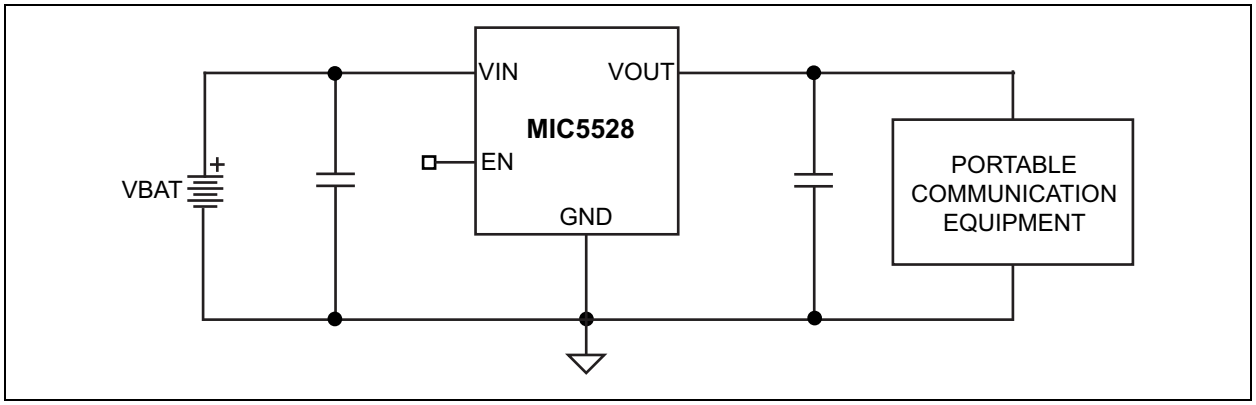
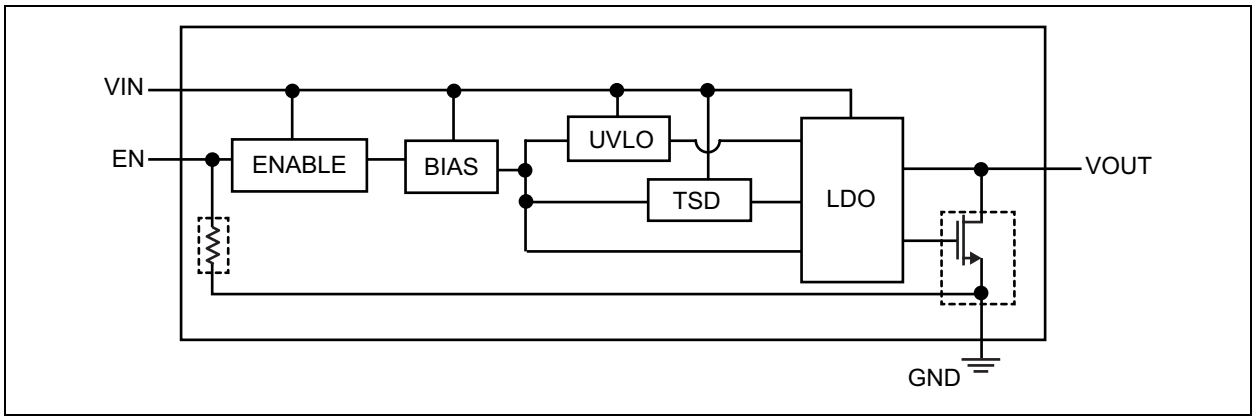
## Typical Application Circuit




## Functional Block Diagram





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# 1.0 ELECTRICAL CHARACTERISTICS

## Absolute Maximum Ratings †

Supply Voltage ($V_{IN}$) ..... –0.3V to +6V
Enable Voltage ($V_{EN}$) ..... –0.3V to $V_{IN}$
Power Dissipation ($P_D$) ..... Internally Limited, Note 1
ESD Rating (Note 2) ..... 3 kV

## Operating Ratings ‡

Supply Voltage ($V_{IN}$) ..... +2.5V to +5.5V
Enable Voltage ($V_{EN}$) ..... 0V to $V_{IN}$

**† Notice:** Stresses above those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at those or any other conditions above those indicated in the operational sections of this specification is not intended. Exposure to maximum rating conditions for extended periods may affect device reliability.

**‡ Notice:** The device is not guaranteed to function outside its operating ratings.

**Note 1:** The maximum allowable power dissipation of any $T_A$ (ambient temperature) is $P_{D(max)} = (T_{J(max)} - T_A)/\theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

**2:** Devices are ESD sensitive. Handling precautions are recommended. Human body model, 1.5 kΩ in series with 100 pF.

### TABLE 1-1: ELECTRICAL CHARACTERISTICS

**Electrical Characteristics:** $V_{IN} = V_{EN} = V_{OUT} + 1V$; $C_{IN} = C_{OUT} = 2.2\ \mu F$; $I_{OUT} = 100\ \mu A$; $T_J = +25°C$, **bold** values indicate –40°C to +85°C, unless noted. Note 1

| Parameter | Symbol | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| Output Voltage Accuracy | — | –2.0 | ±1 | +2.0 | % | Variation from nominal $V_{OUT}$ |
| | | **–3.0** | — | **+3.0** | | Variation from nominal $V_{OUT}$; –40°C to +85°C |
| Line Regulation | — | — | 0.02 | **0.3** | %/V | $V_{IN} = V_{OUT} + 1V$ to 5.5V; $I_{OUT}$ = 100 µA |
| Load Regulation (Note 2) | — | — | 14 | 65 | mV | $I_{OUT}$ = 100 µA to 500 mA |
| Dropout Voltage (Note 3) | $V_{DO}$ | — | 80 | **180** | mV | $I_{OUT}$ = 150 mA |
| | | — | 260 | **500** | | $I_{OUT}$ = 500 mA |
| Ground Pin Current (Note 4) | $I_{GND}$ | — | 38 | **55** | µA | $I_{OUT}$ = 0 mA |
| | | — | 42 | **65** | | $I_{OUT}$ = 500 mA |
| Ground Pin Current in Shutdown | $I_{SHDN}$ | — | 0.05 | 1 | µA | $V_{EN}$ = 0V |
| Ripple Rejection | PSRR | — | 70 | — | dB | f = 100 Hz, $I_{OUT}$ = 100 mA |
| | | — | 60 | — | | f = 1 kHz, $I_{OUT}$ = 100 mA |
| Current Limit | $I_{LIM}$ | **525** | 800 | — | mA | $V_{OUT}$ = 0V |
| Output Voltage Noise | — | — | 175 | — | $\mu V_{RMS}$ | f =10 Hz to 100 kHz |
| Auto-Discharge NFET Resistance | — | — | 25 | — | Ω | $V_{EN}$ = 0V; $V_{IN}$ = 3.6V; $I_{OUT}$ = –3 mA |
| **Enable Input** | | | | | | |
| Enable Pull-Down Resistor | — | — | 4 | — | MΩ | — |
| Enable Input Voltage | $V_{EN}$ | — | — | **0.2** | V | Logic low |
| | | **1.2** | — | — | | Logic high |



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**TABLE 1-1: ELECTRICAL CHARACTERISTICS (CONTINUED)**

**Electrical Characteristics:** $V_{IN} = V_{EN} = V_{OUT} + 1V$; $C_{IN} = C_{OUT} = 2.2\ \mu F$; $I_{OUT} = 100\ \mu A$; $T_J = +25°C$, **bold** values indicate –40°C to +85°C, unless noted. Note 1

| Parameter | Symbol | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| Enable Input Current | $I_{EN}$ | — | 0.01 | 1 | µA | $V_{EN}$ = 0V |
| | | — | 1.4 | 2 | | $V_{EN}$ = 5.5V |
| Turn-On Time | $t_{ON}$ | — | 50 | **125** | µs | $I_{OUT}$ = 150 mA |

**Note 1:** Specification for packaged product only.

**2:** Regulation is measured at constant junction temperature using low duty cycle pulse testing. Changes in output voltage due to heating effects are covered by the thermal regulation specification.

**3:** Dropout voltage is defined as the input-to-output differential at which the output voltage drops 2% below its nominal value measured at 1V differential. For outputs below 2.5V, dropout voltage is the input-to-output differential with the minimum input voltage 2.5V.

**4:** Ground pin current is the regulator quiescent current. The total current drawn from the supply is the sum of the load current plus the ground pin current.


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## TEMPERATURE SPECIFICATIONS (Note 1)

| Parameters | Sym. | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| **Temperature Ranges** | | | | | | |
| Storage Temperature Range | $T_S$ | –65 | — | +150 | °C | — |
| Maximum Junction Temperature Range | $T_J$ | –40 | — | +150 | °C | — |
| Junction Operating Temperature Range | $T_J$ | –40 | — | +125 | °C | — |
| Lead Temperature | — | — | — | +260 | °C | Soldering, 10s |
| **Package Thermal Resistances** | | | | | | |
| Thermal Resistance 6-Lead Extra Thin DFN | $\theta_{JA}$ | — | 173 | — | °C/W | — |

**Note 1:** The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., $T_A$, $T_J$, $\theta_{JA}$). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.



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## 2.0 TYPICAL PERFORMANCE CURVES

**Note:** The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only. The performance characteristics listed herein are not tested or guaranteed. In some graphs or tables, the data presented may be outside the specified operating range (e.g., outside specified power supply range) and therefore outside the warranted range.

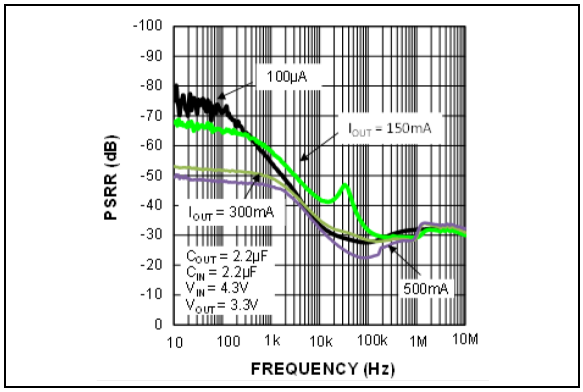


***FIGURE 2-1:*** *Power Supply Rejection Ratio.*

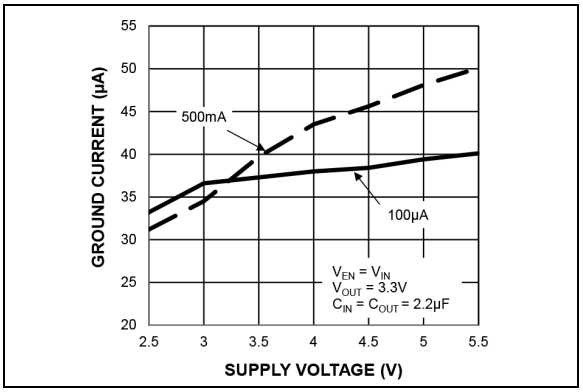


***FIGURE 2-4:*** *Ground Current vs. Supply Voltage.*

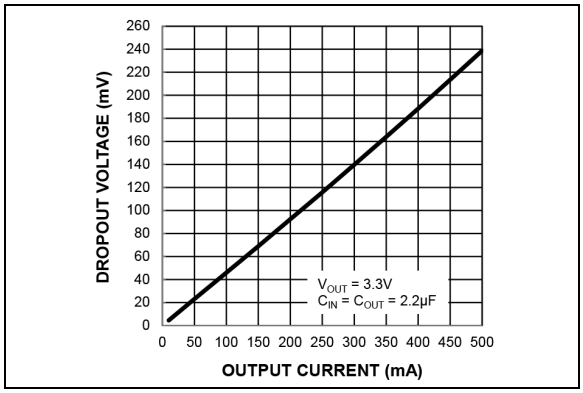


***FIGURE 2-2:*** *Dropout Voltage vs. Output Current.*

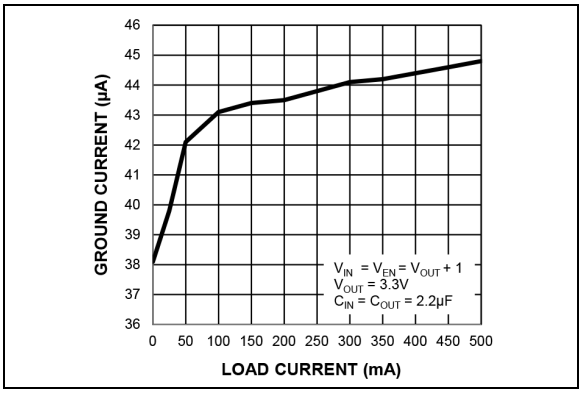


***FIGURE 2-5:*** *Ground Current vs. Load Current.*

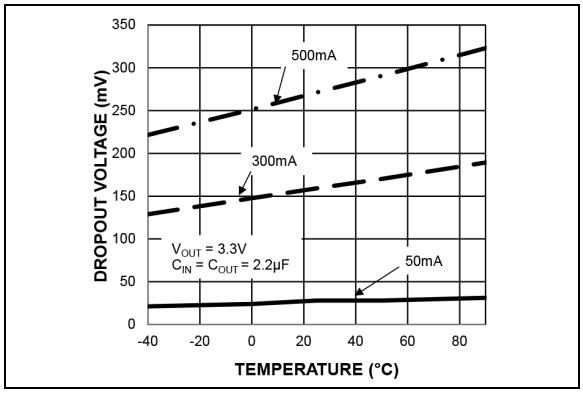


***FIGURE 2-3:*** *Dropout Voltage vs. Temperature.*

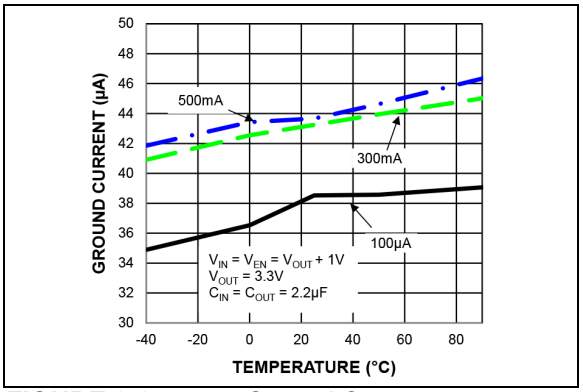


***FIGURE 2-6:*** *Ground Current vs. Temperature.*


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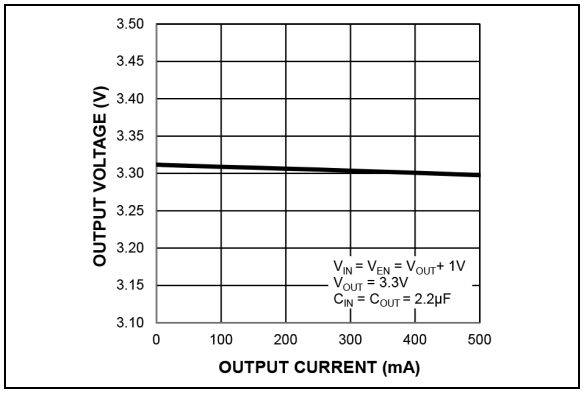


***FIGURE 2-7:*** *Output Voltage vs. Output Current.*

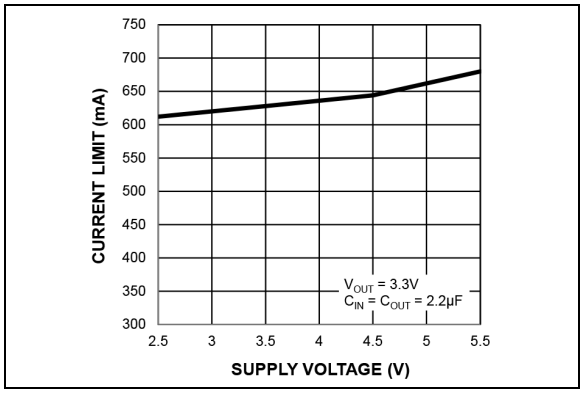


***FIGURE 2-10:*** *Current Limit vs. Supply Voltage.*

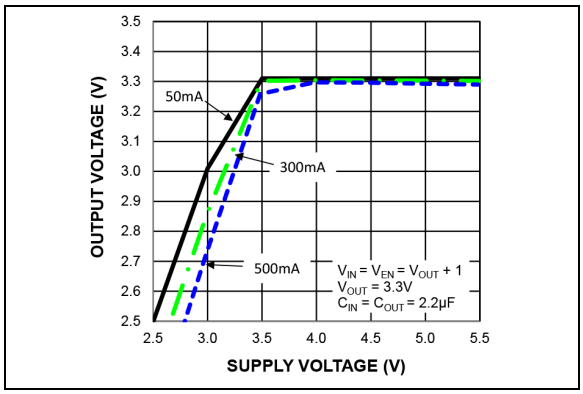


***FIGURE 2-8:*** *Output Voltage vs. Supply Voltage.*

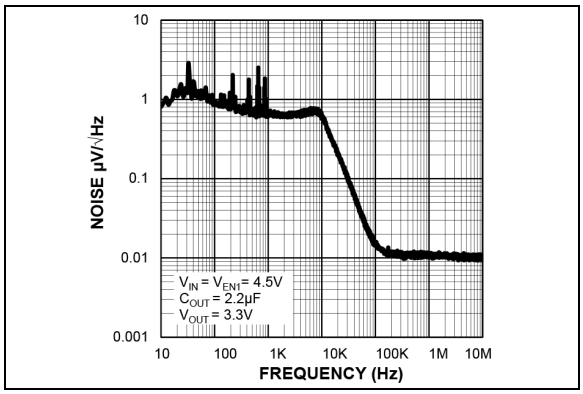


***FIGURE 2-11:*** *Output Noise Spectral Density (MIC5528-3.3YMT).*

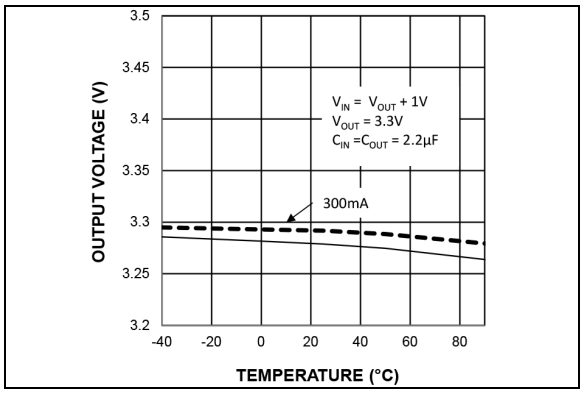


***FIGURE 2-9:*** *Output Voltage vs. Temperature.*

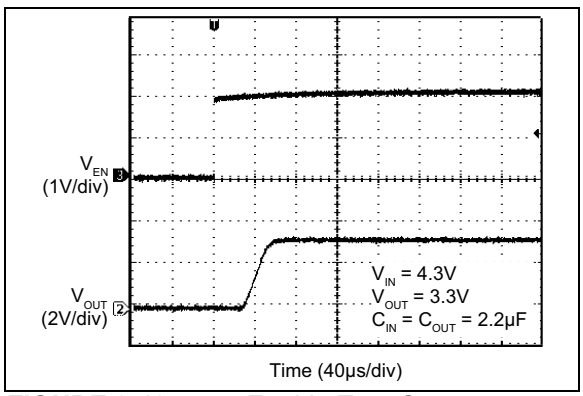


***FIGURE 2-12:*** *Enable Turn-On.*



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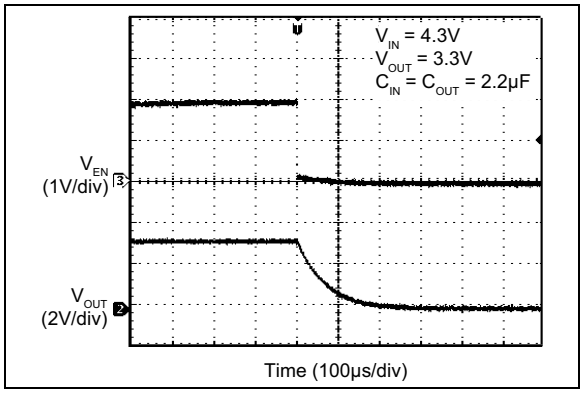


***FIGURE 2-13:*** *Auto-Discharge (No Load).*

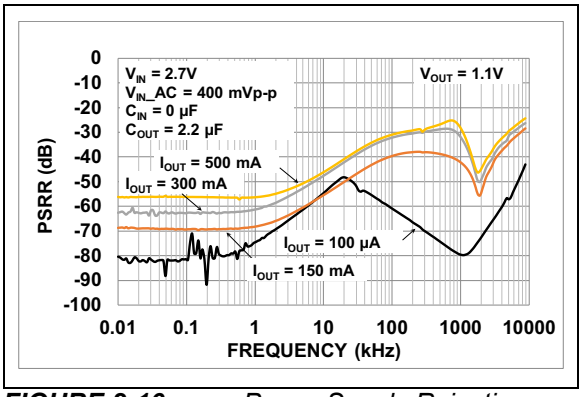


***FIGURE 2-16:*** *Power Supply Rejection Ratio.*

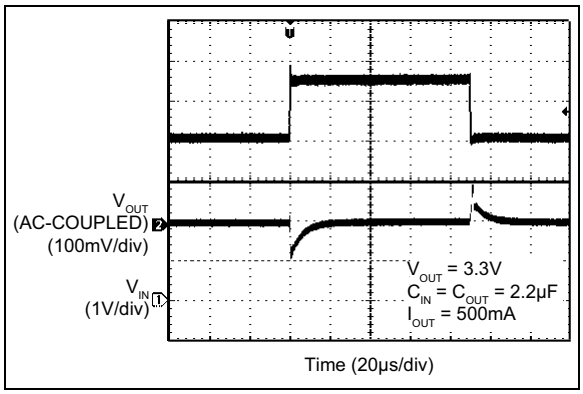


***FIGURE 2-14:*** *Line Transient.*

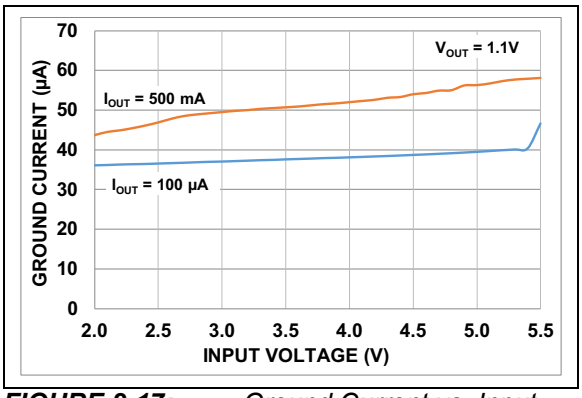


***FIGURE 2-17:*** *Ground Current vs. Input Voltage.*

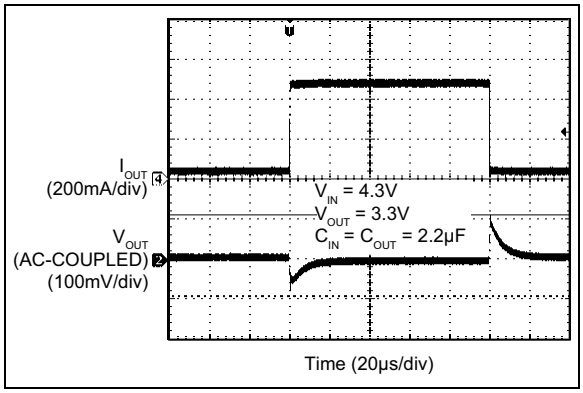


***FIGURE 2-15:*** *Load Transient.*

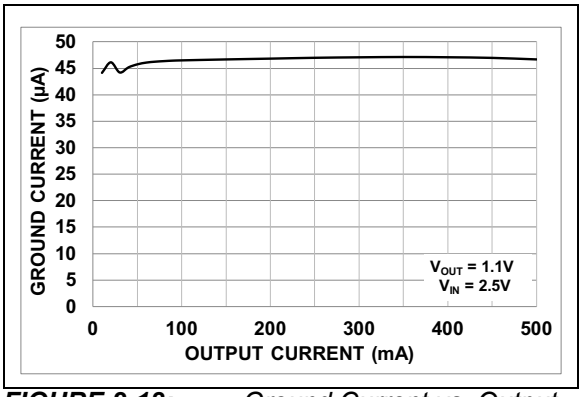


***FIGURE 2-18:*** *Ground Current vs. Output Current.*


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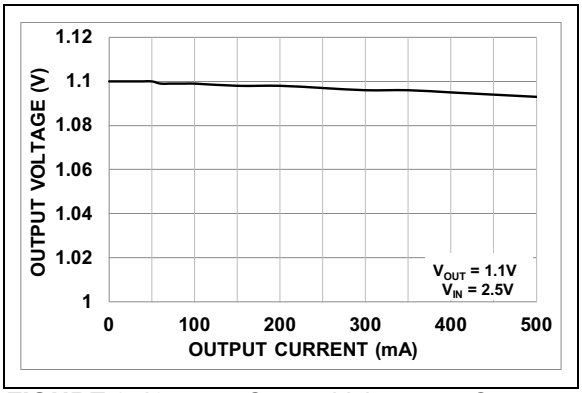


***FIGURE 2-19:*** *Output Voltage vs. Output Current.*

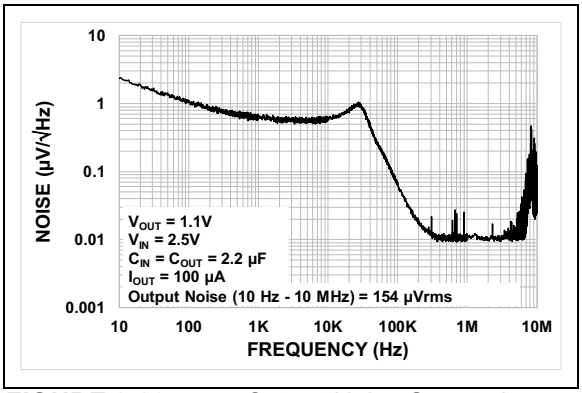


***FIGURE 2-22:*** *Output Noise Spectral Density.*

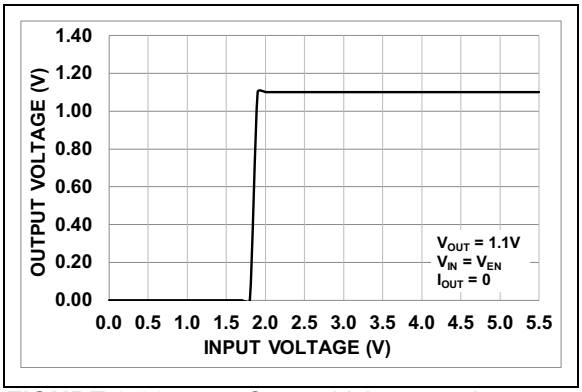


***FIGURE 2-20:*** *Output Voltage vs. Input Voltage.*

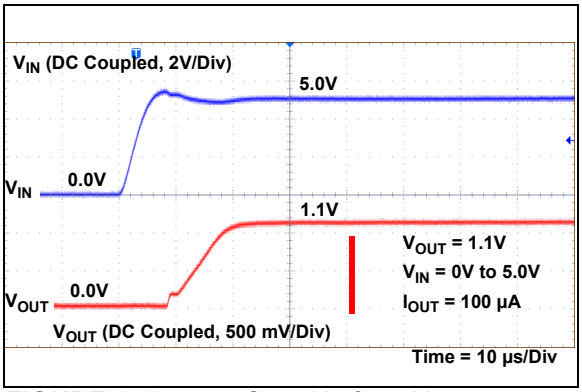


***FIGURE 2-23:*** *Start-Up from $V_{IN}$.*

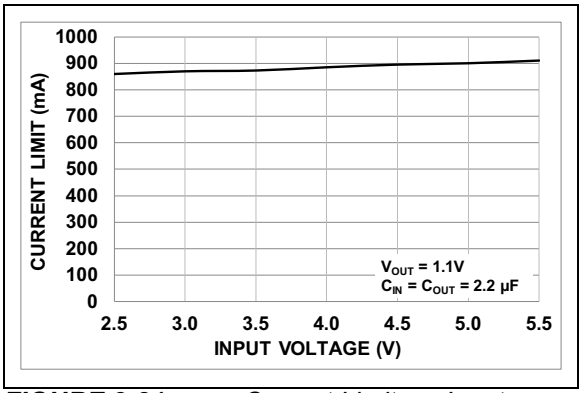


***FIGURE 2-21:*** *Current Limit vs. Input Voltage.*

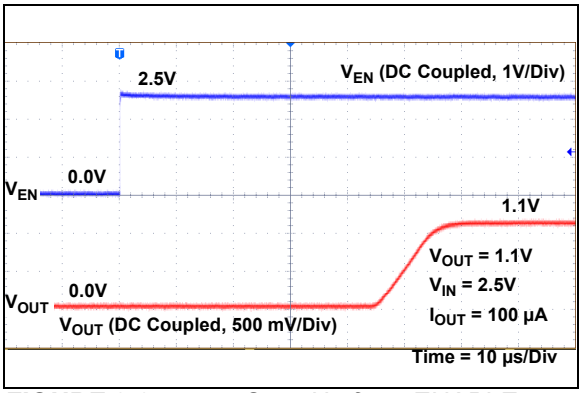


***FIGURE 2-24:*** *Start-Up from ENABLE.*



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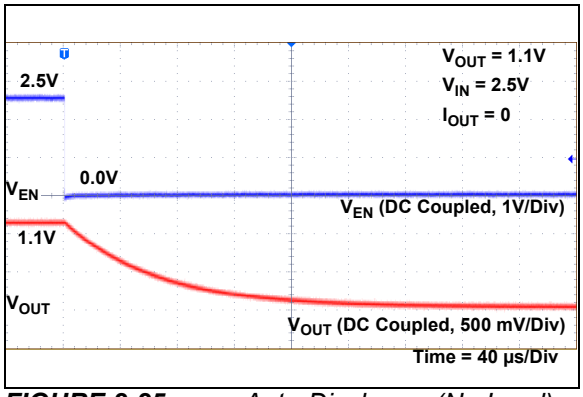


***FIGURE 2-25:*** *Auto-Discharge (No Load).*

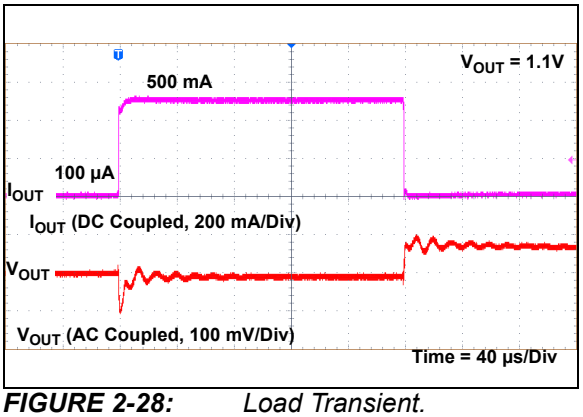


***FIGURE 2-28:*** *Load Transient.*

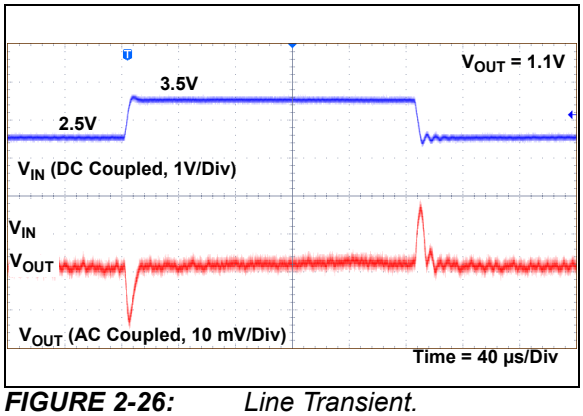


***FIGURE 2-26:*** *Line Transient.*

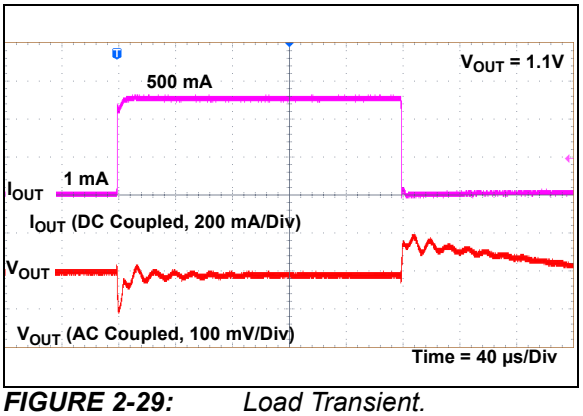


***FIGURE 2-29:*** *Load Transient.*

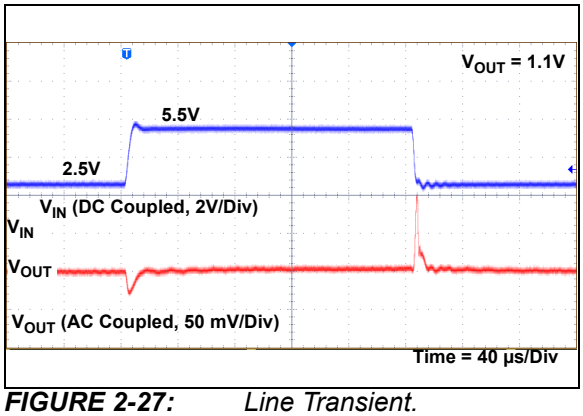


***FIGURE 2-27:*** *Line Transient.*

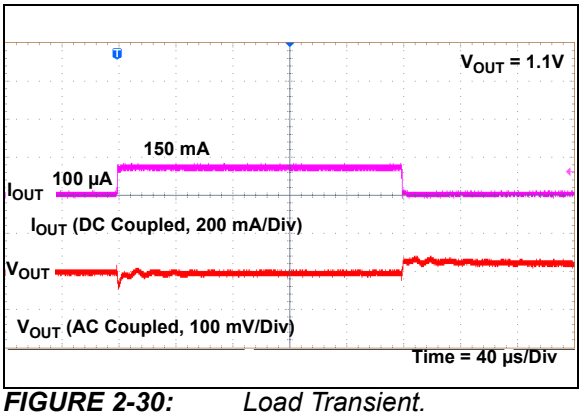


***FIGURE 2-30:*** *Load Transient.*


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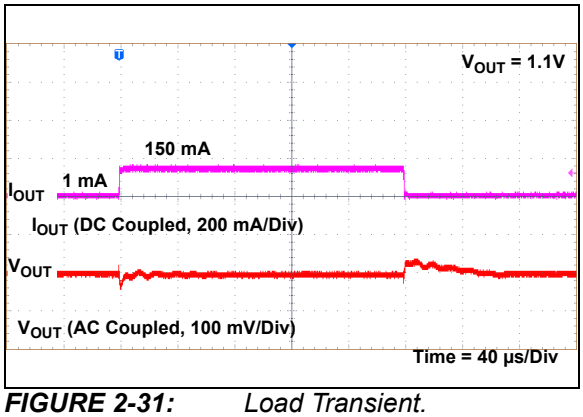


***FIGURE 2-31:*** *Load Transient.*



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## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

**TABLE 3-1: PIN FUNCTION TABLE**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1, 2 | VOUT | Output Voltage. When disabled, the MIC5528 switches in an internal 25Ω load to discharge the external capacitors. |
| 3 | GND | Ground. |
| 4 | EN | Enable Input: Active-High. High = ON; Low = OFF. The MIC5528 has an internal pull-down and this pin can be left floating. |
| 5 | NC | No Connection. |
| 6 | VIN | Supply input. |
| EP | ePad | Exposed Heatsink Pad. Connect to GND for best thermal performance. |


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## 4.0 APPLICATION INFORMATION

The MIC5528 is a high performance, low power 500 mA LDO. The MIC5528 includes an auto-discharge circuit that is switched on when the regulator is disabled through the enable pin. The MIC5528 also offers an internal pull-down resistor on the enable pin to ensure the output is disabled if the control signal is tri-stated. The MIC5528 regulator is fully protected from damage due to fault conditions, offering linear current-limiting and thermal shutdown.

### 4.1 Input Capacitor

The MIC5528 is a high performance, high bandwidth device. An input capacitor of 2.2 µF is required from the input to ground to provide stability. Low-ESR ceramic capacitors provide optimal performance at a minimum of space. Additional high frequency capacitors, such as small-valued NPO dielectric-type capacitors, help filter out high frequency noise and are good practice in any RF-based circuit. X5R or X7R dielectrics are recommended for the input capacitor. Y5V dielectrics lose most of their capacitance over temperature and are therefore, not recommended.

### 4.2 Output Capacitor

The MIC5528 requires an output capacitor of 2.2 µF or greater to maintain stability. The design is optimized for use with low-ESR ceramic chip capacitors. High-ESR capacitors are not recommended because they may cause high frequency oscillation. The output capacitor can be increased, but performance has been optimized for a 2.2 µF ceramic output capacitor and does not improve significantly with larger capacitance.

X7R/X5R dielectric-type ceramic capacitors are recommended because of their temperature performance. X7R-type capacitors change capacitance by 15% over their operating temperature range and are the most stable type of ceramic capacitors. Z5U and Y5V dielectric capacitors change value by as much as 50% and 60%, respectively, over their operating temperature ranges. To use a ceramic chip capacitor with Y5V dielectric, the value must be much higher than an X7R ceramic capacitor to ensure the same minimum capacitance over the equivalent operating temperature range.

### 4.3 No-Load Stability

Unlike many other voltage regulators, the MIC5528 remains stable and in regulation with no load. This is especially important in CMOS RAM keep-alive applications.

### 4.4 Enable/Shutdown

The MIC5528 comes with an active-high enable pin that allows the regulator to be disabled. Forcing the enable pin low disables the regulator and sends it into an off mode current state drawing virtually zero current. When disabled the MIC5528 switches an internal 25Ω load on the regulator output to discharge the external capacitor.

Forcing the enable pin high enables the output voltage. The MIC5528 has an internal pull-down resistor on the enable pin to disable the output when the enable pin is floating.

### 4.5 Thermal Considerations

The MIC5528 is designed to provide 500 mA of continuous current in a very small package. Maximum ambient operating temperature can be calculated based on the output current and the voltage drop across the part. For example, if the input voltage is 3.6V, the output voltage is 3.3V, and the output current is 500 mA. The actual power dissipation of the regulator circuit can be determined using Equation 4-1:

**EQUATION 4-1:**

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

Because this device is CMOS and the ground current is typically <100 µA over the load range, the power dissipation contributed by the ground current is <1% and can be ignored Equation 4-2:

**EQUATION 4-2:**

$$P_D = (3.6V - 3.3V) \times 500mA = 0.150W$$

To determine the maximum ambient operating temperature of the package, use the junction-to-ambient thermal resistance of the device Equation 4-3:



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**EQUATION 4-3:**

$$P_{D(MAX)} = \frac{T_{J(MAX)} - T_A}{\theta_{JA}}$$

Where:

$T_{J(MAX)}$ = 125°C, the maximum junction temperature of the die.

$\theta_{JA}$ = Thermal resistance of 173°C/W for the XTDFN.

Substituting $P_D$ for $P_{D(MAX)}$ and solving for the ambient operating temperature will give the maximum operating conditions for the regulator circuit. The junction-to-ambient thermal resistance for the minimum footprint is 173°C/W.

The maximum power dissipation must not be exceeded for proper operation.

For example, when operating the MIC5528-3.3YMX at an input voltage of 3.6V and a 500 mA load with a minimum footprint layout, the maximum ambient operating temperature $T_A$ can be determined as in Equation 4-4:

**EQUATION 4-4:**

$$0.15W = (125°C - T_A)/(173°C/\mathrm{W})$$

$$T_A = 99°C$$

Therefore, the maximum ambient operating temperature allowed in a thermally enhanced 1.2 mm × 1.2 mm XTDFN package is 99°C. For a full discussion of heat sinking and thermal effects on voltage regulators, refer to the “Regulator Thermals” section of Microchip’s Designing with Low-Dropout Voltage Regulators handbook.


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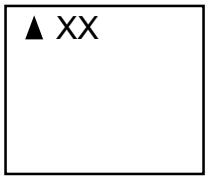
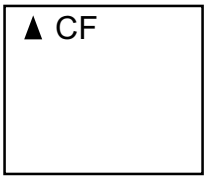
## 5.0 PACKAGING INFORMATION

### 5.1 Package Marking Information

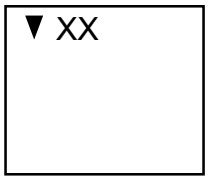
6-Lead TDFN*



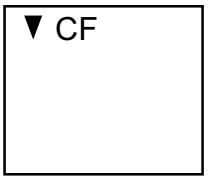

Example




6-Lead XTDFN*




Example




| | | |
|---|---|---|
| **Legend:** | XX...X | Product code or customer-specific information |
| | Y | Year code (last digit of calendar year) |
| | YY | Year code (last 2 digits of calendar year) |
| | WW | Week code (week of January 1 is week ‘01’) |
| | NNN | Alphanumeric traceability code |
| | (e3) | Pb-free JEDEC® designator for Matte Tin (Sn) |
| | * | This package is Pb-free. The Pb-free JEDEC designator ((e3)) can be found on the outer packaging for this package. |
| | ●, ▲, ▼ | Pin one index is identified by a dot, delta up, or delta down (triangle mark). |
| **Note**: | In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo. | |
| | Underbar (_) and/or Overbar (¯) symbol may not be to scale. | |



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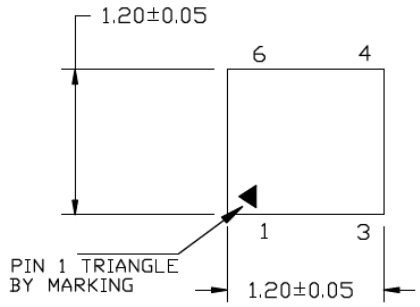
## 6-Lead Thin DFN 1.2 mm x 1.2 mm Package Outline and Recommended Land Pattern

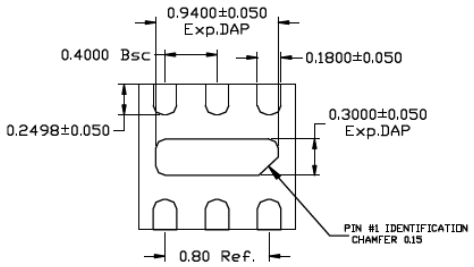
**TITLE**
6 LEAD TDFN 1.2x1.2mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

| DRAWING # | TDFN1212-6LD-PL-1 | UNIT | MM |
|---|---|---|---|



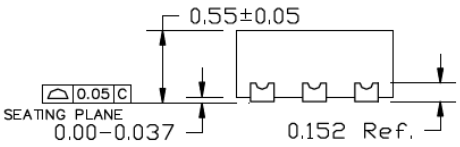

TOP VIEW

NOTE: 1, 2, 3



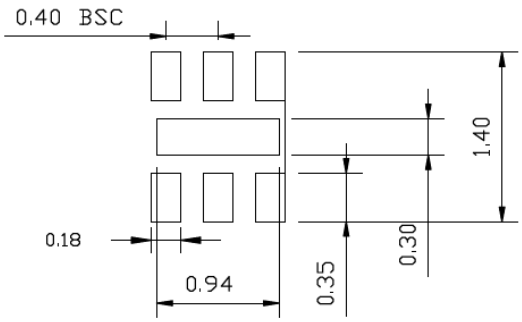

BOTTOM VIEW

NOTE: 1, 2, 3




SIDE VIEW

NOTE: 1, 2, 3




RECOMMENDED LAND PATTERN

NOTE:
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.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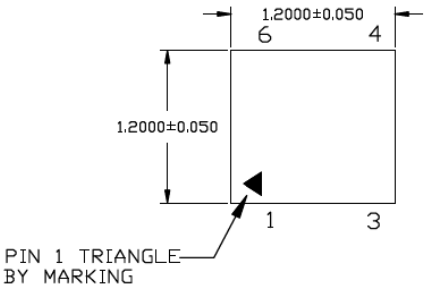
## 6-Lead Extra Thin DFN 1.2 mm x 1.2 mm Package Outline and Recommended Land Pattern

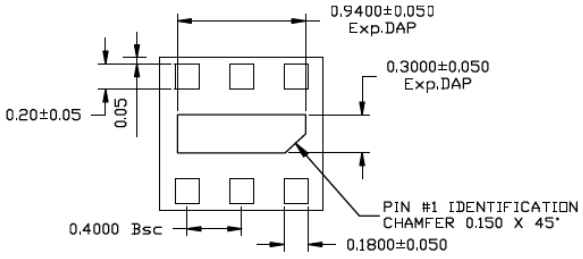
**TITLE**
6 LEAD XTDFN 1.2x1.2mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

| DRAWING # | XTDFN1212-6LD-PL-1 | UNIT | MM |
|---|---|---|---|
| Lead Frame | NiPdAu | Lead Finish | NiPdAu |



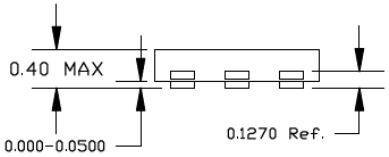

TOP VIEW

NOTE: 1, 2



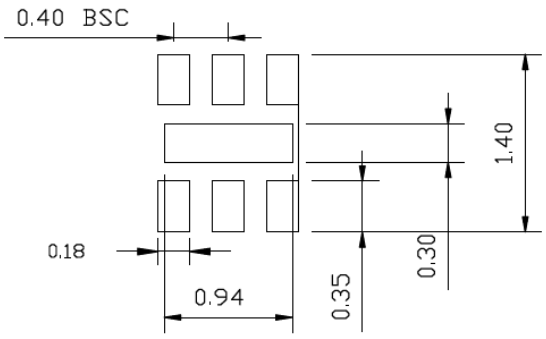

BOTTOM VIEW

NOTE: 1, 2, 3




SIDE VIEW

NOTE: 1, 2




RECOMMENDED LAND PATTERN

NOTE:
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. LEAD AND EPAD CORNER MAXIMUM RADIUS 0.075MM

Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging.



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# APPENDIX A: REVISION HISTORY

## Revision A (March 2018)

- Converted Micrel document MIC5528 to Microchip data sheet DS20005982A.
- Minor text changes throughout.

## Revision B (October 2018)

- Updated Output Voltage information in Features.
- Updated Output Voltage information in Product Identification System section accordingly.



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## PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

| Device | -X.X | X | XX | -XX |
|---|---|---|---|---|
| Part No. | Output Voltage | Junction Temp. Range | Package | Media Type |

| | | |
|---|---|---|
| **Device:** | MIC5528: | High Performance Single 500 mA µCap LDO in Thin and Extra Thin DFN Packages, Featuring Auto Discharge & Internal Enable Pull-Down |
| **Output Voltage:** | 1.1 = | 1.1V (MX Package only) |
| | 1.2 = | 1.2V (MX Package only) |
| | 1.8 = | 1.8V (MX Package only) |
| | 2.8 = | 2.8V (MX Package only) |
| | 3.0 = | 3.0V (MX Package only) |
| | 3.3 = | 3.3V |
| **Junction Temperature Range:** | Y = | –40°C to +125°C, RoHS-Compliant |
| **Package:** | MT = | 6-Lead 1.2 mm x 1.2 mm x 0.6 mm TDFN |
| | MX = | 6-Lead 1.2 mm x 1.2 mm x 0.4 mm XTDFN |
| **Media Type:** | T5 = | 500/Reel |
| | TR = | 5,000/Reel |

**Note:** Other voltage options available. Contact your Microchip Sales Office for more information.

**Examples:**

| | |
|---|---|
| a) MIC5528-1.1YMX-T5: | MIC5528, 1.1V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead XTDFN, 500/Reel |
| b) MIC5528-1.2YMX-TR: | MIC5528, 1.2V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead XTDFN, 5,000/Reel |
| c) MIC5528-1.8YMX-T5: | MIC5528, 1.8V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead XTDFN, 500/Reel |
| d) MIC5528-2.8YMX-TR: | MIC5528, 2.8V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead XTDFN, 5,000/Reel |
| e) MIC5528-3.3YMT-T5: | MIC5528, 3.3V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead TDFN, 500/Reel |
| f) MIC5528-3.3YMT-TR: | MIC5528, 3.3V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead TDFN, 5,000/Reel |
| g) MIC5528-3.0YMX-T5: | MIC5528, 3.0V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead XTDFN, 500/Reel |
| h) MIC5528-3.3YMX-TR: | MIC5528, 3.3V Output Voltage, –40°C to +125°C Temperature Range, 6-Lead XTDFN, 5,000/Reel |

**Note 1:** Tape and Reel identifier only appears in the catalog part number description. This identifier is used for ordering purposes and is not printed on the device package. Check with your Microchip Sales Office for package availability with the Tape and Reel option.



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