

Description

The AP3428/A is a 1A step-down DC-DC converter. At heavy load, the constant-frequency PWM control performs excellent stability and transient response. No external compensation components are required.

The AP3428/A supports a range of input voltages from 2.5V to 5.5V, allowing the use of a single Li+/Li-polymer cell, multiple Alkaline/NiMH cell, and other standard power sources. The output voltage is adjustable from 0.6V to the input voltage. The AP3428/A employs internal power switch and synchronous rectifier to minimize external part count and realize high efficiency. During shutdown, the input is disconnected from the output and the shutdown current is less than 1 μ A. Other key features include over-temperature and short circuit protection, and under-voltage lockout to prevent deep battery discharge.

The AP3428/A delivers 1A maximum output current while consuming only 40 μ A of no-load quiescent current. Ultra-low $R_{DS(ON)}$ integrated MOSFETs and 100% duty cycle operation make the AP3428/A an ideal choice for high output voltage, high current applications which require a low dropout threshold. Pulse skip mode allows to maintain high efficiency at light-load conditions.

The AP3428/A is available in TSOT25, TSOT25 (Type SM), U-DFN2020-6 (Type J) packages.

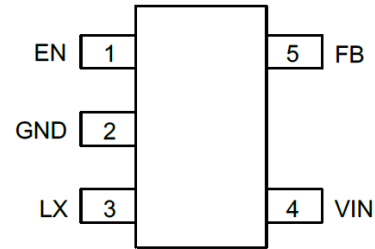
Features

- Output Current: Up to 1A
- Output Voltage: 0.6V to V_{IN}
- Input Voltage: 2.5V to 5.5V
- 0.6V Reference Voltage with $\pm 2\%$ Precision
- 40 μ A (typ) No Load Quiescent Current
- Shutdown Current: <1 μ A
- 100% Duty Cycle Operation
- 1.5MHz Switching Frequency
- Internal Soft Start
- No External Compensation Required
- Current Limit Protection
- Thermal Shutdown
- TSOT25, TSOT25 (Type SM), U-DFN2020-6 (Type J) Packages
- **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](mailto:contact@diodes.com) or your local Diodes representative. <https://www.diodes.com/quality/product-definitions/>**

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.

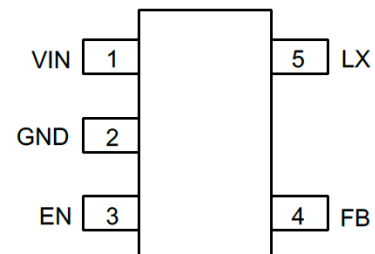
Pin Assignments

(Top View)



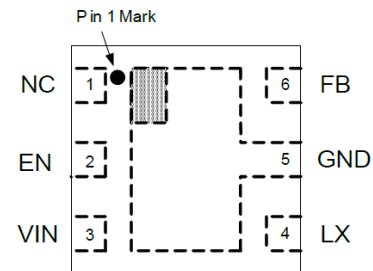
TSOT25/TSOT25 (Type SM) for AP3428

(Top View)



TSOT25/TSOT25 (Type SM) for AP3428A

(Top View)

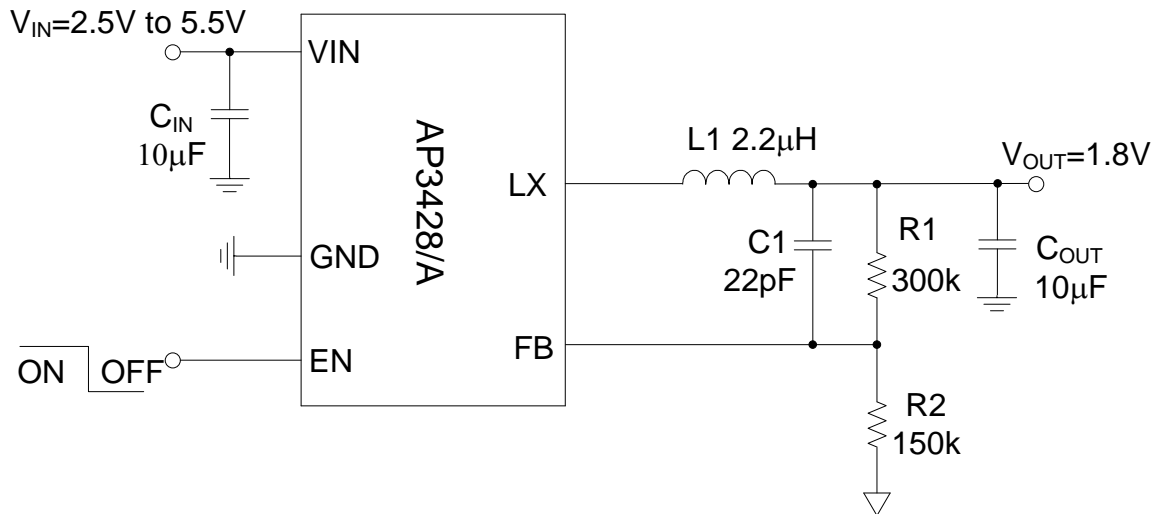


U-DFN2020-6 (Type J)

Applications

- Post DC-DC Voltage Regulation
- Set Top Boxes
- Notebook Computer
- PAD

Typical Applications Circuit



Pin Descriptions

| Pin Number | | | Pin Name | Function |
|---|--|-------------------------|----------|---|
| TSOT25/ TSOT25 (Type SM) for AP3428 | TSOT25/ TSOT25 (Type SM) for AP3428A | U-DFN2020-6 (Type J) | | |
| 1 | 3 | 2 | EN | Enable control input. Force this pin voltage above 1.5V enables the chip, and below 0.4V shuts down the device. |
| 2 | 2 | 5 | GND | Ground pin |
| 3 | 5 | 4 | LX | The drains of the internal main and synchronous power MOSFET. |
| 4 | 1 | 3 | VIN | Bias supply. Chip main power supply pin |
| 5 | 4 | 6 | FB | Feedback voltage to internal error amplifier, the threshold voltage is 0.6V. |
| — | — | 1 | NC | NC |

Absolute Maximum Ratings (Note 4)

| Symbol | Parameter | Rating | Unit | |
|---------------|--|----------------------------|------------------|---------------------------|
| V_{IN} | Input Voltage | -0.3 to 6 | V | |
| V_{EN} | EN Pin Voltage | -0.3 to $V_{IN}+0.3$ | V | |
| V_{LX} | LX Pin Voltage | -0.3 to $V_{IN}+0.3$ | V | |
| | | -3V to 7V (<40ns) | V | |
| V_{FB} | Feedback Pin Voltage | -0.3 to $V_{IN}+0.3$ | V | |
| P_D | Power Dissipation (on PCB, $T_A = +25^\circ\text{C}$) | TSOT25 TSOT25 (Type SM) | 0.4 | W |
| | | U-DFN2020-6 (Type J) | 1.89 | |
| θ_{JA} | Thermal Resistance (Junction to Ambient) | TSOT25 TSOT25 (Type SM) | 220 | $^\circ\text{C}/\text{W}$ |
| | | U-DFN2020-6 (Type J) | 53 | |
| θ_{JC} | Thermal Resistance (Junction to Case, Simulation) | TSOT25 TSOT25 (Type SM) | 130 | $^\circ\text{C}/\text{W}$ |
| | | U-DFN2020-6 (Type J) | 25 | |
| T_J | Operating Junction Temperature | +155 | $^\circ\text{C}$ | |
| T_{STG} | Storage Temperature | -55 to +150 | $^\circ\text{C}$ | |
| V_{MM} | ESD (Machine Model) | 200 | V | |
| V_{HBM} | ESD (Human Body Model) | 2000 | V | |
| V_{CDM} | ESD (Charge Device Mode) | 1000 | V | |

Note 4: Stresses greater than 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 or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to *Absolute Maximum Ratings* for extended periods can affect device reliability.

Recommended Operating Conditions

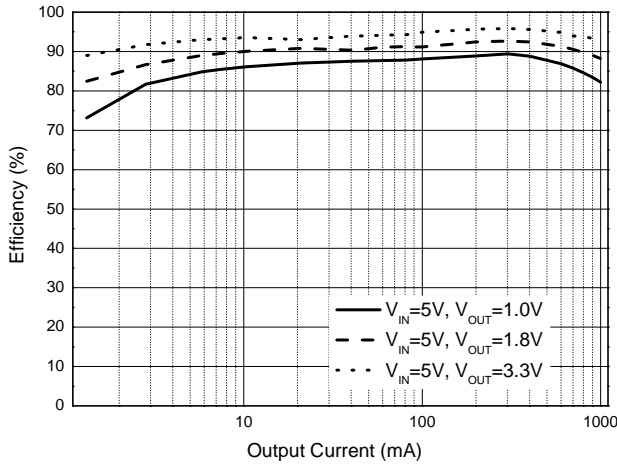
| Symbol | Parameter | Min | Max | Unit |
|----------|-------------------------------|-----|------|------------------|
| V_{IN} | Supply Voltage | 2.5 | 5.5 | V |
| T_J | Junction Temperature Range | -40 | +125 | $^\circ\text{C}$ |
| T_A | Operating Ambient Temperature | -40 | +85 | $^\circ\text{C}$ |

Electrical Characteristics (@ $T_A = +25^\circ\text{C}$, $V_{IN} = 5.0\text{V}$, $V_{OUT} = 2.5\text{V}$, $C_{OUT} = 10\mu\text{F}$, $L = 2.2\mu\text{H}$, unless otherwise specified.)

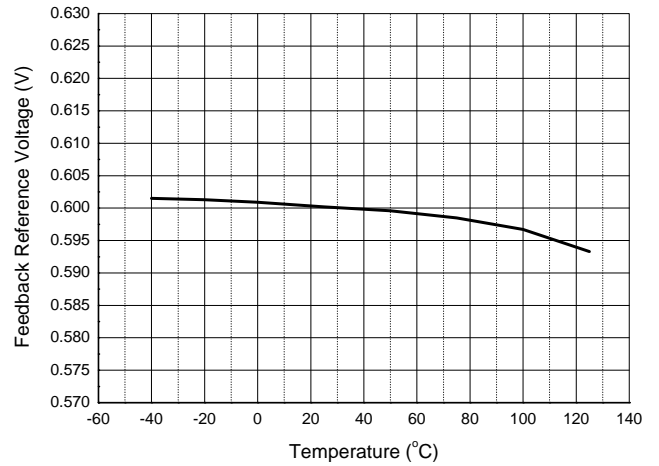
| Symbol | Parameter | Condition | Min | Typ | Max | Unit |
|--------------|-------------------------------------|-----------------------------------|-------|------|----------|------------------|
| V_{IN} | Input Voltage Range | — | 2.5 | — | 5.5 | V |
| V_{OUT} | Output Voltage Range | — | 0.6 | — | V_{IN} | V |
| I_Q | Quiescent Current | $V_{FB} = 0.65\text{V}$ | — | 40 | — | μA |
| I_{SD} | Shutdown Current | $V_{EN} = 0\text{V}$ | — | 0.1 | 1 | μA |
| V_{FB} | Regulated Feedback Voltage | — | 0.588 | 0.6 | 0.612 | V |
| I_{FB} | FB Leakage Current | $V_{FB} = 1\text{V}$ | — | — | 0.2 | μA |
| I_{LIM} | Peak Inductor Current | — | 1.3 | — | — | A |
| fosc | Oscillator Frequency | — | — | 1.5 | — | MHz |
| $R_{DS(ON)}$ | Drain-Source On-State Resistance | $I_{SW} = 100\text{mA}$ High Side | — | 250 | — | m Ω |
| | | $I_{SW} = 100\text{mA}$ Low Side | — | 170 | — | m Ω |
| R_{DISCH} | Output Discharge Switch On Resistor | — | — | 2.1 | — | k Ω |
| V_{ENH} | EN Threshold High | — | 1.5 | — | — | V |
| V_{ENL} | EN Threshold Low | — | — | — | 0.4 | V |
| I_{EN} | EN Leakage Current | $V_{IN} = V_{EN} = 5\text{V}$ | -1.0 | — | 1.0 | μA |
| V_{UVLO} | Input UVLO Threshold | — | — | 2.4 | 2.7 | V |
| V_{HYS} | UVLO Hysteresis | — | — | 0.1 | — | V |
| T_{OTP} | Over Temperature Protection | — | — | +160 | — | $^\circ\text{C}$ |
| T_{OTH} | OTP Hysteresis | — | — | +15 | — | $^\circ\text{C}$ |
| tss | Soft-Start Time | — | — | 2 | — | ms |

Performance Characteristics (@ $T_A = +25^\circ\text{C}$, $V_{IN} = 5\text{V}$, $V_{OUT} = 1.8\text{V}$, unless otherwise specified.)

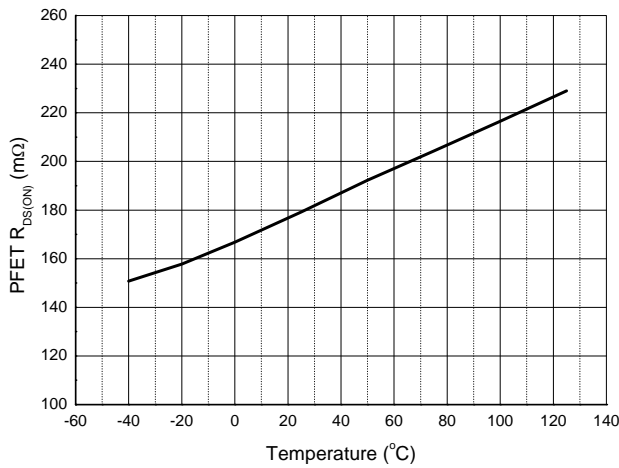
Efficiency vs. Load Current



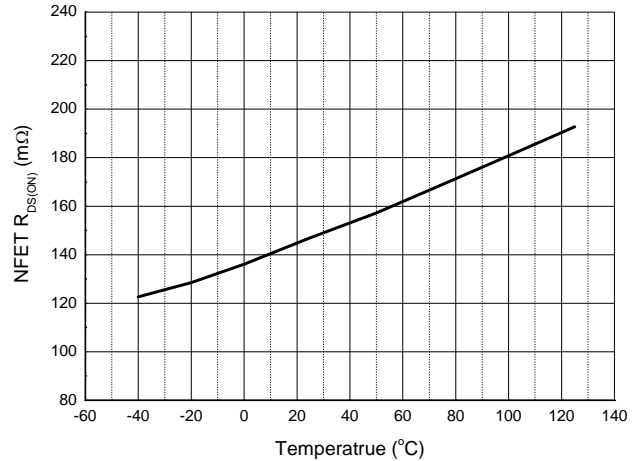
Feedback Reference Voltage vs. Temperature



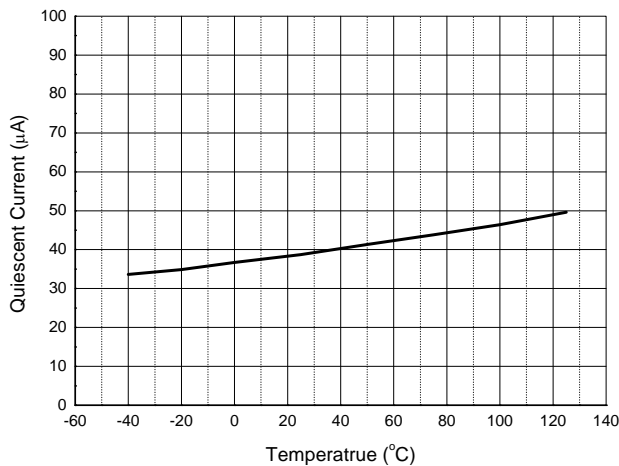
PFET Drain-Source On-State Resistance vs. Temperature



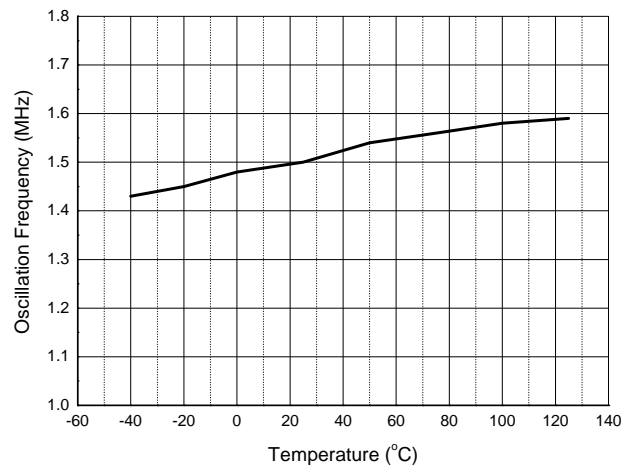
NFET Drain-Source On-State Resistance vs. Temperature



Quiescent Current vs. Temperature

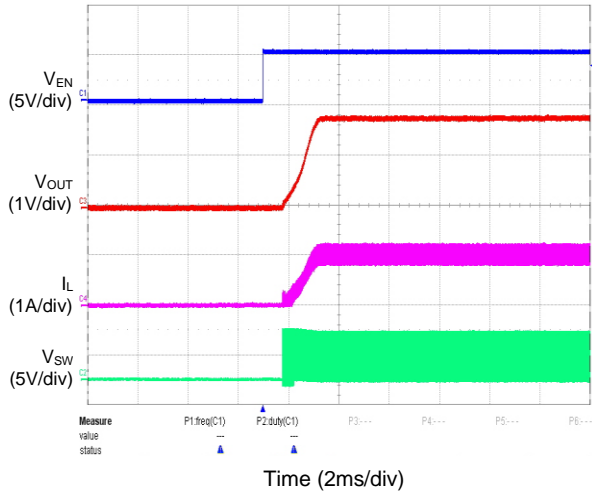


Oscillation Frequency vs. Temperature

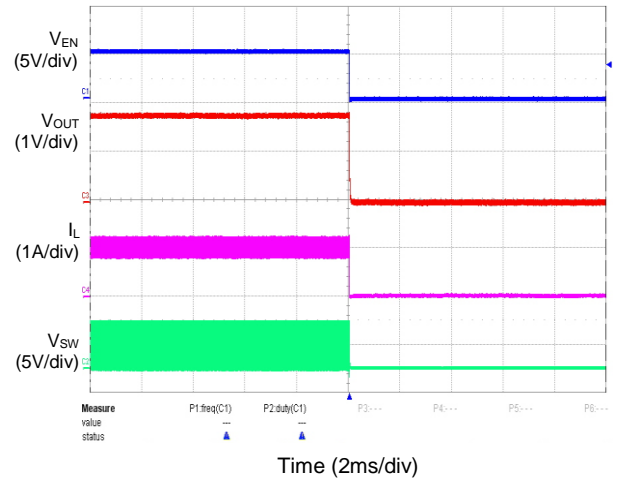


Performance Characteristics (@ $T_A = +25^\circ\text{C}$, $V_{IN} = 5\text{V}$, $V_{OUT} = 1.8\text{V}$, unless otherwise specified.) (continued)

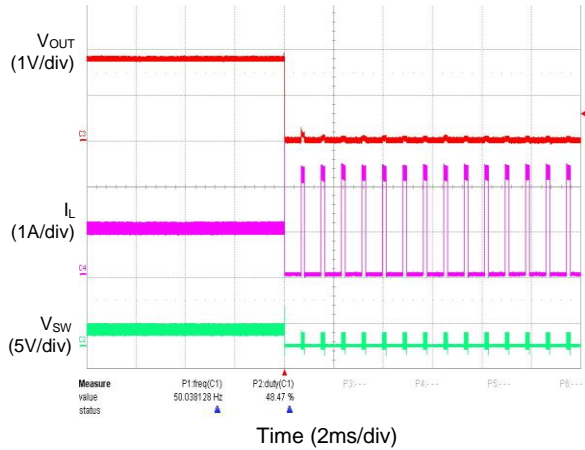
Enable Turn On Characteristic ($I_{OUT} = 1\text{A}$)



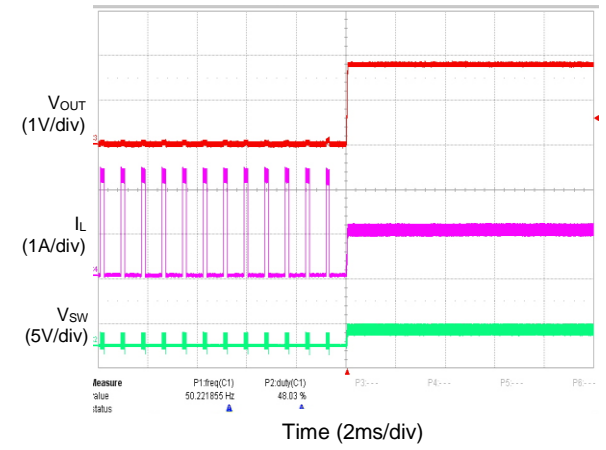
Enable Turn Off Characteristic ($I_{OUT} = 1\text{A}$)



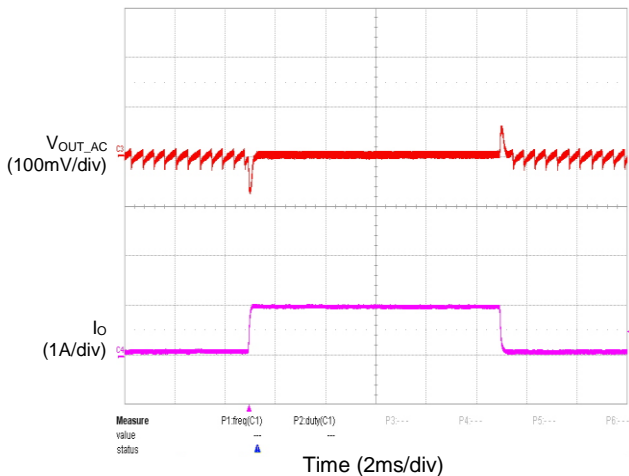
Short Current Protection ($I_{OUT} = 1\text{A}$)



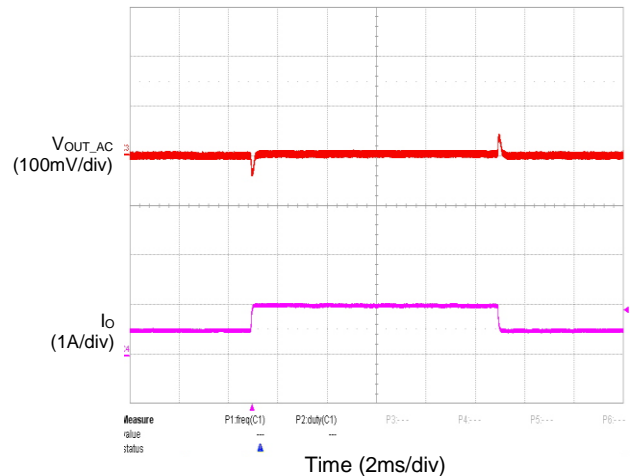
SCP Recovery ($I_{OUT} = 1\text{A}$)



Load Transient ($I_{OUT} = 0.1\text{A}$ to 1A)



Load Transient ($I_{OUT} = 0.5\text{A}$ to 1A)



Application Information

Typical application circuit is shown in the *Typical Applications Circuit* and for the circuit parameters setting please refers to the following descriptions.

Under Voltage Lockout (UVLO) Circuit

When the V_{IN} drops lower than the UVLO detector threshold, the UVLO circuit starts to operate, V_{REF} stops, and high-side switch and low-side switch built-in switch transistors turn "OFF". As a result, V_{OUT} drops according to the C_{OUT} capacitance value and the load. When the V_{IN} is rising higher than UVLO released voltage, the IC will restart the operation.

Short Circuit Protection and Recovery

When the AP3428/A output node is shorted to GND that V_{FB} drops under 0.42V, AP3428/A will enter hiccup mode to protect itself. If short circuit is removed, and V_{FB} rises over 0.42V, the AP3428/A recovers to normal operation again. If the AP3428/A reaches OCP threshold while short circuit, the AP3428/A will enter cycle by cycle current limit mode until the current under OCP threshold.

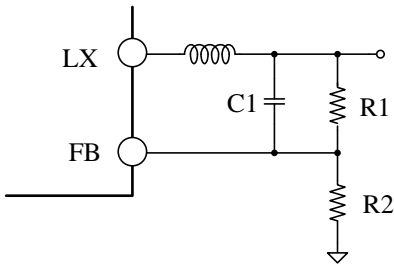
Over Temperature Protection

The internal thermal temperature protection circuitry is provided to protect the integrated circuit in the event that the maximum junction temperature is exceeded. When the junction temperature exceeds +160°C, it shuts down the internal control circuit and switching power MOSFET. The AP3428/A will restart automatically under the control of soft start circuit when the junction temperature decreases to +145°C.

Setting the Output Voltage

The output voltage can be adjusted from 1 to 5V using an external resistor divider. Table 1 shows a list of resistor selections for common output voltages. Resistor R1 is selected based on a design tradeoff between efficiency and output voltage accuracy. For high values of R1 there is less current consumption in the feedback network. However the tradeoff is output voltage accuracy due to the bias current in the error amplifier. R1 can be determined by the following equation. Meanwhile, the input capacitor should close to IC for preventing unexpected influences.

$$R1 = R2 \cdot \left(\frac{V_{out}}{0.6} - 1 \right)$$

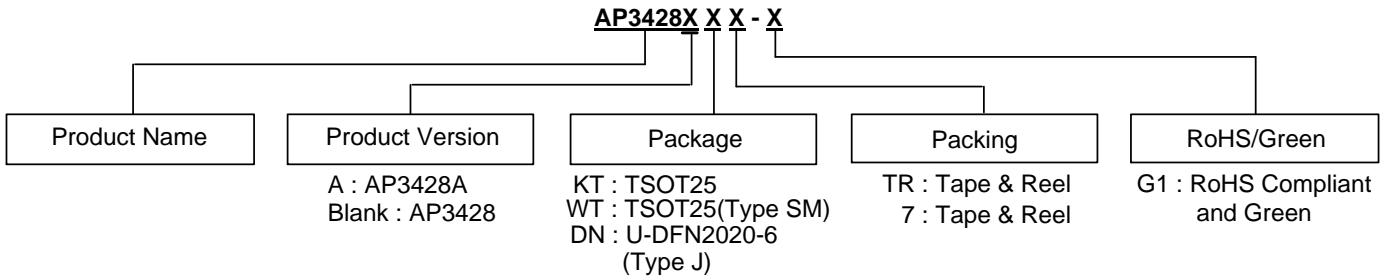


| Out Voltage | R1 | R2 | C1 |
|-------------|-------|-------|------|
| 1.0V | 91kΩ | 120kΩ | 22pF |
| 1.2V | 100kΩ | 100kΩ | 22pF |
| 1.5V | 150kΩ | 100kΩ | 22pF |
| 1.8V | 300kΩ | 150kΩ | 22pF |
| 2.5V | 380kΩ | 120kΩ | 22pF |
| 2.8V | 440kΩ | 120kΩ | 22pF |
| 3.3V | 430kΩ | 100kΩ | 22pF |

Figure 1. Feedback Divider Network

Table 1. Resistor Selection for Common Output

Ordering Information



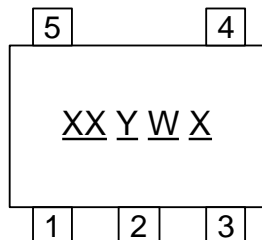
| Part Number | Status | Package | Identification Code | Temperature Range | Packing |
|----------------|--------|---------------------|---------------------|-------------------|------------------|
| AP3428AKTTR-G1 | NRND | TSOT25 | L2J | -40 to +85°C | 3000/Tape & Reel |
| AP3428KTTR-G1 | NRND | TSOT25 | L2H | -40 to +85°C | 3000/Tape & Reel |
| AP3428DNTR-G1 | Active | U-DFN2020-6(Type J) | CQ | -40 to +85°C | 3000/Tape & Reel |
| AP3428AWT-7 | Active | TSOT25 (Type SM) | BD | -40 to +85°C | 3000/Tape & Reel |
| AP3428WT-7 | Active | TSOT25 (Type SM) | BC | -40 to +85°C | 3000/Tape & Reel |

Note 5: NRND = Not Recommended for New Design.

Marking Information

TSOT25 (Type SM) for AP3428WT-7 and AP3428AWT-7

(Top View)



- XX : 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

| Part Number | Package | Identification Code |
|-------------|------------------|---------------------|
| AP3428WT-7 | TSOT25 (Type SM) | BC |
| AP3428AWT-7 | TSOT25 (Type SM) | BD |

Marking Information (continued)

(1) TSOT25 for AP3428

(Top View)



First Line: Logo and Marking ID

(2) TSOT25 for AP3428A

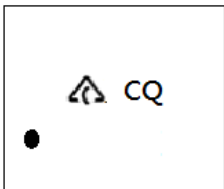
(Top View)



First Line: Logo and Marking ID

(3) U-DFN2020-6 (Type J)

(Top View)

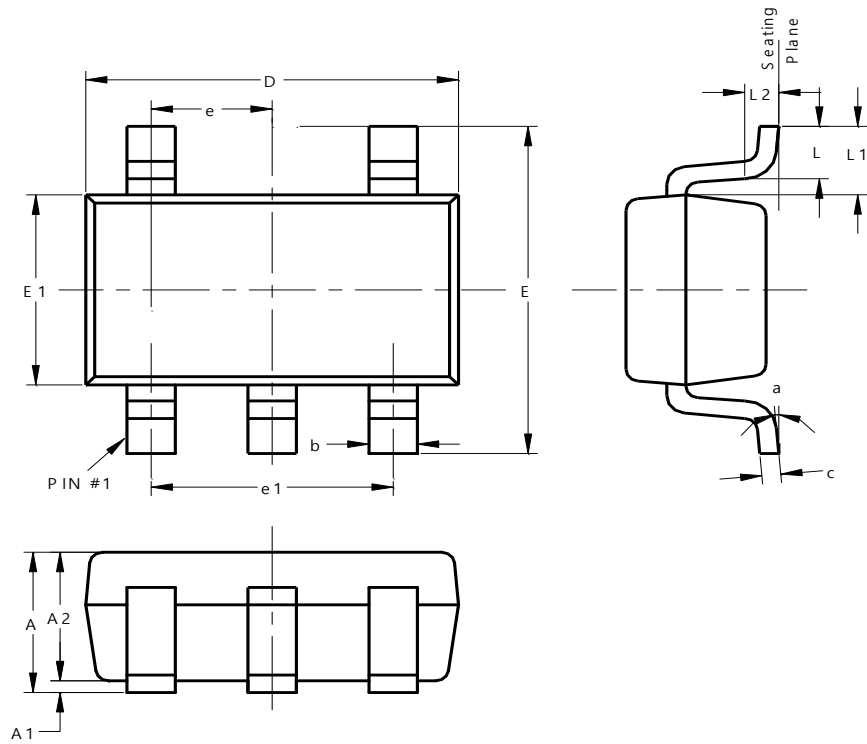


First Line: Logo and Marking ID

Package Outline Dimensions

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

(1) Package Type: TSOT25 (Type SM)

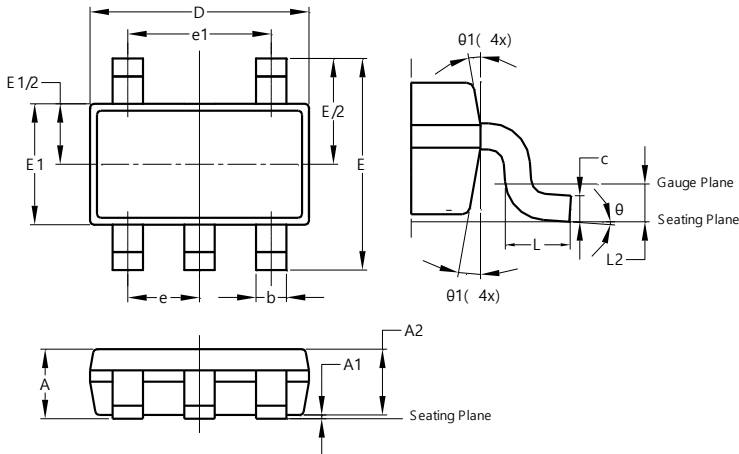


| TSOT25 (Type SM) | | | |
|----------------------|----------|------|------|
| Dim | Min | Max | Typ |
| A | 0.70 | 0.90 | -- |
| A1 | 0.00 | 0.10 | -- |
| A2 | 0.70 | 0.80 | 0.75 |
| b | 0.35 | 0.50 | -- |
| c | 0.08 | 0.20 | -- |
| D | 2.82 | 3.02 | 2.92 |
| E | 2.65 | 2.95 | 2.80 |
| E1 | 1.60 | 1.70 | 1.65 |
| e | 0.95 BSC | | |
| e1 | 1.90 BSC | | |
| L | 0.30 | 0.60 | 0.40 |
| L1 | 0.59 REF | | |
| L2 | 0.25 BSC | | |
| a | 0° | 8° | -- |
| All Dimensions in mm | | | |

Package Outline Dimensions (continued)

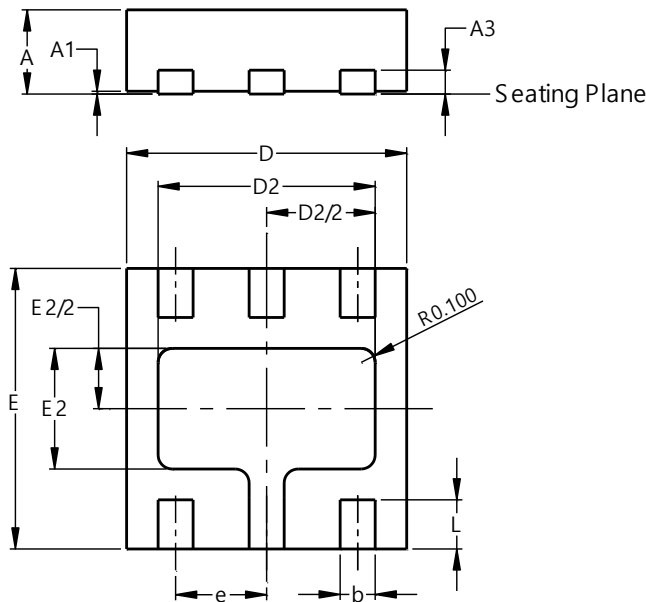
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

(2) Package Type: TSOT25



| TSOT25 | | | |
|----------------------|----------|------|------|
| Dim | Min | Max | Typ |
| A | - | 1.00 | - |
| A1 | 0.01 | 0.10 | - |
| A2 | 0.84 | 0.90 | - |
| b | 0.30 | 0.45 | - |
| c | 0.12 | 0.20 | - |
| D | - | - | 2.90 |
| E | - | - | 2.80 |
| E1 | - | - | 1.60 |
| e | 0.95 BSC | | |
| e1 | 1.90 BSC | | |
| L | 0.30 | 0.50 | - |
| L2 | 0.25 BSC | | |
| theta | 0° | 8° | 4° |
| theta1 | 4° | 12° | - |
| All Dimensions in mm | | | |

(3) Package Type: U-DFN2020-6 (Type J)

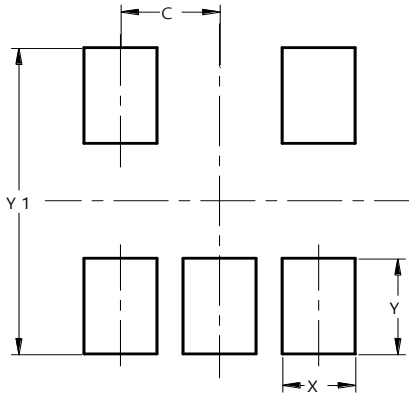


| U-DFN2020-6 (Type J) | | | |
|-------------------------|----------|-------|-------|
| Dim | Min | Max | Typ |
| A | 0.50 | 0.60 | -- |
| A1 | 0.00 | 0.05 | 0.03 |
| A3 | -- | -- | 0.203 |
| b | 0.20 | 0.30 | 0.25 |
| D | 1.95 | 2.075 | 2.00 |
| D2 | 1.45 | 1.65 | 1.55 |
| E | 1.95 | 2.075 | 2.00 |
| E2 | 0.76 | 0.96 | 0.86 |
| e | 0.65 BSC | | |
| L | 0.30 | 0.40 | 0.35 |
| All Dimensions in mm | | | |

Suggested Pad Layout

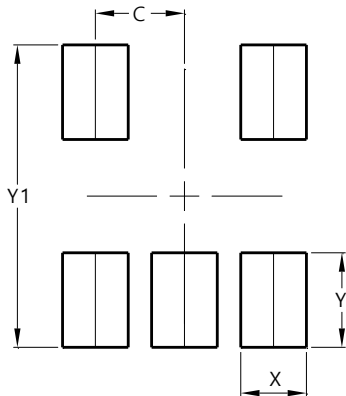
Please see <http://www.diodes.com/package-outlines.html> for the latest version.

(1) Package Type: TSOT25 (Type SM)



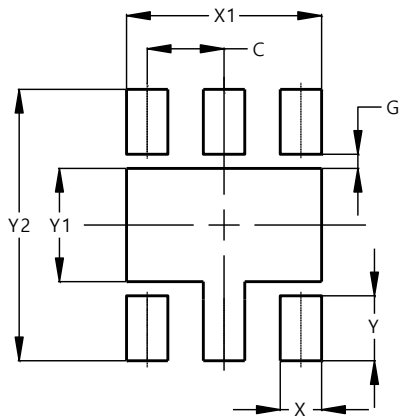
| Dimensions | Value (in mm) |
|------------|---------------|
| C | 0.950 |
| X | 0.700 |
| Y | 1.000 |
| Y1 | 3.199 |

(2) Package Type: TSOT25



| Dimensions | Value (in mm) |
|------------|---------------|
| C | 0.950 |
| X | 0.700 |
| Y | 1.000 |
| Y1 | 3.199 |

(3) Package Type: U-DFN2020-6 (Type J)



| Dimensions | Value (in mm) |
|------------|---------------|
| C | 0.650 |
| G | 0.120 |
| X | 0.350 |
| X1 | 1.650 |
| Y | 0.550 |
| Y1 | 0.960 |
| Y2 | 2.300 |

Mechanical Data

TSOT25/TSOT25 (Type SM)

- Moisture Sensitivity: Level 3 per J-STD-020
- Terminals: Finish - Mate Tin Plated Leads, Solderable per MIL-STD-202, Method 208 ^(e3)
- Weight: 0.014 grams (Approximate)

U-DFN2020-6 (Type J)

- Moisture Sensitivity: Level 1 per J-STD-020
- Terminals: Finish - NiPdAu over Copper Leads, Solderable per MIL-STD-202, Method 208 ^(e4)
- Weight: 0.007 grams (Approximate)

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