## Description

The AP7387 is a wide input voltage range (60V), low quiescent current, high-PSRR, linear regulator able to drive 150mA output current.

The device features a very fast line/load transient response against rapid input-voltage and load-current changes. The IC consists of a voltage reference, an error amplifier, a current-limit circuit for current-protection, short-circuit, and thermal-shutdown protection.

The AP7387 has 3.0V, 3.3V, 3.6V, and 5V fixed output voltage versions, and is available in the SOT23, SOT25, SOT89, and U-DFN2020-6 (Type C) packages.

## Features

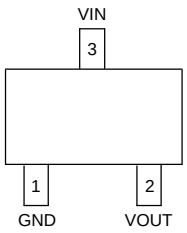
- Wide Input Voltage Range: 5V to 60V
- Maximum Output Current: 150mA
- Dropout Voltage:
  $V_{DROP}$ = 700mV @ $I_{OUT}$ = 100mA (typ.)
  $V_{DROP}$ = 1100mV @ $I_{OUT}$ = 150mA (typ.)
- Low Quiescent Current: 2μA (typ.)
- High Output Voltage Accuracy: ±2%
- High PSRR: 70dB @ 1kHz
- Excellent Line/Load Regulation
- Thermal Shutdown Function
- Short-Current Protection Function
- Output Current Limit
- **Totally Lead-Free & Fully RoHS Compliant (Notes 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**
- **An automotive-compliant part is available under separate datasheet (AP7387Q)**

## Applications

- Battery-powered equipment
- Smoke detectors and sensors
- EV and HEV battery management systems
- Micro-controller applications
- Home appliances

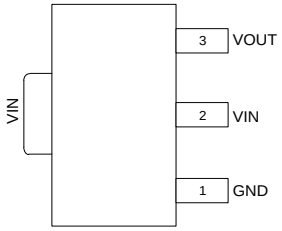
## Pin Assignments

**(Top View)**



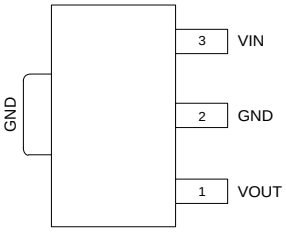

**SOT23**

**(Top View)**



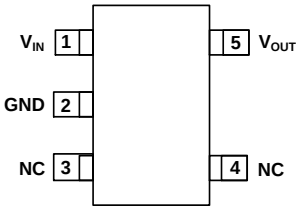

**SOT89**
**(AP7387-XXY-13)**

**(Top View)**



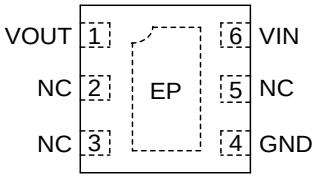

**SOT89**
**(AP7387-XXYR-13)**

**(Top View)**



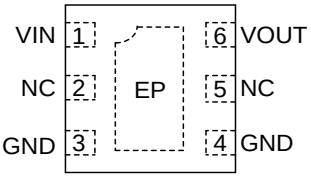

**SOT25**

**(Top View)**




**U-DFN2020-6 (Type C)**
**(AP7387-XXFDC-7)**

**(Top View)**

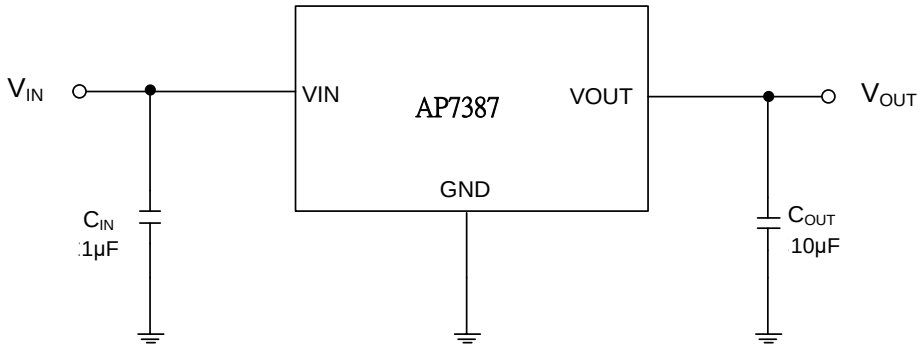



**U-DFN2020-6 (Type C)**
**(AP7387-XXFDCR-7)**

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.


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## Typical Applications Circuit

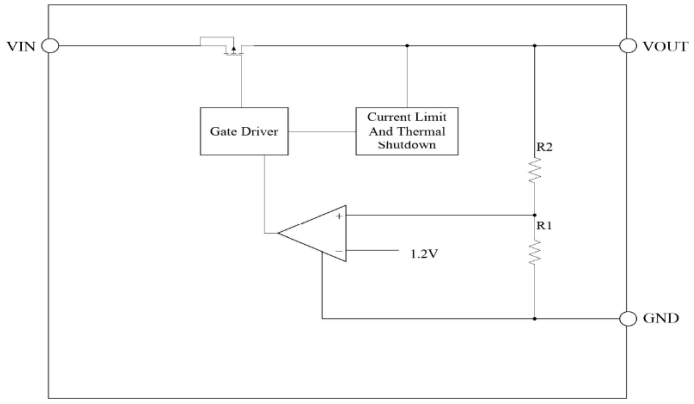



## Pin Descriptions

| Pin Number | | | | | | Pin Name | Function |
|---|---|---|---|---|---|---|---|
| SOT25 | SOT23 | SOT89 (AP7387-XXY-13) | SOT89 (AP7387-XXYR-13) | U-DFN2020-6 (Type C) (AP7387-XXFDC-7) | U-DFN2020-6 (Type C) (AP7387-XXFDCR-7) | | |
| 1 | 3 | 2 | 3 | 6 | 1 | VIN | Input voltage |
| 2 | 1 | 1 | 2 | 4 | 3, 4 | GND | Ground |
| 3,4 | — | — | — | 2, 3, 5 | 2, 5 | NC | Not connected internally, recommend connection to GND to maximize PCB copper for thermal dissipation |
| 5 | 2 | 3 | 1 | 1 | 6 | VOUT | Regulated output voltage |
| — | — | — | — | EP | EP | Exposed Pad | In PCB layout, prefer to use large copper area to cover this pad for better thermal dissipation, then connect this area to GND. This pad is connected with GND internally. |


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## Functional Block Diagram




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

| Symbol | Parameter | Rating | | Unit |
|---|---|---|---|---|
| $V_{IN}$ | Supply Input Voltage | -0.3 to 80 | | V |
| $V_{OUT}$ | Regulated Output Voltage | -0.3 to 6 | | V |
| $I_{OUT}$ | Output Current | Internally Limited | | mA |
| $T_{LEAD}$ | Lead Temperature (Soldering, 10sec) | +260 | | °C |
| $T_J$ | Operating Junction Temperature | +150 | | °C |
| $T_A$ | Operating Ambient Temperature | -40 to +85 | | °C |
| $\theta_{JA}$ | Thermal Resistance | SOT25 | 150 | °C/W |
| | | SOT23 | 248.5 | |
| | | SOT89 (AP7387-XXY-13) | 165 | |
| | | SOT89 (AP7387-XXYR-13) | 79 | |
| | | U-DFN2020-6 (Type C) | 48 | |
| $T_{STG}$ | Storage Temperature Range | -40 to +150 | | °C |
| CDM | ESD (Change Device Model) | 2kV | | V |
| HBM | ESD (Human Body Model) | 4kV | | V |

Note: 4. a). Stresses beyond those listed under *Absolute Maximum Ratings* can cause permanent damage to the device. These are stress ratings only and functional operation of the device at these conditions is not implied. Exposure to absolute-maximum-rated conditions for extended period can affect device reliability.
b). Ratings apply to ambient temperature at +25°C. The JEDEC STD.51 High-K board design used to derive this data was a 3 inch x 3 inch multilayer board with 1oz. internal power and ground planes and 2oz. copper traces on the top and bottom of the board.

## Recommended Operating Conditions

| Symbol | Parameter | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| $V_{IN}$ | Supply Input Voltage | 5.0 | — | 60 | V |
| $V_{OUT}$ | Supply Output Voltage | 3.0 | — | 5 | V |
| $T_J$ | Operating Junction Temperature | -40 | — | +125 | °C |
| $C_{IN}$ | Input Capacitor | — | 1 | — | µF |
| $C_{OUT}$ | Output Capacitor | 1 | 10 | — | µF |


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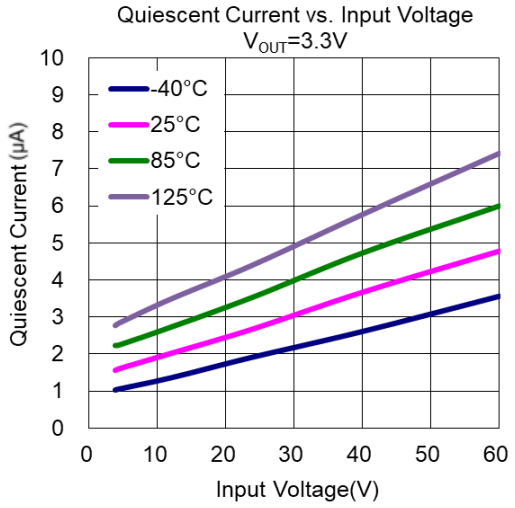
## Electrical Characteristics ($T_A$ = +25°C, $I_{OUT}$ = 1mA, $C_{IN}$ = 1µF, $C_{OUT}$ = 10µF ceramic capacitor, $V_{IN}$ = $V_{OUTNOM}$ +2.0V)

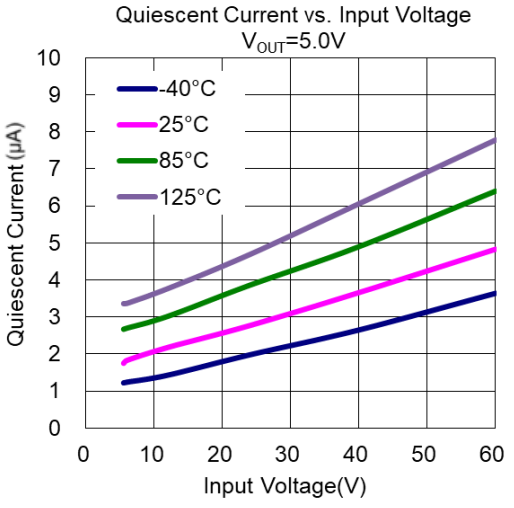
| Symbol | Parameter | Test Conditions | Min | Typ | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{IN}$ | Input Voltage | — | 5.0 | — | 60 | V |
| $I_{GND}$ | Quiescent Current | $V_{IN}$ = 12V, No Load | — | 2 | 4 | µA |
| $V_{OUT}$ | Output Voltage | $V_{IN}$ = 12V, $I_{OUT}$ = 10mA | $V_{OUT}$x98% | — | $V_{OUT}$x102% | V |
| $I_{OUT_MAX}$ | Output Current | — | — | 150 | — | mA |
| $V_{DROP}$ | Dropout Voltage | $I_{OUT}$ = 100mA, $V_{OUT}$ = $V_{OUTNOM}$ – 0.1V | — | 700 | 850 | mV |
| | | $I_{OUT}$ = 150mA, $V_{OUT}$ = $V_{OUTNOM}$ – 0.1V | — | 1100 | 1350 | mV |
| $\Delta V_{OUT}/\Delta I_{OUT}$ | Load Regulation (Note 5) | $V_{IN}$ = 12V, 1mA ≤ $I_{OUT}$ ≤ 100mA | — | 0.02 | 0.025 | %/mA |
| | | $V_{IN}$ = $V_{OUT}$+2V, 1mA ≤ $I_{OUT}$ ≤ 150mA | — | 0.015 | 0.02 | |
| $\Delta V_{OUT}/\Delta V_{IN}$ | Line Regulation | $V_{OUTNOM}$ + 0.5 V ≤ $V_{IN}$ ≤ 60V, $I_{OUT}$ = 1mA | — | 0.01 | 0.02 | %/V |
| $I_{LIMIT}$ | Current Limit | — | — | 250 | — | mA |
| $T_{OTSD}$ | Thermal Shutdown Temperature | — | — | +150 | — | °C |
| $T_{HYOTSD}$ | Thermal Shutdown Hysteresis | — | — | +30 | — | °C |
| PSRR | Power Supply Rejection Ratio | $V_{IN}$ = 12V, $I_{OUT}$ = 1mA, $V_{OUT}$ = 3.3V @ 1kHz | — | 70 | — | dB |
| $\theta_{JC}$ | Thermal Resistance Junction to Case (Note 5) | SOT25 | — | 59.5 | — | °C/W |
| | | SOT23 | — | 140.5 | — | |
| | | SOT89 (AP7387-XXY-13) | — | 97 | — | |
| | | SOT89 (AP7387-XXYR-13) | — | 25 | — | |
| | | U-DFN2020-6 (Type C) | — | 15.5 | — | |

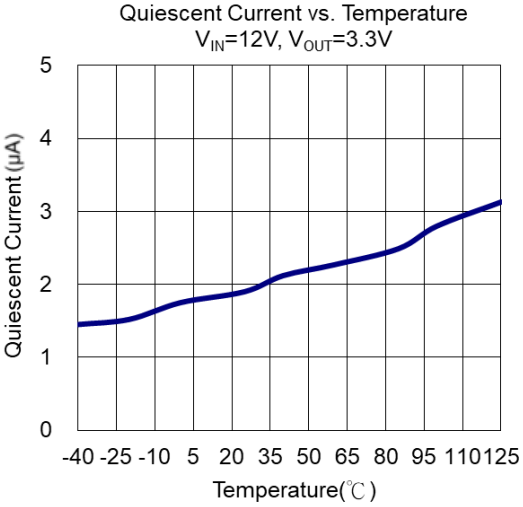
Note: 5. The load regulation SPEC is depended on the package and operating temperature, be careful the operating junction temperature not over OTP threshold.

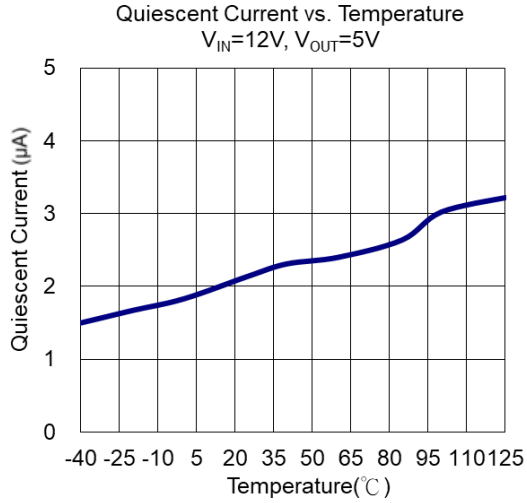

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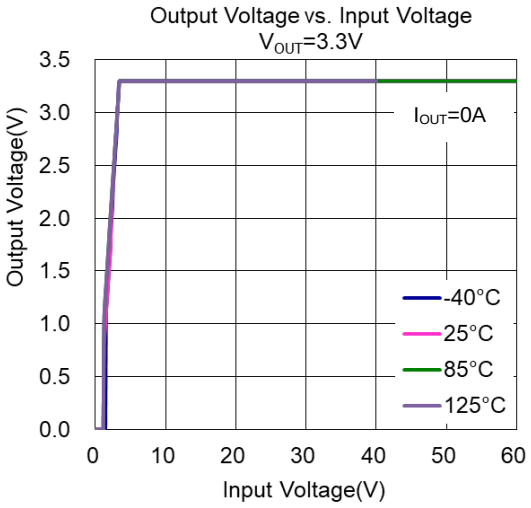
## Performance Characteristics

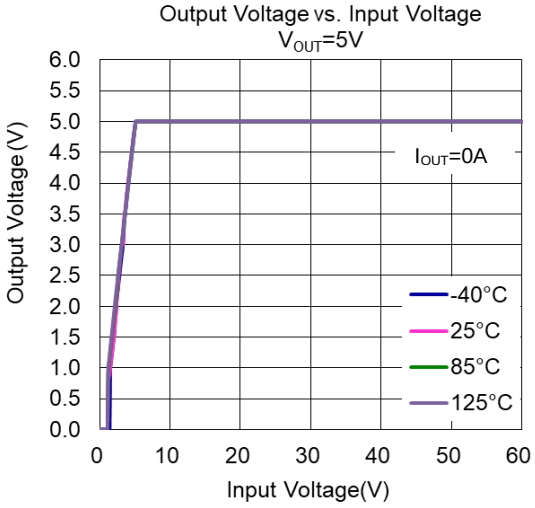


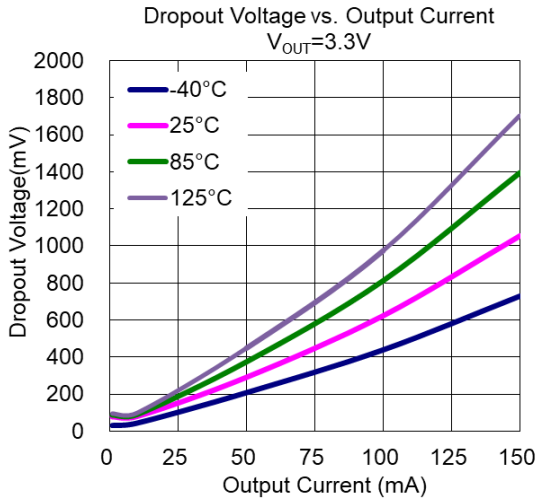



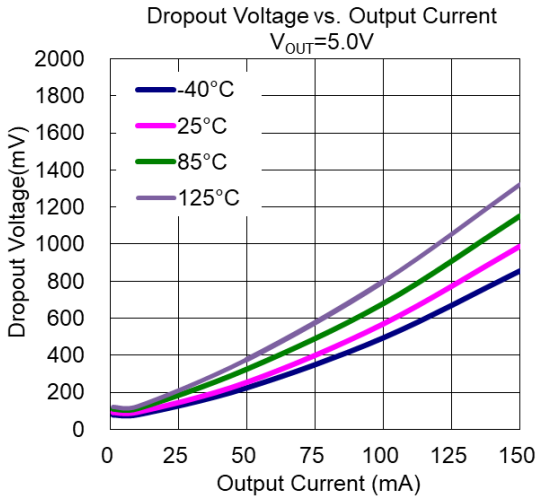



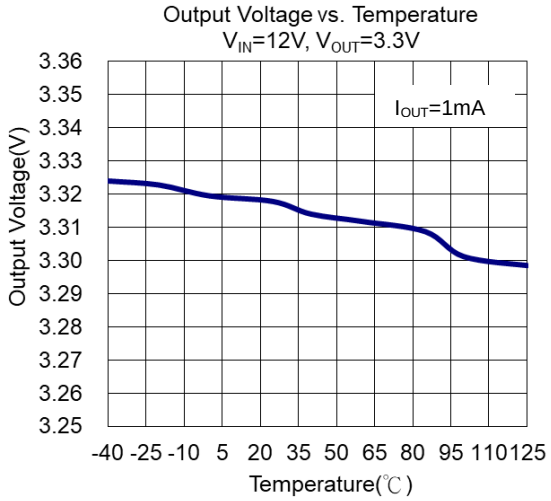


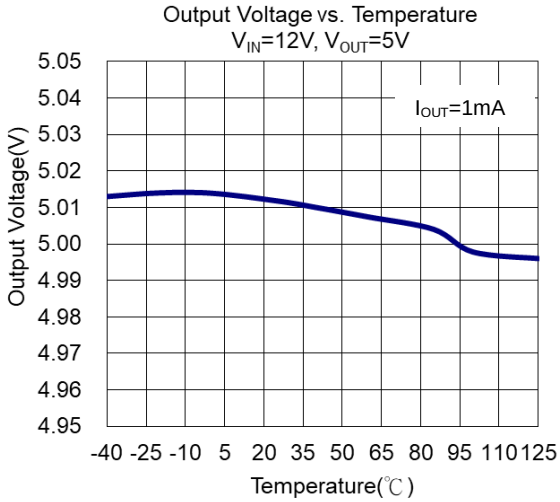
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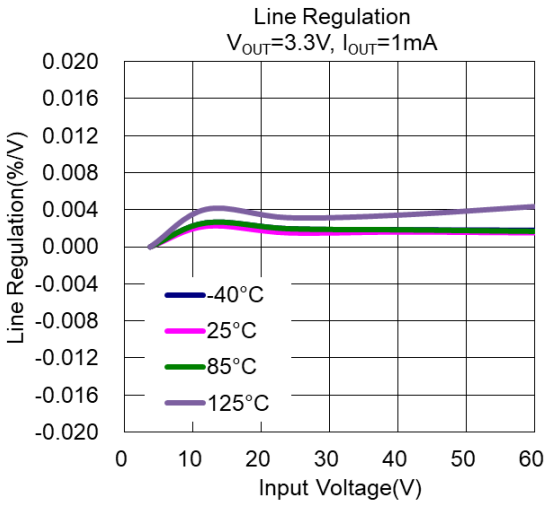
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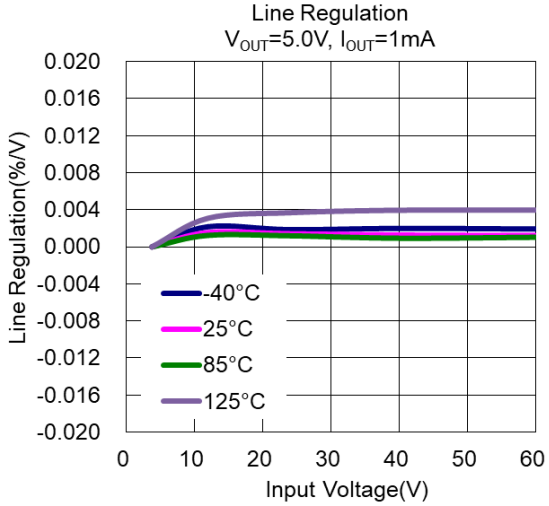


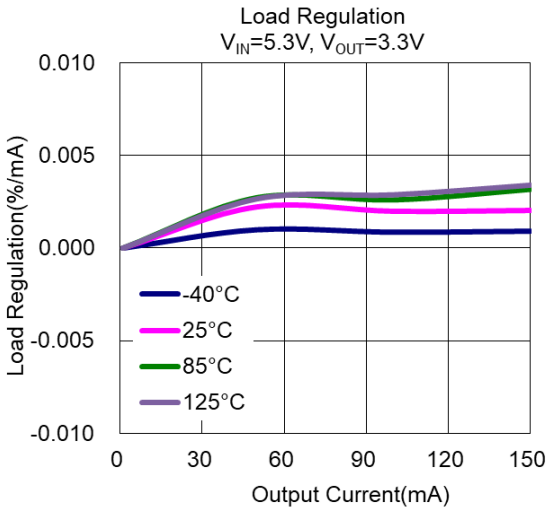



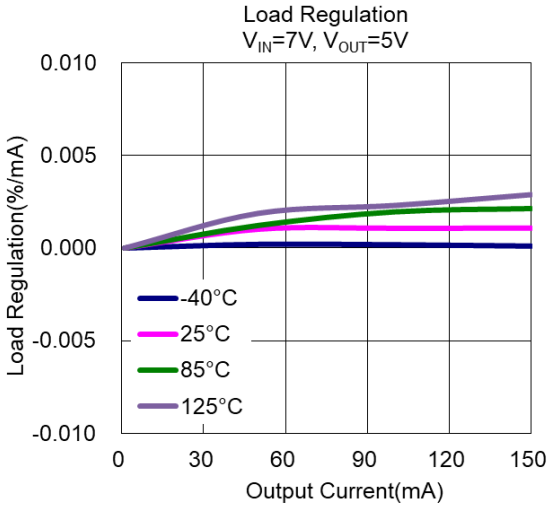



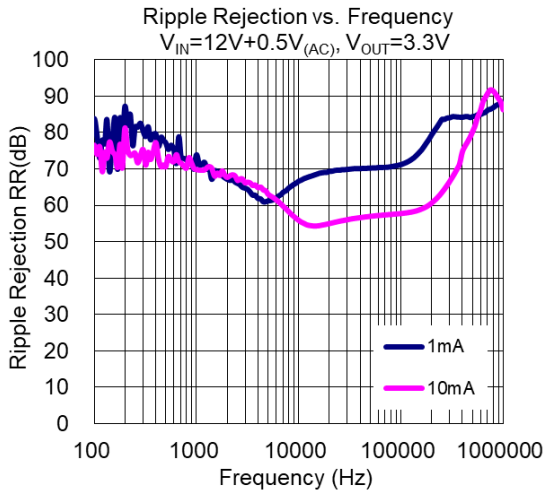


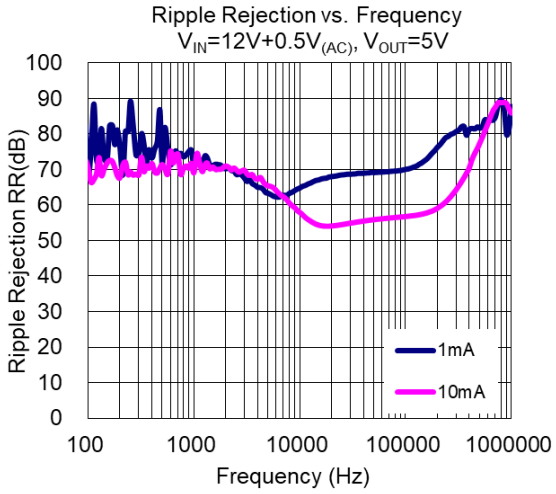
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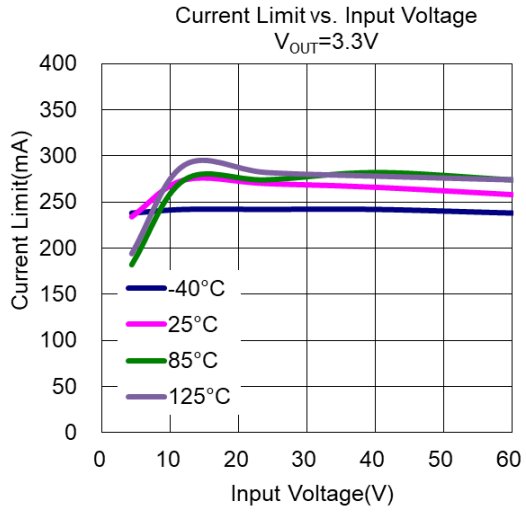
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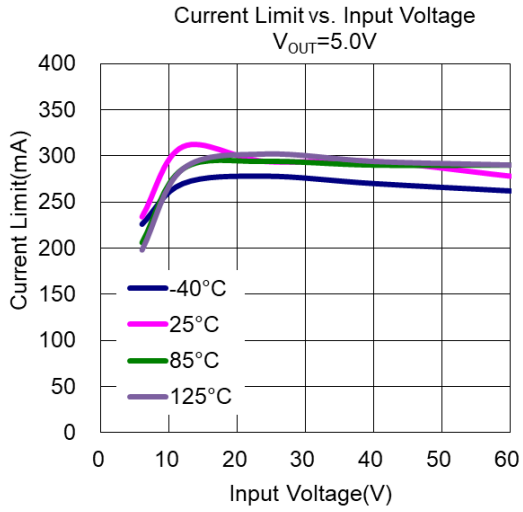


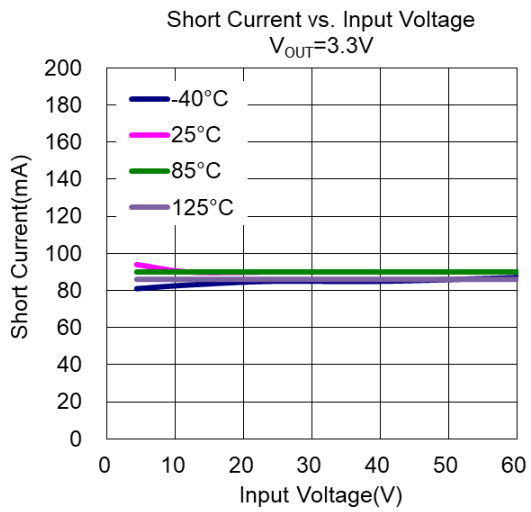



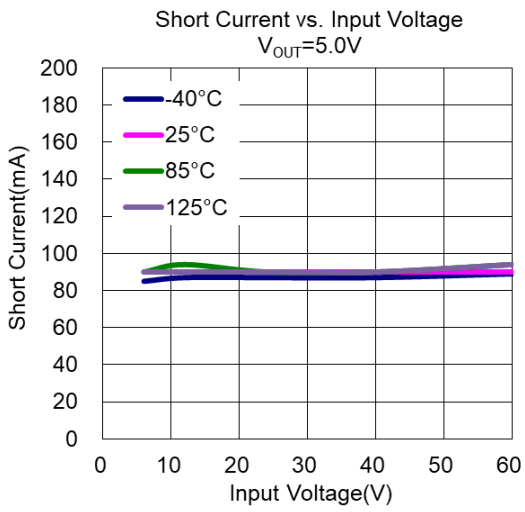



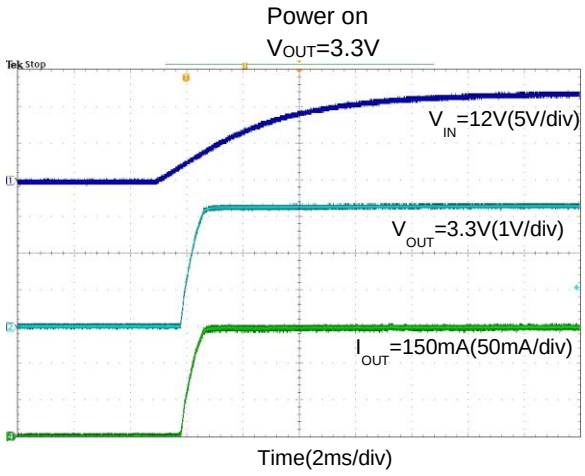


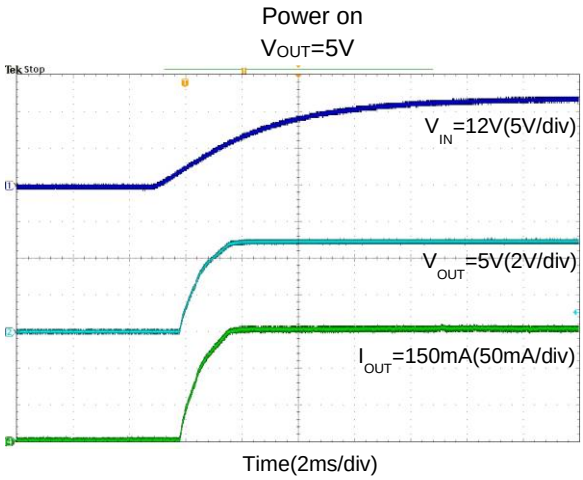
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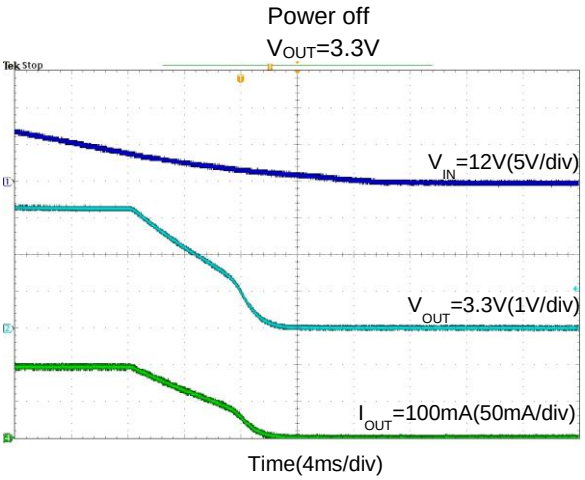
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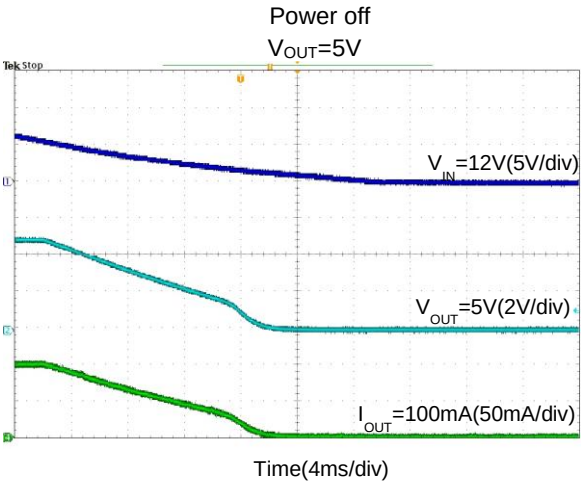


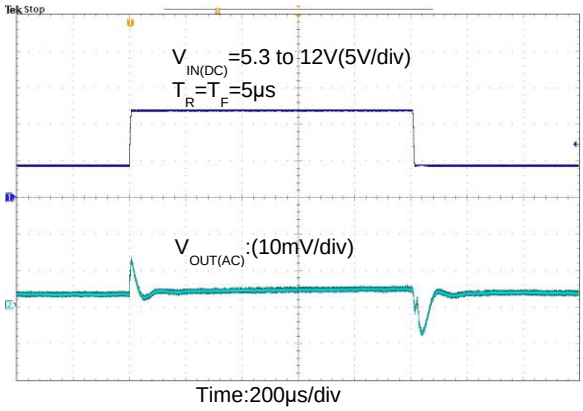





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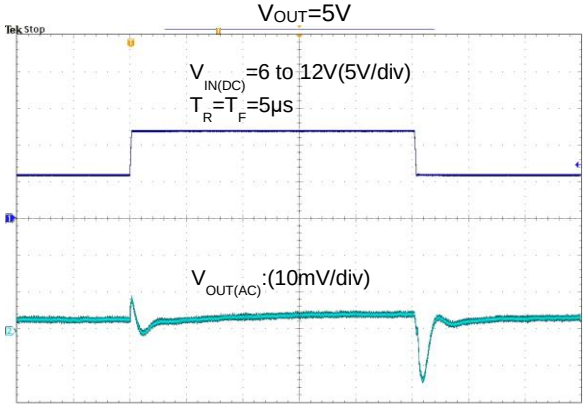
## Typical Characteristics (continued)

Line Transient Response
$V_{OUT}$=3.3V



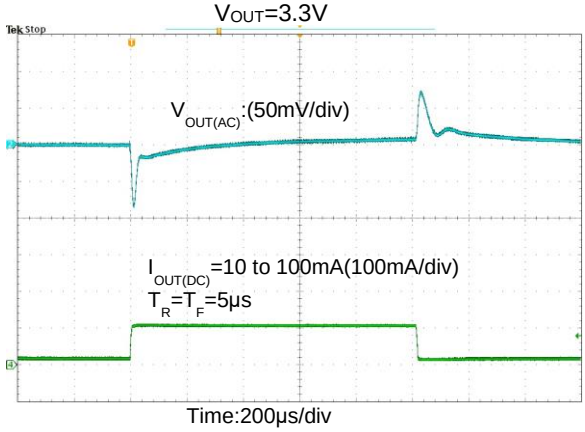

Time:200μs/div

Line Transient Response
$V_{OUT}$=5V



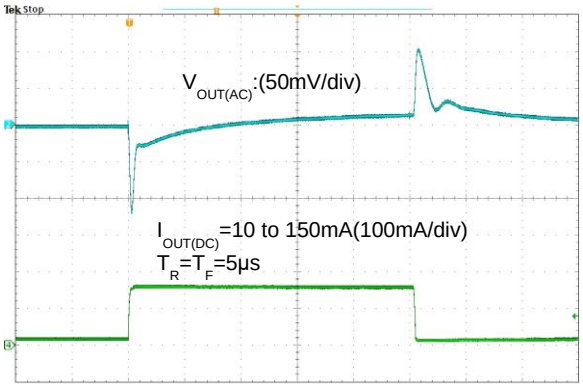

Time:200μs/div

Load Transient Response
$V_{OUT}$=3.3V



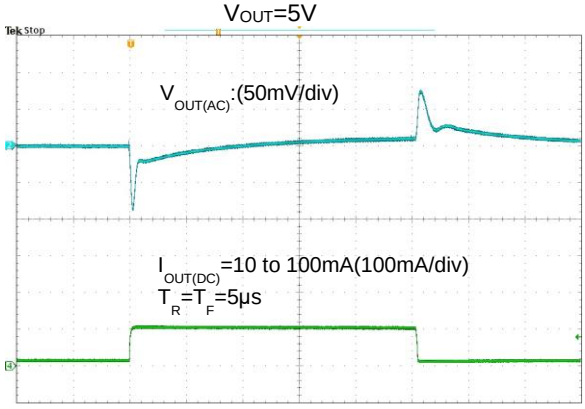

Time:200μs/div

Load Transient Response
$V_{OUT}$=3.3V



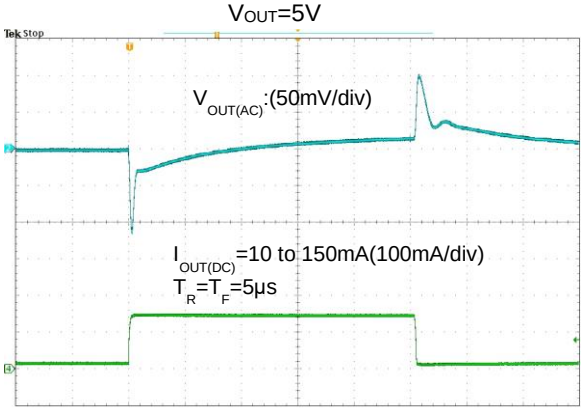

Time:200μs/div

Load Transient Response
$V_{OUT}$=5V




Time:200μs/div

Load Transient Response
$V_{OUT}$=5V




Time:200μs/div


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## Ordering Information

**AP7387 - XX XXXX - XX**

| Output Voltage | Package | Packing |
|---|---|---|
| 30 : 3.0V<br>33 : 3.3V<br>36 : 3.6V<br>50 : 5.0V | SA : SOT23<br>Y : SOT89<br>YR : SOT89<br>W5 : SOT25<br>FDC : U-DFN2020-6 (Type C)<br>FDCR : U-DFN2020-6 (Type C) | 13/7: Tape & Reel |

| Orderable Part Number | Package Code | Package | Packing | |
|---|---|---|---|---|
| | | | Qty. | Carrier |
| AP7387-XXSA-7 | SA | SOT23 | 3,000 | Tape & Reel |
| AP7387-XXY-13 | Y | SOT89 | 2,500 | Tape & Reel |
| AP7387-XXYR-13 | YR | SOT89 | 2,500 | Tape & Reel |
| AP7387-XXW5-7 | W5 | SOT25 | 3,000 | Tape & Reel |
| AP7387-XXFDC-7 | FDC | U-DFN2020-6 (Type C) | 3,000 | Tape & Reel |
| AP7387-XXFDCR-7 | FDCR | U-DFN2020-6 (Type C) | 3,000 | Tape & Reel |

## Application Information

**Output Capacitor**

An output capacitor is required for the stability of the LDO. The recommended minimum output capacitance is 10μF. A ceramic capacitor is recommended with the temperature characteristics of X7R or X5R. Higher capacitance values help to improve load/line transient response. The output capacitance may be increased to keep low undershoot/overshoot. Place the output capacitor as close as possible to OUT and GND pins.

**Input Capacitor**

A 1μF ceramic capacitor is recommended to connect between VIN 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 less noise. For PCB layout, a wide copper trace is required for both VIN and GND.

**Current-Limit and Short-Circuit Protection**

When the output current at VOUT pin is higher than the current-limit threshold or the VOUT pin is directly shorted to GND, current-limit protection will trigger and clamp the output current at a pre-designed level to prevent overcurrent and thermal damage.

**Thermal Protection**

The AP7387 has internal thermal sense and protection circuits. When excessive power dissipation happens on the device, such as short circuit at the output pin or very heavy load current with a large voltage drop across the device, the internal thermal protection circuit will trigger, and it will shut down the power MOSFET to prevent the LDO from damage. As soon as the excessive thermal condition is removed and the temperature of the device drops down, the thermal protection circuit will release the control of the power MOSFET and the LDO device will return to normal operation.

**Layout Considerations**

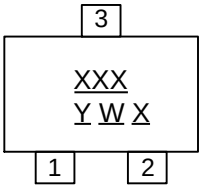
For good ground loop and stability, the input and output capacitors should be located close to the input, output, and ground pins of the device. The regulator ground pin should be connected to the external circuit ground to reduce voltage drop caused by trace impedance. Ground plane is generally used to reduce trace impedance. Wide trace should be used for large current paths from $V_{IN}$ to $V_{OUT}$, and load circuit.


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## Marking Information

**(1) SOT23**

**(Top View)**

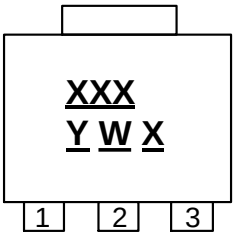



XXX: Identification Code
Y: Year: 0 to 9
W: Week: A to Z: 1 to 26 Week;
a to z: 27 to 52 Week;
z Represents 52 and 53 Week
X: Internal Code

| Orderable Part Number | Package | Identification Code |
|---|---|---|
| AP7387-30SA-7 | SOT23 | H7A |
| AP7387-33SA-7 | SOT23 | H7B |
| AP7387-36SA-7 | SOT23 | H7C |
| AP7387-50SA-7 | SOT23 | H7D |

**(2) SOT89 (AP7387-XXY-13)**

**(Top View)**




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

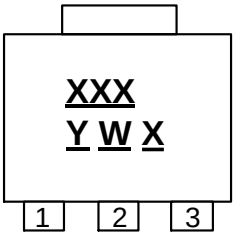
| Orderable Part Number | Package | Identification Code |
|---|---|---|
| AP7387-30Y-13 | SOT89 | H7A |
| AP7387-33Y-13 | SOT89 | H7B |
| AP7387-36Y-13 | SOT89 | H7C |
| AP7387-50Y-13 | SOT89 | H7D |


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## Marking Information (continued)

**(3) SOT89 (AP7387-XXYR-13)**

**(Top View)**

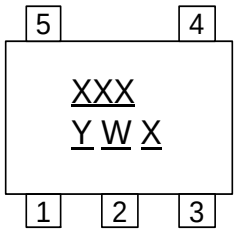



XXX: Identification Code
Y: Year: 0 to 9
W: Week: A to Z: 1 to 26 Week;
a to z: 27 to 52 Week;
z Represents 52 and 53 Week
X: Internal Code

| Orderable Part Number | Package | Identification Code |
|---|---|---|
| AP7387-30YR-13 | SOT89 | H7E |
| AP7387-33YR-13 | SOT89 | H7F |
| AP7387-36YR-13 | SOT89 | H7G |
| AP7387-50YR-13 | SOT89 | H7H |

**(4) SOT25**

**(Top View)**




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

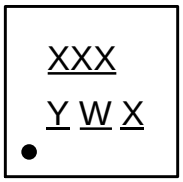
| Orderable Part Number | Package | Identification Code |
|---|---|---|
| AP7387-30W5-7 | SOT25 | H7A |
| AP7387-33W5-7 | SOT25 | H7B |
| AP7387-36W5-7 | SOT25 | H7C |
| AP7387-50W5-7 | SOT25 | H7D |


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## Marking Information (continued)

**(5) U-DFN2020-6 (Type C) (AP7387-XXFDC-7)**

**(Top View)**

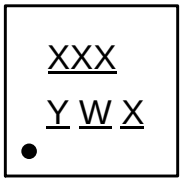



XXX: Identification Code
Y: Year: 0 to 9
W: Week: A to Z: 1 to 26 Week;
a to z: 27 to 52 Week;
z Represents 52 and 53 Week
X: Internal Code

| Orderable Part Number | Package | Identification Code |
|---|---|---|
| AP7387-30FDC-7 | U-DFN2020-6 (Type C) | H7A |
| AP7387-33FDC-7 | U-DFN2020-6 (Type C) | H7B |
| AP7387-36FDC-7 | U-DFN2020-6 (Type C) | H7C |
| AP7387-50FDC-7 | U-DFN2020-6 (Type C) | H7D |

**(6) U-DFN2020-6 (Type C) (AP7387-XXFDCR-7)**

**(Top View)**




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

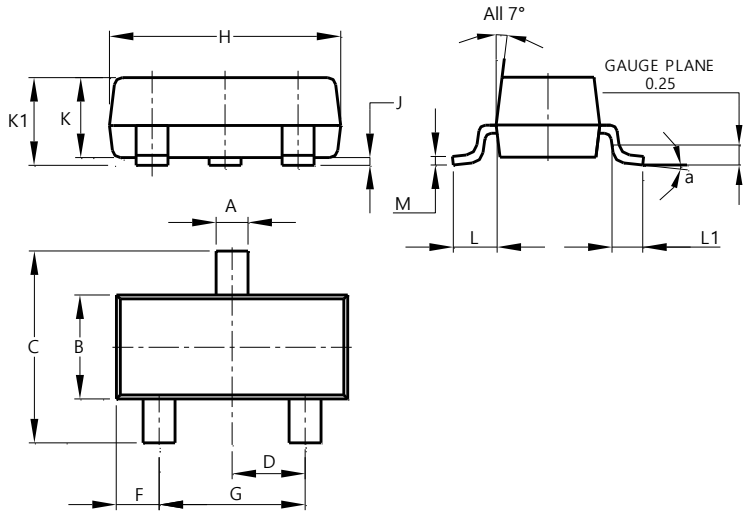
| Orderable Part Number | Package | Identification Code |
|---|---|---|
| AP7387-30FDCR-7 | U-DFN2020-6 (Type C) | H7E |
| AP7387-33FDCR-7 | U-DFN2020-6 (Type C) | H7F |
| AP7387-36FDCR-7 | U-DFN2020-6 (Type C) | H7G |
| AP7387-50FDCR-7 | U-DFN2020-6 (Type C) | H7H |


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## Package Outline Dimensions

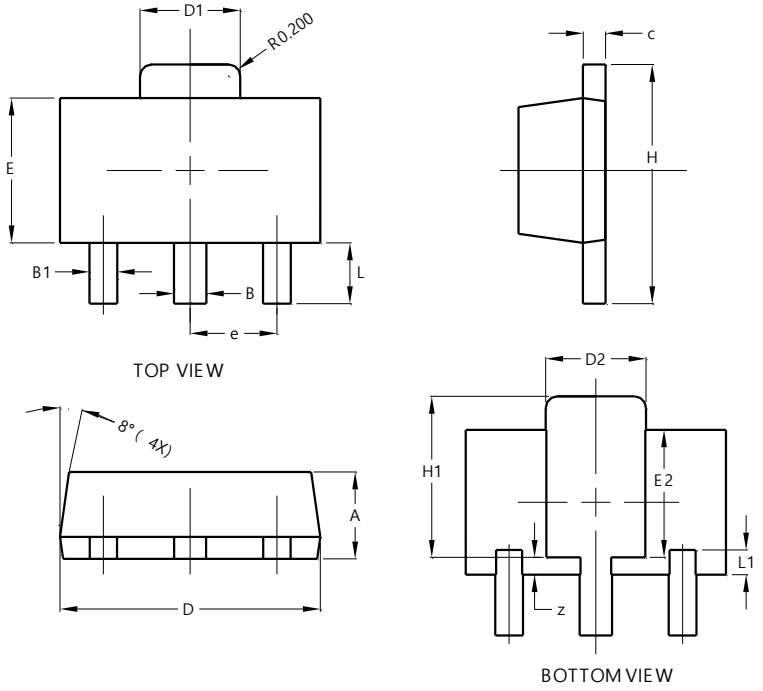
Please see http://www.diodes.com/package-outlines.html for the latest version.

**(1) Package Type: SOT23**




| SOT23 | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A** | 0.37 | 0.51 | 0.40 |
| **B** | 1.20 | 1.40 | 1.30 |
| **C** | 2.30 | 2.50 | 2.40 |
| **D** | 0.89 | 1.03 | 0.915 |
| **F** | 0.45 | 0.60 | 0.535 |
| **G** | 1.78 | 2.05 | 1.83 |
| **H** | 2.80 | 3.00 | 2.90 |
| **J** | 0.013 | 0.10 | 0.05 |
| **K** | 0.890 | 1.00 | 0.975 |
| **K1** | 0.903 | 1.10 | 1.025 |
| **L** | 0.45 | 0.61 | 0.55 |
| **L1** | 0.25 | 0.55 | 0.40 |
| **M** | 0.085 | 0.150 | 0.110 |
| **a** | 0° | 8° | -- |
| **All Dimensions in mm** | | | |

**(2) SOT89**



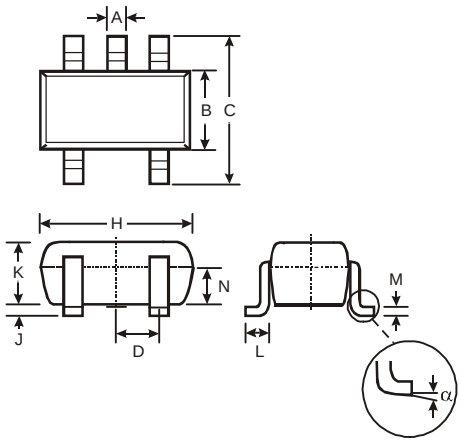

| SOT89 | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A** | 1.40 | 1.60 | 1.50 |
| **B** | 0.50 | 0.62 | 0.56 |
| **B1** | 0.42 | 0.54 | 0.48 |
| **c** | 0.35 | 0.43 | 0.38 |
| **D** | 4.40 | 4.60 | 4.50 |
| **D1** | 1.62 | 1.83 | 1.733 |
| **D2** | 1.61 | 1.81 | 1.71 |
| **E** | 2.40 | 2.60 | 2.50 |
| **E2** | 2.05 | 2.35 | 2.20 |
| **e** | - | - | 1.50 |
| **H** | 3.95 | 4.25 | 4.10 |
| **H1** | 2.63 | 2.93 | 2.78 |
| **L** | 0.90 | 1.20 | 1.05 |
| **L1** | 0.327 | 0.527 | 0.427 |
| **z** | 0.20 | 0.40 | 0.30 |
| **All Dimensions in mm** | | | |


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## Package Outline Dimensions (continued)

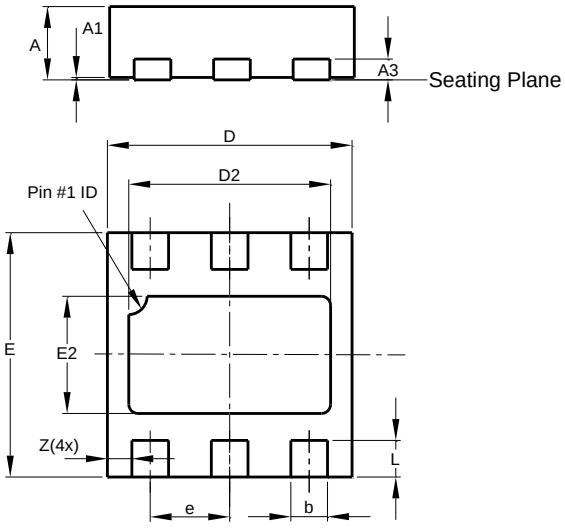
Please see http://www.diodes.com/package-outlines.html for the latest version.

**(3) SOT25**




| SOT25 | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A** | 0.35 | 0.50 | 0.38 |
| **B** | 1.50 | 1.70 | 1.60 |
| **C** | 2.70 | 3.00 | 2.80 |
| **D** | - | - | 0.95 |
| **H** | 2.90 | 3.10 | 3.00 |
| **J** | 0.013 | 0.10 | 0.05 |
| **K** | 1.00 | 1.30 | 1.10 |
| **L** | 0.35 | 0.55 | 0.40 |
| **M** | 0.10 | 0.20 | 0.15 |
| **N** | 0.70 | 0.80 | 0.75 |
| **α** | 0° | 8° | - |
| **All Dimensions in mm** | | | |

**(4) U-DFN2020-6 (Type C)**



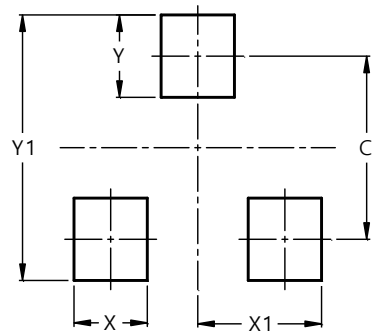

| U-DFN2020-6 Type C | | | |
|---|---|---|---|
| **Dim** | **Min** | **Max** | **Typ** |
| **A** | 0.57 | 0.63 | 0.60 |
| **A1** | 0.00 | 0.05 | 0.02 |
| **A3** | — | — | 0.15 |
| **b** | 0.25 | 0.35 | 0.30 |
| **D** | 1.95 | 2.075 | 2.00 |
| **D2** | 1.55 | 1.75 | 1.65 |
| **E** | 1.95 | 2.075 | 2.00 |
| **E2** | 0.86 | 1.06 | 0.96 |
| **e** | — | — | 0.65 |
| **L** | 0.25 | 0.35 | 0.30 |
| **Z** | — | — | 0.20 |
| **All Dimensions in mm** | | | |


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## Suggested Pad Layout

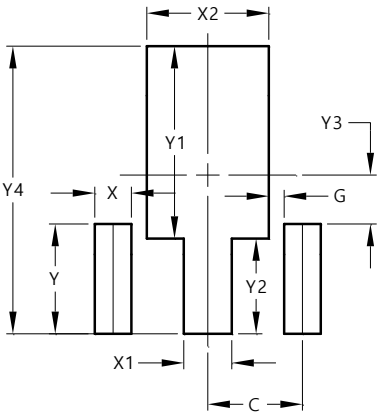
Please see http://www.diodes.com/package-outlines.html for the latest version.

**(1) SOT23**




| Dimensions | Value (in mm) |
|---|---|
| **C** | 2.0 |
| **X** | 0.8 |
| **X1** | 1.35 |
| **Y** | 0.9 |
| **Y1** | 2.9 |

**(2) SOT89**



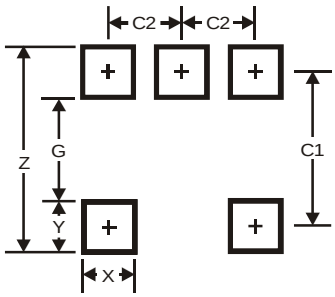

| Dimensions | Value (in mm) |
|---|---|
| **C** | 1.500 |
| **G** | 0.244 |
| **X** | 0.580 |
| **X1** | 0.760 |
| **X2** | 1.933 |
| **Y** | 1.730 |
| **Y1** | 3.030 |
| **Y2** | 1.500 |
| **Y3** | 0.770 |
| **Y4** | 4.530 |


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## Suggested Pad Layout (continued)

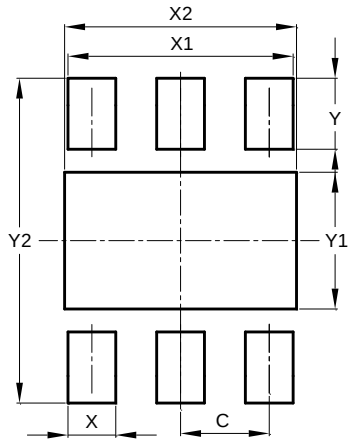
Please see http://www.diodes.com/package-outlines.html for the latest version.

**(3) SOT25**




| Dimensions | Value |
|---|---|
| Z | 3.20 |
| G | 1.60 |
| X | 0.55 |
| Y | 0.80 |
| C1 | 2.40 |
| C2 | 0.95 |

**(4) U-DFN2020-6 (Type C)**




| Dimensions | Value (in mm) |
|---|---|
| C | 0.650 |
| X | 0.350 |
| X1 | 1.650 |
| X2 | 1.700 |
| Y | 0.525 |
| Y1 | 1.010 |
| Y2 | 2.400 |

## Mechanical Data

- Moisture Sensitivity:
  - SOT23/SOT25/U-DFN2020-6 (Type C)/SOT89 (AP7387-XXYR-13): Level 1 Per J-STD-020
  - SOT89 (AP7387-XXY-13): Level 3 Per J-STD-020
- Terminals:
  - SOT89/ SOT23/ SOT25: Finish - Matte Tin Plated Leads, Solderable per MIL-STD-202, Method 208 e3
  - U-DFN2020-6 (Type C): Finish - NiPdAu over Copper Leads, Solderable per MIL-STD-202, Method 208 e4
- Weight:
  - SOT89: 0.054 grams (Approximate)
  - SOT23: 0.009 grams (Approximate)
  - SOT25: 0.018 grams (Approximate)
  - U-DFN2020-6 (Type C): 0.007 grams (Approximate)


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