40 | 85 | °C |

Note: 3. 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.

**1A LOW DROPOUT ADJUSTABLE AND FIXED-MODE
REGULATOR WITH ENABLE**
Electrical Characteristics

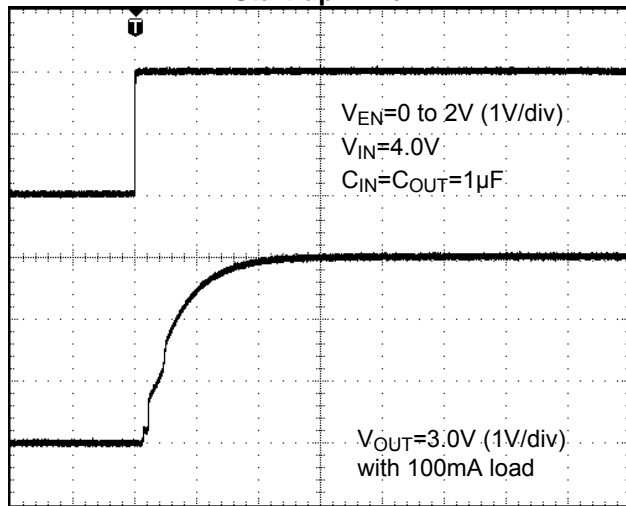
 (T_A = 25°C, V_{IN} = V_{OUT} + 1V, C_{IN} = 1μF, C_{OUT} = 4.7μF, V_{EN} = V_{IN}, unless otherwise stated)

| Symbol | Parameter | Test Conditions | Min | Typ. | Max | Unit |
|---|--|--|------|------|-----------------|--------|
| V _{REF} | FB reference voltage | I _{OUT} = 10mA, T _A = 25°C | | 0.8 | | V |
| I _{ADJ} | ADJ pin leakage | | | 0.1 | 0.5 | μA |
| I _Q | Input Quiescent Current | Enabled, I _{OUT} = 0A | | 70 | 90 | 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 | | 1 | % |
| | | I _{OUT} = 100mA, -40°C ≤ T _A ≤ 85°C | -2 | | 2 | |
| | | Over V _{IN} , I _{OUT} , and T _A | -3 | ±0.5 | 3 | |
| $\frac{\Delta V_{OUT}}{\Delta V_{IN} \times V_{OUT}}$ | Line Regulation | V _{IN} = V _{OUT} + 1V to 6V, I _{OUT} = 100mA | | 0.01 | 0.1 | % / V |
| | | T _A = 25°C | | | | |
| | | -40°C ≤ T _A ≤ 85°C | | | 0.2 | |
| ΔV _{OUT} / V _{OUT} | Load Regulation | I _{OUT} from 1mA to 300mA | -1.0 | 0.5 | 1.0 | % |
| | | I _{OUT} from 1mA to 1A | -1.0 | 0.5 | 1.0 | % |
| V _{DROPOUT} | Dropout Voltage (Note 4) | I _{OUT} = 300mA | | 150 | 200 | mV |
| | | I _{OUT} = 500mA | | 250 | 350 | |
| | | I _{OUT} = 1A | | 500 | 700 | |
| V _{IL} | EN Input Logic Low Voltage | | 0 | | 0.3 | V |
| V _{IH} | EN Input Logic High Voltage | | 1.0 | | V _{IN} | V |
| I _{EN} | EN Input leakage | V _{IN} = 6V, V _{EN} = 0V or 6V | -0.1 | 0.01 | 0.1 | μA |
| I _{LIMIT} | Current limit | V _{IN} = V _{OUT} + 1V | 1.1 | 1.5 | | A |
| I _{SHORT} | Short-circuit Current | V _{IN} = V _{OUT} + 1V, Output Voltage < 25% V _{out} | | 200 | | mA |
| PSRR | Power Supply Rejection Ratio (Note 5) | f = 1KHz, I _{OUT} = 100mA | 60 | 65 | | dB |
| | | f = 10KHz, I _{OUT} = 100mA | | 45 | | |
| t _{ST} | Start-up Time | V _{OUT} = 3V, C _{OUT} = 1μF, R _L = 30Ω | | 200 | | μs |
| $\frac{\Delta V_{OUT}}{\Delta T_A \times V_{OUT}}$ | Output voltage temperature coefficient | I _{OUT} = 100mA, -40°C ≤ T _A ≤ 85°C | | ±130 | | 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 6) | | 70 | | °C/W |
| | | TO252 (Note 6) | | 95 | | |
| | | SOT223-3L (Note 6) | | 110 | | |
| | | SOT89-5L (Note 6) | | 150 | | |

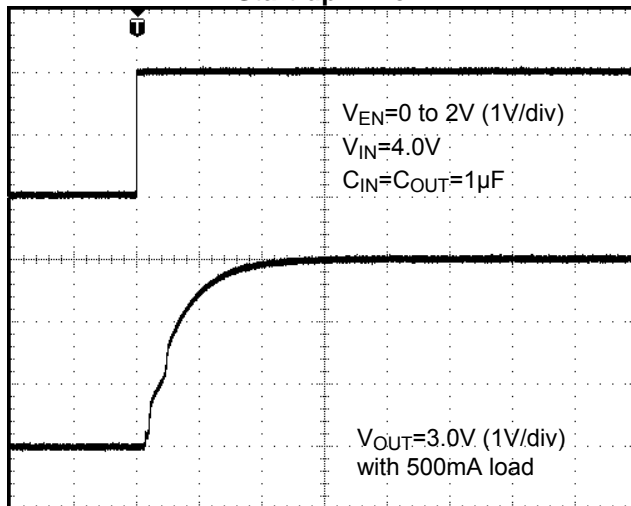
- Notes:
- Dropout voltage is the voltage difference between the input and the output at which the output voltage drops 2% below its nominal value. This parameter only applies to output voltages above 1.5V since minimum V_{IN} = 2.2V.
 - For V_{IN} ≥ 2.5V and V_{IN} = V_{OUT} + 1V. For V_{IN} < 2.5V, the PSRR performance may be reduced.
 - Test condition : U-DFN3030-8 Type E device mounted on 2"x2" FR-4 substrate PCB, with minimum recommended pad on top layer and thermal vias to bottom layer ground plane. TO252 device mounted on 2"x2" FR-4 substrate PC board, 2oz copper, with minimum recommended pad layout. SOT223-3L the device is mounted on FR-4 substrate PC board, with minimum recommended pad layout. SOT89-5L device mounted on 1"x1" FR-4 substrate PC board, with minimum recommended pad layout

Typical Performance Characteristics

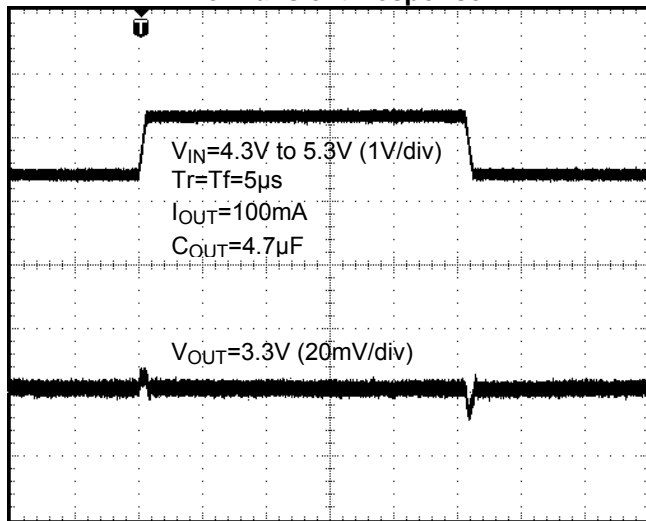
Start-up Time



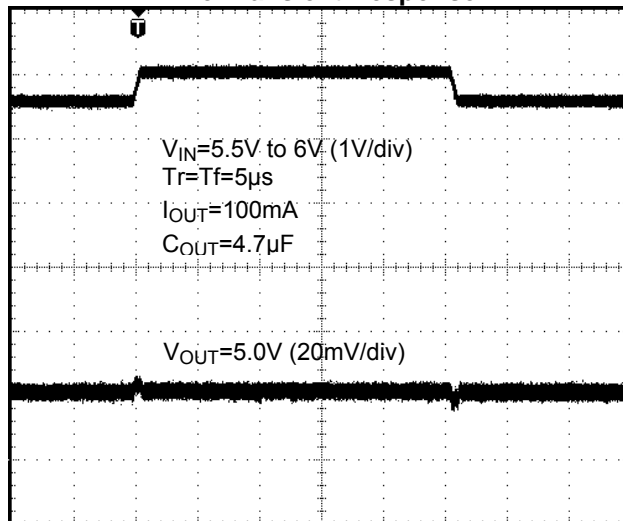
Start-up Time



Line Transient Response

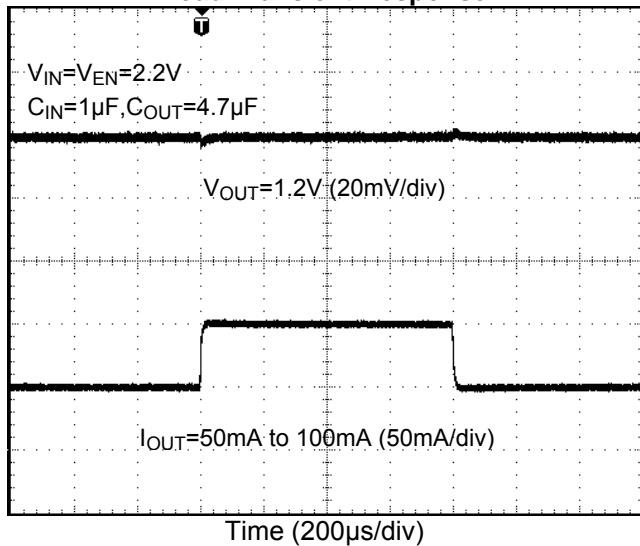


Line Transient Response

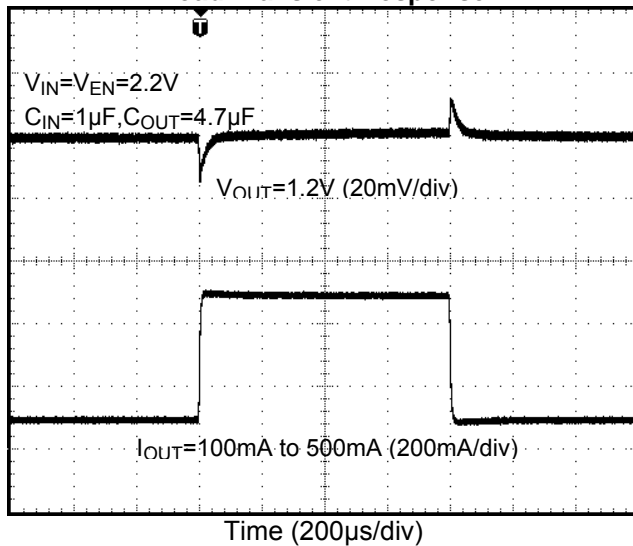


Typical Performance Characteristics (cont.)

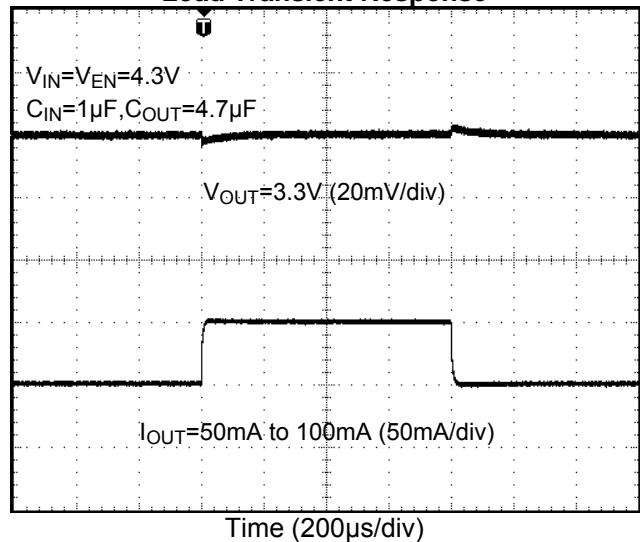
Load Transient Response



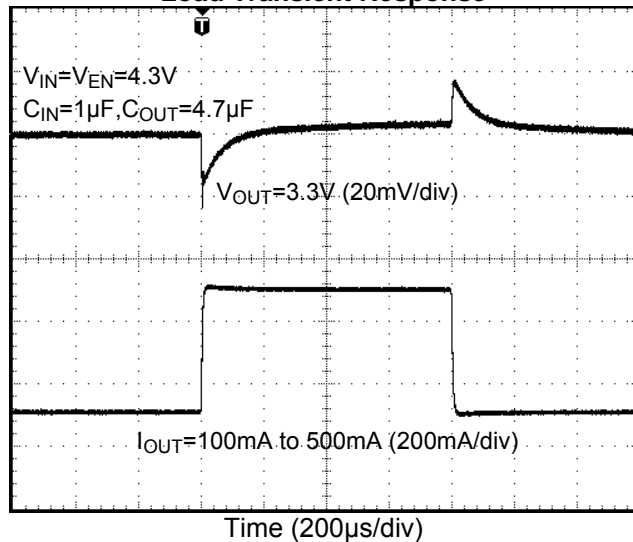
Load Transient Response



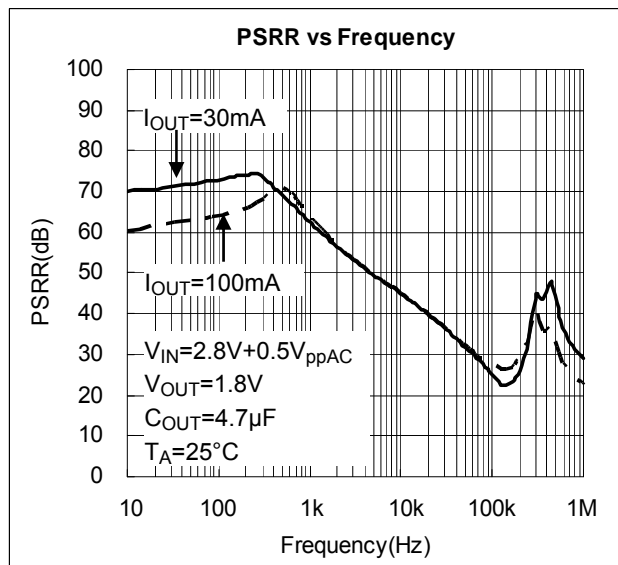
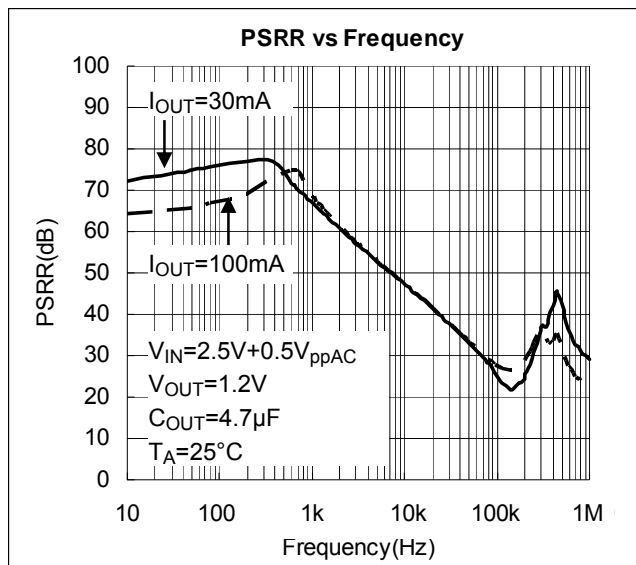
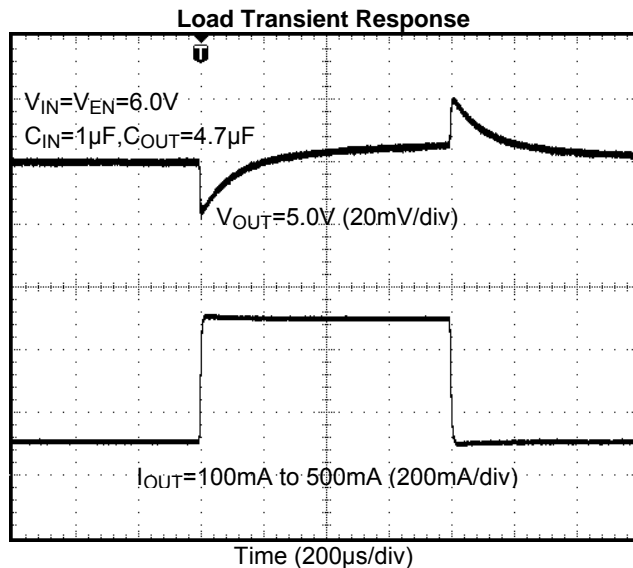
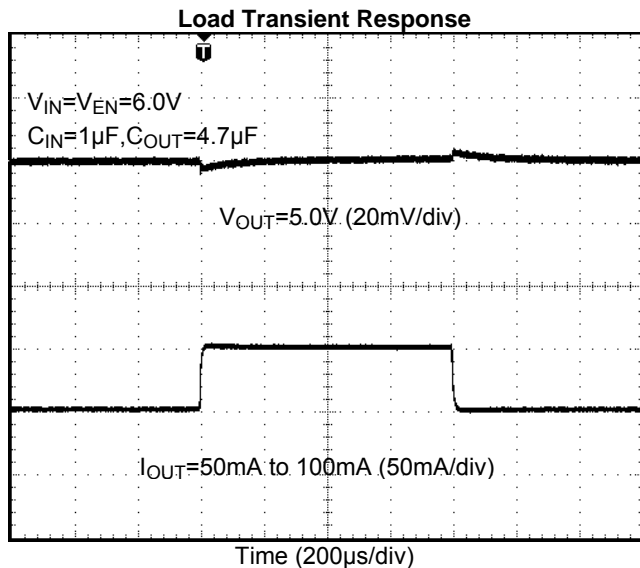
Load Transient Response



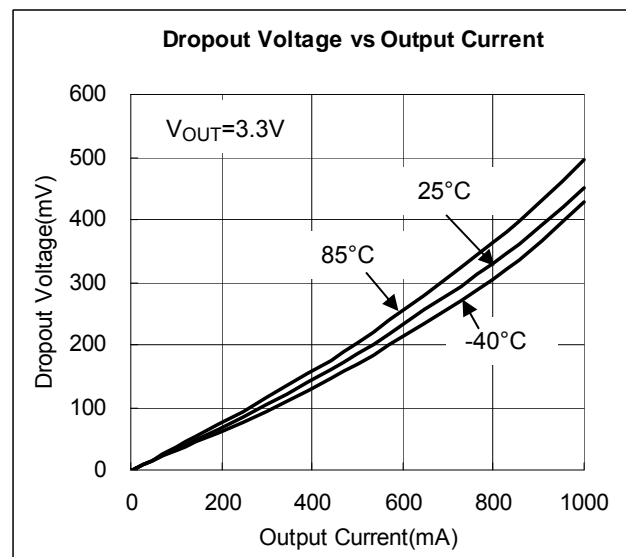
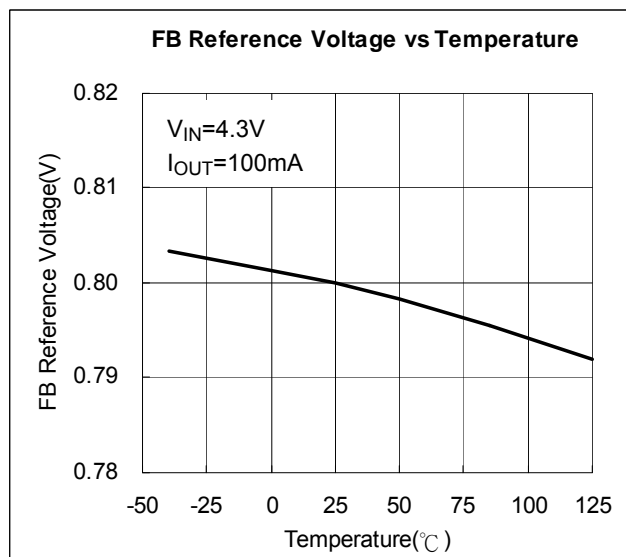
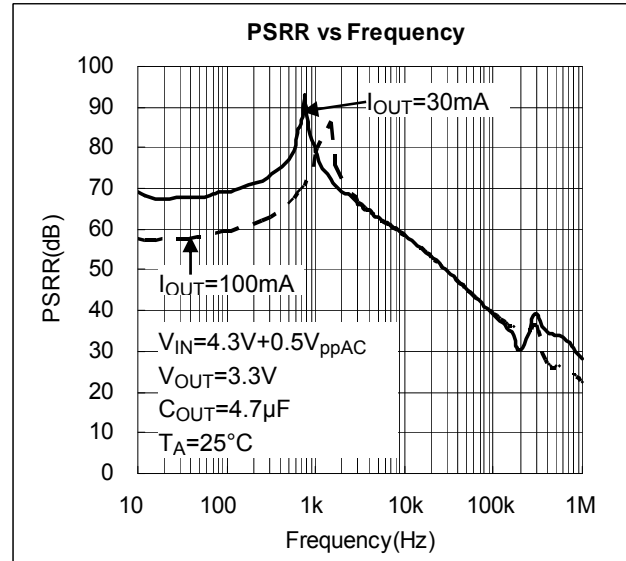
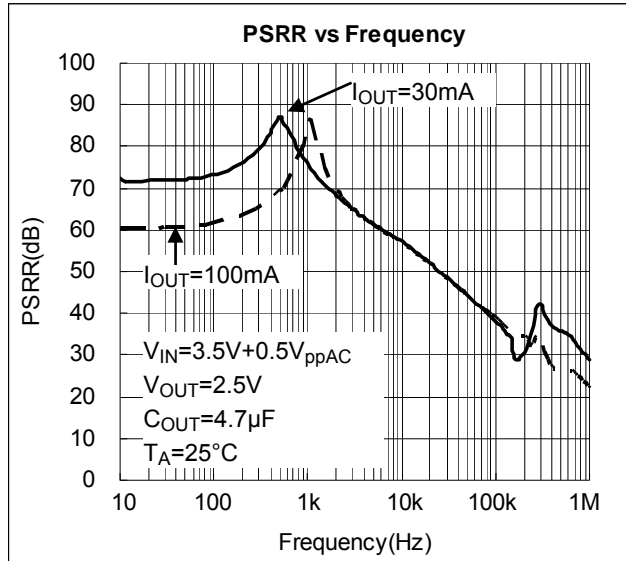
Load Transient Response



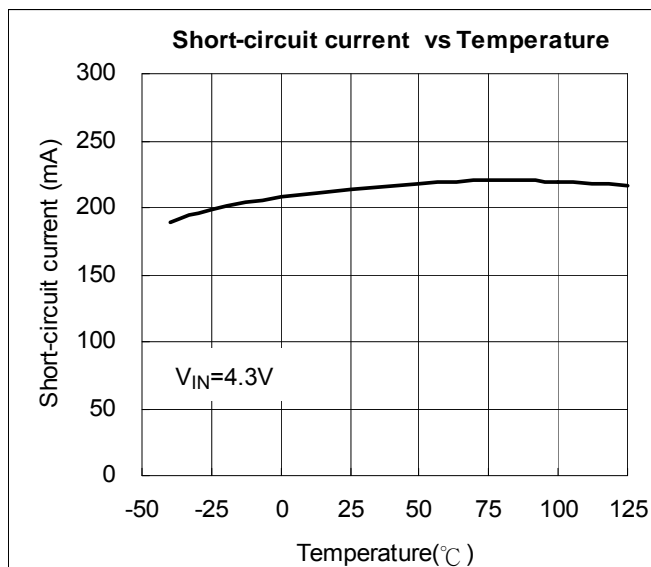
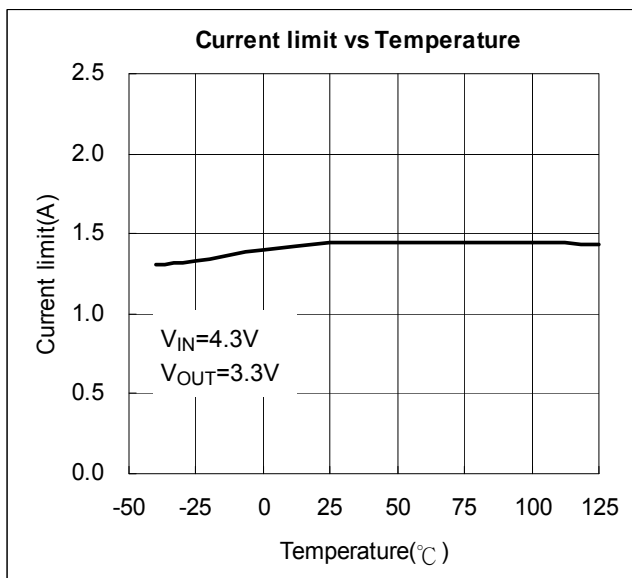
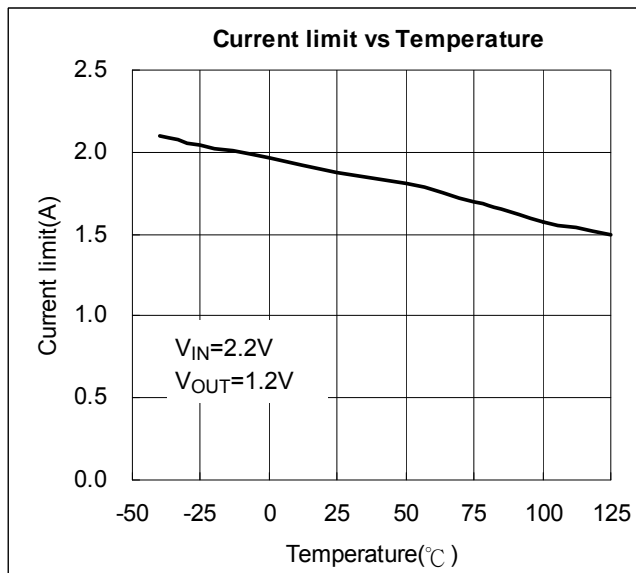
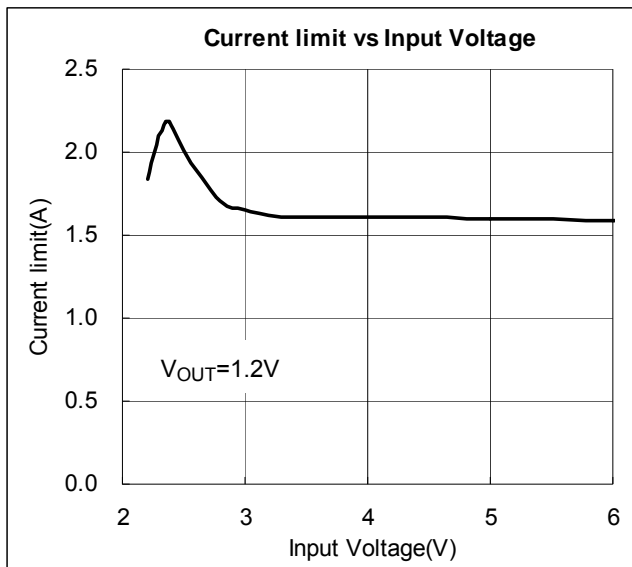
Typical Performance Characteristics (cont.)



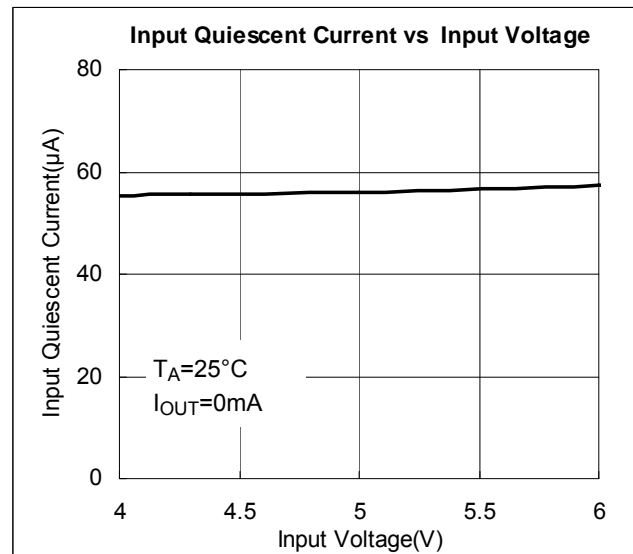
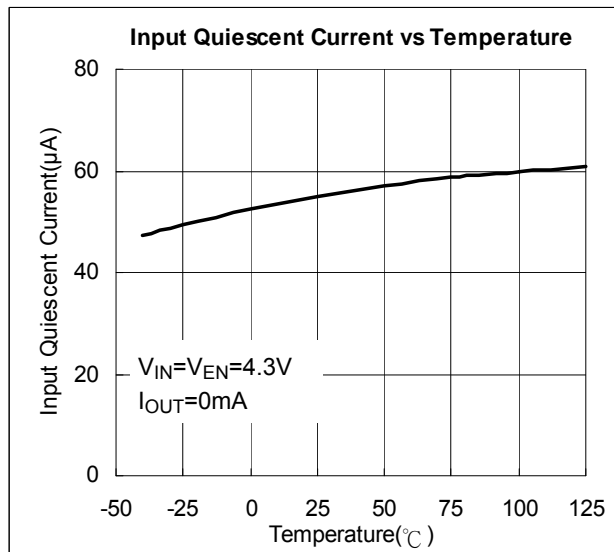
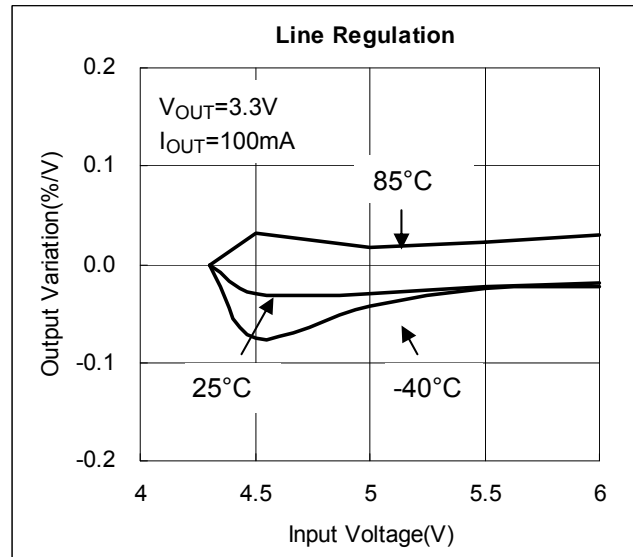
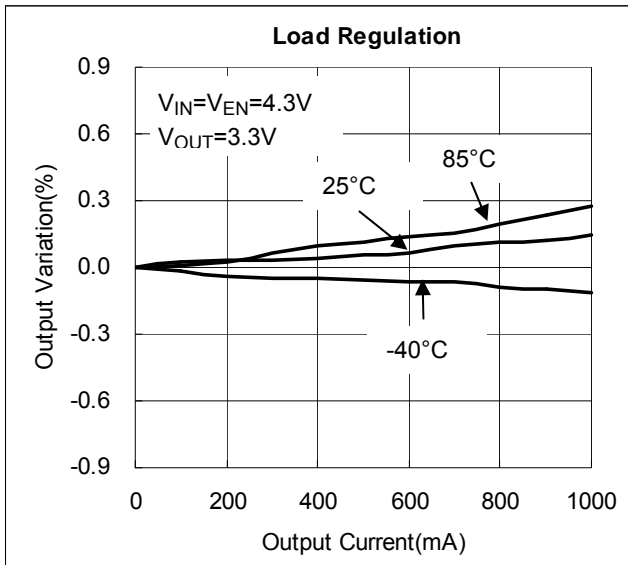
Typical Performance Characteristics (cont.)



Typical Performance Characteristics (cont.)



Typical Performance Characteristics (cont.)



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.

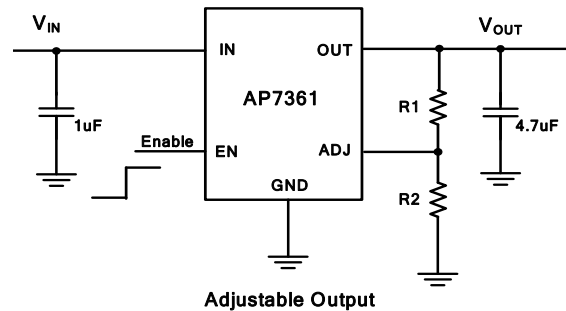
Output Capacitor

The output capacitor is required to stabilize and improve the transient response of the LDO. The AP7361 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

Adjustable operation is not available in the SOT223-3L and TO252-3L package.

The AP7361 provides output voltage from 0.8V to 5.0V through external resistor divider as shown below.



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:

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

To maintain the stability of the internal reference voltage, R_2 need to be kept smaller than 80kΩ.

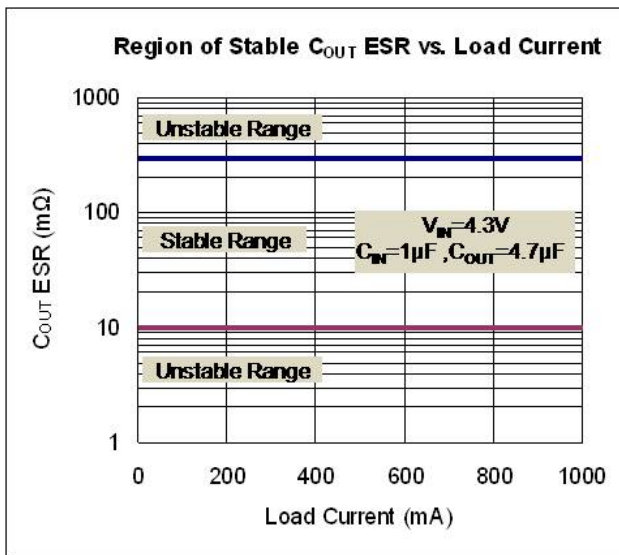
No Load Stability

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 ON/OFF feature is not available in the SOT223-3L and TO252-3L package.

The AP7361 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} .



Application Information (cont.)

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 200mA. Full current is restored when the output voltage exceeds 25% of V_{OUT}. This feature protects the regulator from over-current and damage due to overheating.

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 AP7361 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 AP7361, consuming only around 70μA for all input range, provides great power saving in portable and low power applications.

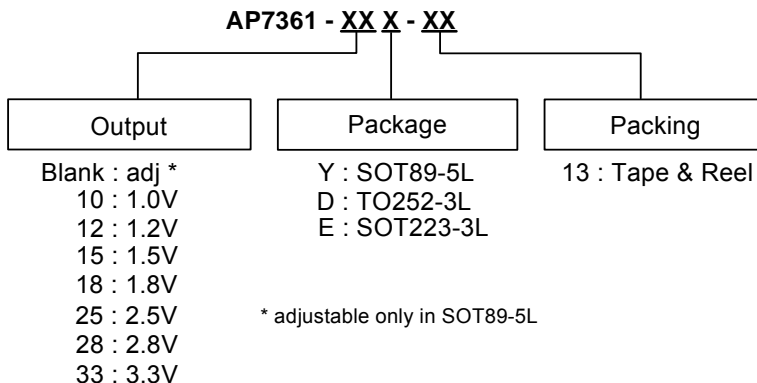
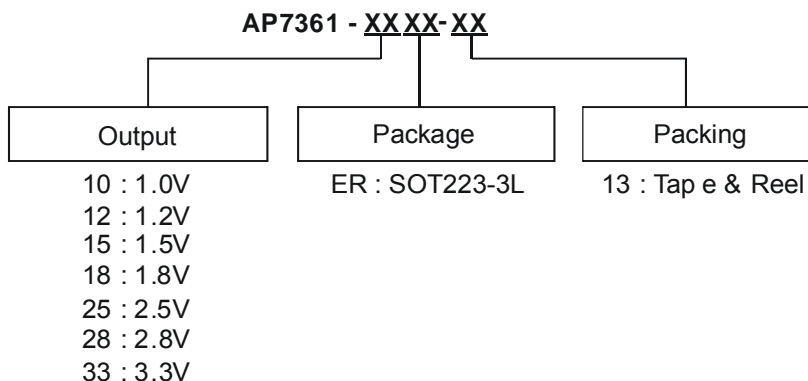
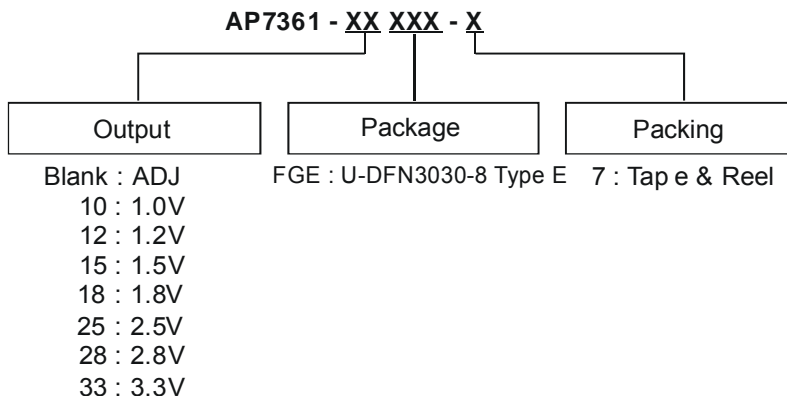
Power Dissipation

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:

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

**1A LOW DROPOUT ADJUSTABLE AND FIXED-MODE
 REGULATOR WITH ENABLE**
Ordering Information


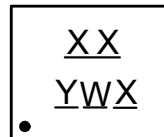
| Device | Package Code | Packaging (Note 8) | 7"/13" Tape and Reel | |
|----------------|--------------|-----------------------|----------------------|--------------------|
| | | | Quantity | Part Number Suffix |
| AP7361-XXFGE-7 | FGE | U-DFN3030-8 Type E | 3000/Tape & Reel | -7 |
| AP7361-XXY-13 | Y | SOT89-5L | 2500/Tape & Reel | -13 |
| AP7361-XXD-13 | D | TO252-3L | 2500/Tape & Reel | -13 |
| AP7361-XXE-13 | E | SOT223-3L | 2500/Tape & Reel | -13 |
| AP7361-XXER-13 | ER | SOT223R-3L | 2500/Tape & Reel | -13 |

Note: 7. Pad layout as shown on Diodes Inc. suggested pad layout document AP02001, which can be found on our website at <http://www.diodes.com/datasheets/ap02001.pdf>.

Marking Information

(1) U-DFN3030-8 Type E

(Top View)

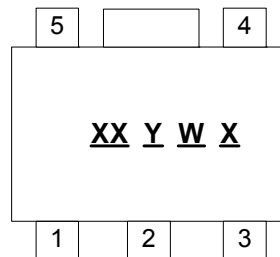


XX : Identification Code
Y : Year : 0~9
W : Week : A~Z : 1~26 week;
a~z : 27~52 week; z represents
52 and 53 week
X : A~Z : Internal code

| Device | Package | Identification Code |
|-----------|--------------------|---------------------|
| AP7361ADJ | U-DFN3030-8 Type E | PA |
| AP7361-10 | U-DFN3030-8 Type E | PB |
| AP7361-12 | U-DFN3030-8 Type E | PC |
| AP7361-15 | U-DFN3030-8 Type E | PD |
| AP7361-18 | U-DFN3030-8 Type E | PE |
| AP7361-25 | U-DFN3030-8 Type E | PF |
| AP7361-28 | U-DFN3030-8 Type E | PG |
| AP7361-33 | U-DFN3030-8 Type E | PH |

(2) SOT89-5L

(Top View)



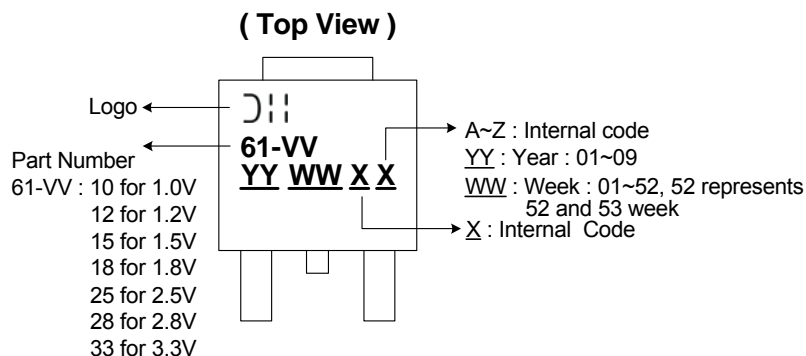
XX : Identification code
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a~z : 27~52 week;
z represents 52 and 53 week
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| Device | Package | Identification Code |
|-----------|----------|---------------------|
| AP7361ADJ | SOT89-5L | PA |
| AP7361-10 | SOT89-5L | PB |
| AP7361-12 | SOT89-5L | PC |
| AP7361-15 | SOT89-5L | PD |
| AP7361-18 | SOT89-5L | PE |
| AP7361-25 | SOT89-5L | PF |
| AP7361-28 | SOT89-5L | PG |
| AP7361-33 | SOT89-5L | PH |

Marking Information (cont.)

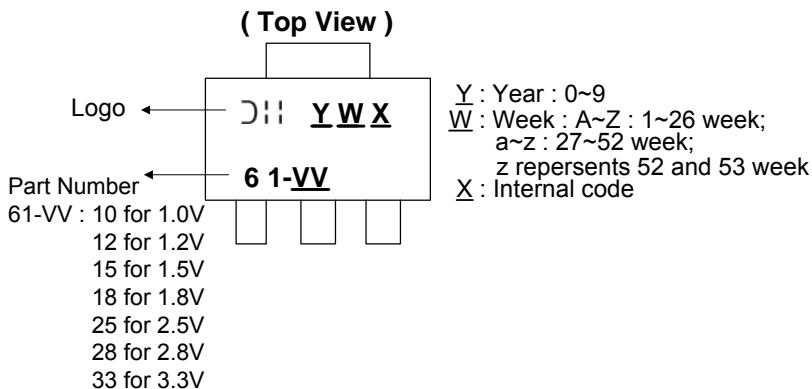
(3) TO252-3L

Pin 1: V_{IN} , Pin 2: GND, Pin 3: V_{OUT}



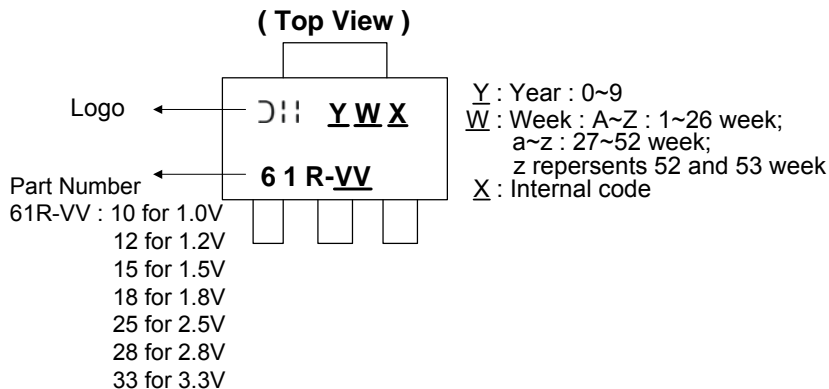
(4) SOT223-3L

Pin 1: V_{IN} , Pin 2: GND, Pin 3: V_{OUT}



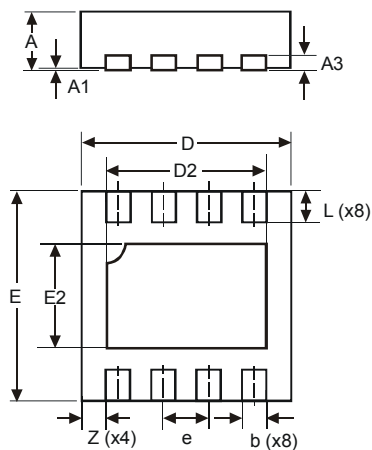
(5) SOT223R-3L

Pin 1: GND, Pin 2: V_{OUT} , Pin 3: V_{IN}



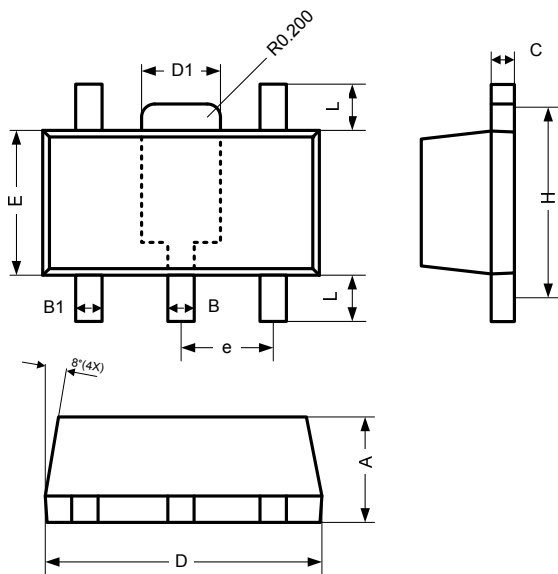
Package Outline Dimensions

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



| U-DFN3030-8 Type E | | | |
|-----------------------|------|------|------|
| Dim | Min | Max | Typ |
| A | 0.57 | 0.63 | 0.60 |
| A1 | 0 | 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 |
| e | — | — | 0.65 |
| E2 | 1.40 | 1.60 | 1.50 |
| L | 0.30 | 0.60 | 0.45 |
| Z | — | — | 0.40 |
| All Dimensions in mm | | | |

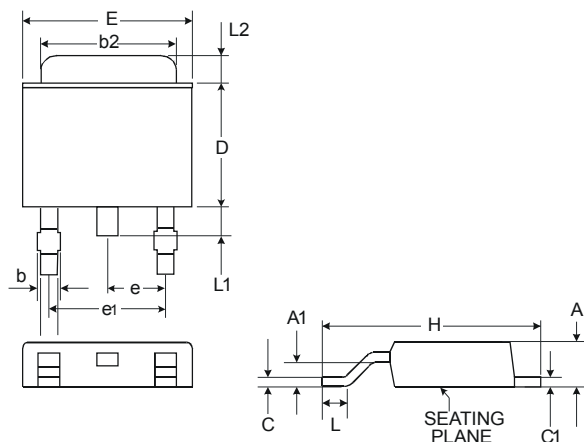
(2) Package type: SOT89-5L



| SOT89-5L | | | |
|----------------------|------|------|-------|
| DIM | Min | Max | Typ |
| A | 1.40 | 1.60 | 1.50 |
| C | 0.35 | 0.43 | 0.38 |
| D | 4.40 | 4.60 | 4.50 |
| E | 2.40 | 2.60 | 2.50 |
| D1 | 1.62 | 1.83 | 1.733 |
| B1 | 0.44 | 0.54 | 0.48 |
| B | 0.50 | 0.62 | 0.56 |
| E | — | — | 1.50 |
| H | 3.95 | 4.25 | 4.10 |
| L | 0.65 | 0.95 | 0.80 |
| All dimensions in mm | | | |

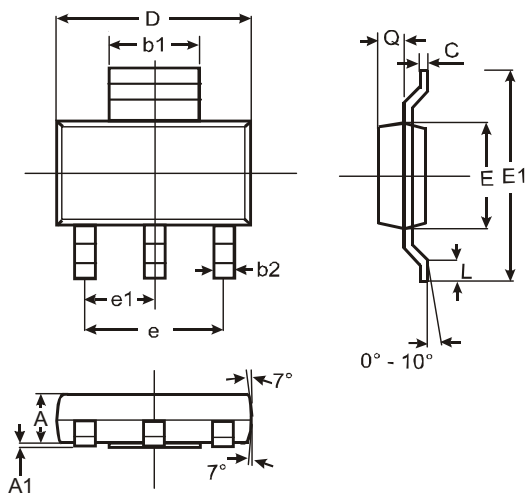
Package Outline Dimensions (cont.)

(3) Package type: TO252-3L



| TO252-3L | | |
|----------------------|----------|-------|
| Dim | Min | Max |
| A | 2.18 | 2.40 |
| A1 | 0.89 | 1.14 |
| b | 0.61 Typ | |
| b2 | 5.20 | 5.50 |
| C | 0.45 | 0.58 |
| C1 | 0.45 | 0.58 |
| D | 5.40 | 6.20 |
| E | 6.35 | 6.80 |
| e | 2.28 Typ | |
| e1 | 4.57 Typ | |
| H | 9.00 | 10.40 |
| L | 0.51 | — |
| L1 | 0.64 | 1.02 |
| L2 | 0.88 | 1.27 |
| All Dimensions in mm | | |

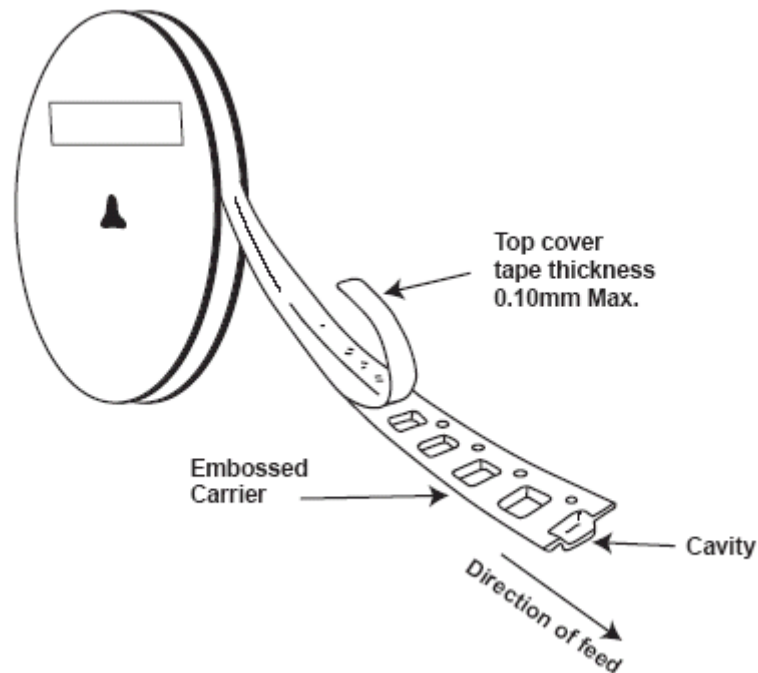
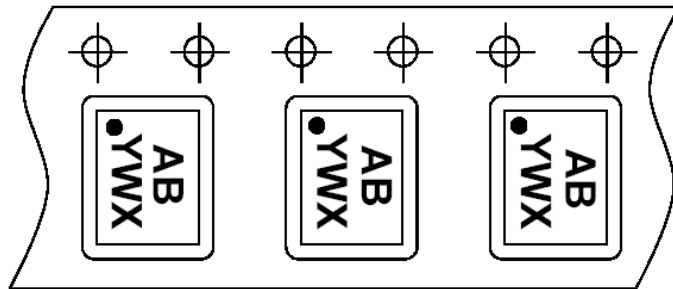
(4) Package Type: SOT223-3L and SOT223R-3L



| SOT223-3L | | | |
|----------------------|-------|------|------|
| Dim | Min | Max | Typ |
| A | 1.55 | 1.65 | 1.60 |
| A1 | 0.010 | 0.15 | 0.05 |
| b1 | 2.90 | 3.10 | 3.00 |
| b2 | 0.60 | 0.80 | 0.70 |
| C | 0.20 | 0.30 | 0.25 |
| D | 6.45 | 6.55 | 6.50 |
| E | 3.45 | 3.55 | 3.50 |
| E1 | 6.90 | 7.10 | 7.00 |
| e | — | — | 4.60 |
| e1 | — | — | 2.30 |
| L | 0.85 | 1.05 | 0.95 |
| Q | 0.84 | 0.94 | 0.89 |
| All Dimensions in mm | | | |

Taping Orientation (Note 9)

For U-DFN3030-8 Type E



Note: 9. The taping orientation of the other package type can be found on our website at <http://www.diodes.com/datasheets/ap02007.pdf>

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