# MIC2920X

## 400 mA Low Dropout Regulators

### Features

- High Output Voltage Accuracy
- Ensured 400 mA Output
- Low Quiescent Current
- Low Dropout Voltage
- Extremely Tight Load and Line Regulation
- Very Low Temperature Coefficient
- Current and Thermal Limiting
- Input Withstands –20V Reverse Battery and +60V Positive Transients
- Error Flag Warns of Output Dropout
- Logic-Controlled Electronic Shutdown
- Output Programmable from 1.24V to 26V (MIC29202/MIC29204)
- Available in TO-220-3, TO-220-5, and Surface-Mount TO-263-5, SOT-223, and SOIC-8 Packages

### Applications

- Battery-Powered Equipment
- Cellular Telephones
- Laptop, Notebook, and Palmtop Computers
- PCMCIA $V_{CC}$ and $V_{PP}$ Regulation/Switching
- Barcode Scanners
- Automotive Electronics
- SMPS Post-Regulators
- Voltage Reference
- High-Efficiency Linear Power Supplies

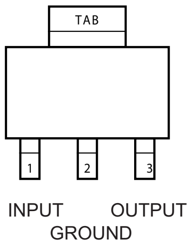
### General Description

The MIC2920 family (MIC2920A, MIC29201, MIC29202, and MIC29204) are efficient voltage regulators with very low dropout voltage (typically 40 mV at light loads and 370 mV at 250 mA) and very low quiescent current (140 µA typical). The quiescent current of the MIC2920A increases only slightly in dropout, prolonging battery life. Key MIC2920A features include protection against reversed battery, fold-back current limiting, and automotive “load dump” protection (60V positive transient).

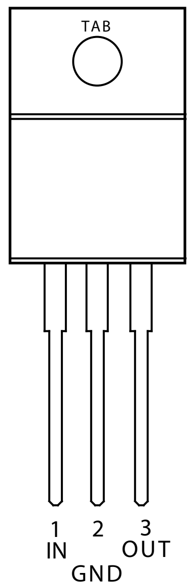
The MIC2920 family of devices are available in several configurations. The MIC2920A-x.x devices are 3-lead fixed-voltage regulators available in 3.3V, 4.85V, 5V, and 12V outputs. The MIC29201 is a fixed-voltage regulator that offers a logic-compatible ON/OFF (shutdown) input and an error flag output. This flag may also be used as a power-on reset signal. A logic-compatible shutdown input is provided on the adjustable MIC29202, which allows the regulator to be switched on and off. The MIC29204 8-lead SOIC adjustable regulator includes both shutdown and error flag pins and may be pin-strapped for 5V output or programmed from 1.24V to 26V using two external resistors.

## Package Types

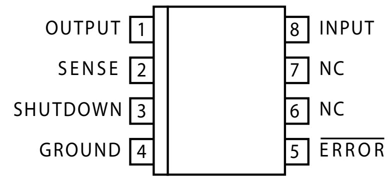
**MIC2920A (FIXED)**
3-Lead SOT-223 (S)



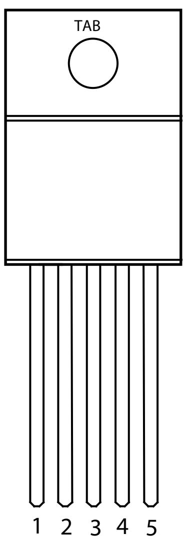

**MIC2920A (FIXED)**
3-Lead TO-220 (T)



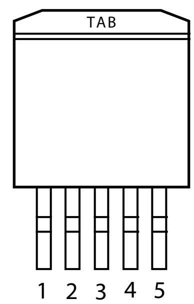

**MIC29201 (FIXED)**
8-Lead SOIC (M)



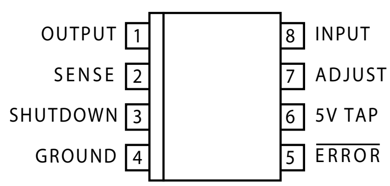

**MIC29201/MIC29202 (ADJ.)**
5-Lead TO-220 (T)




**MIC29201/MIC29202 (ADJ.)**
5-Lead TO-263 (U)




**MIC29204 (ADJ.)**
8-Lead SOIC/8-Lead PDIP (M/N)

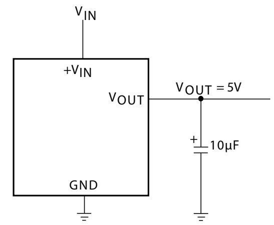



5-Lead Package Pinouts:

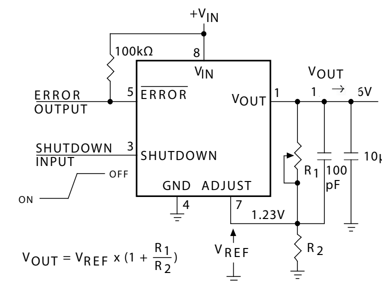
| Pin # | MIC29201 | MIC29202 |
|---|---|---|
| 1 | Error | Adjust |
| 2 | Input | Shutdown |
| 3 | Ground | Ground |
| 4 | Output | Input |
| 5 | Shutdown | Output |

## Typical Application Circuits

**MIC2920A-5.0 Fixed 5V Regulator**

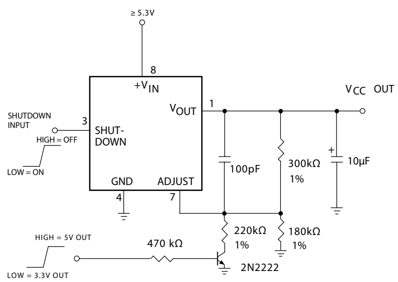



**MIC29202/4 Adjustable Regulator (Pinout for MIC29204)**



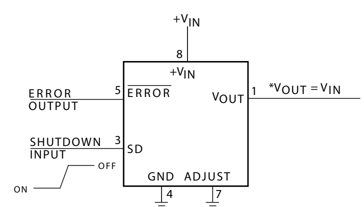

NOTE: PINS 2 AND 6 ARE LEFT OPEN

**MIC29202/4 5V or 3.3V Selectable Regulator with Shutdown (Pinout for MIC29204)**



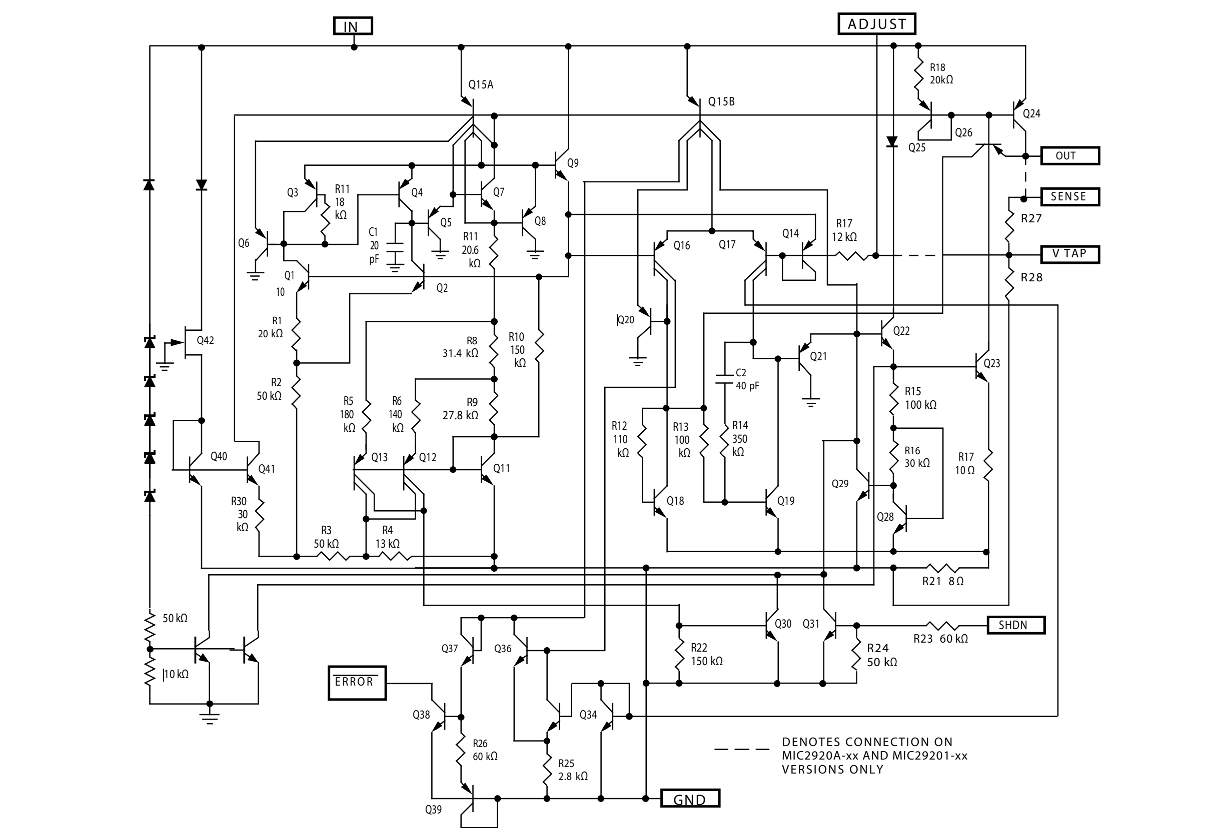

PIN 3 LOW= ENABLE OUTPUT. Q1 ON = 3.3V, Q1 OFF = 5.0V.

**MIC29204 Wide Input Voltage Range Current Limiter**




* Minimum Input-Output Voltage ranges from 40mV to 400mV, depending on load current

## Schematic Diagram



## 1.0 ELECTRICAL CHARACTERISTICS

### Absolute Maximum Ratings †

Input Supply Voltage ........ –20V to +60V
Adjust Input Voltage (Note 1, Note 2)........ –1.5V to +26V
Power Dissipation (Note 3)........ Internally Limited

### Operating Ratings ‡

Operating Input Supply Voltage (Note 4)........ +2V to +26V
Adjust Input Voltage (Note 1, Note 2)........ –1.5V to +26V
Shutdown Input Voltage ........ –0.3V to +30V
Error Comparator Output Voltage........ –0.3V to +30V

**† 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:** Comparator thresholds are expressed in terms of a voltage differential at the Adjust terminal below the nominal reference voltage measured at 6V input. To express these thresholds in terms of output voltage change, multiply by the error amplifier gain = $V_{OUT}/V_{REF}$ = (R1 + R2)/R2. For example, at a programmed output voltage of 5V, the Error output is ensured to go low when the output drops by 95 mV x 5V/1.235V = 384 mV. Thresholds remain constant as a percent of $V_{OUT}$ as $V_{OUT}$ is varied, with the dropout warning occurring at typically 5% below nominal, 7.7% ensured.

**2:** $V_{SHUTDOWN} \geq 2V$, $V_{IN} \leq 26V$, $V_{OUT} = 0$, with the Adjust pin tied to 5V Tap or to the R1, R2 junction (see the MIC29202/29204 Adjustable Regulator in Typical Application Circuits) with R1 ≥ 150 kΩ.

**3:** The maximum allowable power dissipation is a function of the maximum junction temperature, $T_{J(MAX)}$, the junction-to-ambient thermal resistance, $\theta_{JA}$, and the ambient temperature, $T_A$. The maximum allowable power dissipation at any ambient temperature is calculated using: $P_{(MAX)} = (T_{J(MAX)} – T_A) \div \theta_{JA}$. Exceeding the maximum allowable power dissipation will result in excessive die temperature, and the regulator will go into thermal shutdown.

**4:** Across the full operating temperature, the minimum input voltage range for full output current is 4.3V to 26V. Output will remain in-regulation at lower output voltages and low current loads down to an input of 2V at 25°C.

## ELECTRICAL CHARACTERISTICS

**Electrical Characteristics:** Limits in standard typeface are for $T_J$ = +25°C and limits in **boldface** apply over the full operating temperature range. Unless otherwise specified, $V_{IN}$ = $V_{OUT}$ + 1V, $I_L$ = 1 mA, $C_L$ = 10 µF. Adjustable versions are set for an output of 5V. The MIC29202 $V_{SHUTDOWN}$ ≤ 0.7V. The 8-lead MIC29204 is configured with the Adjust pin tied to the 5V Tap, the Output is tied to Output Sense ($V_{OUT}$ = 5V), and $V_{SHUTDOWN}$ ≤ 0.7V. (Note 1)

| Parameter | Symbol | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| Output Voltage Accuracy | $V_O$ | –1 | — | 1 | % | Variation from factory trimmed $V_{OUT}$ |
| | | **–2** | — | **2** | | |
| | | **–2.5** | — | **2.5** | | 1 mA ≤ $I_L$ ≤ 400 mA, across temp range |
| | | –1.5 | — | 1.5 | | MIC2920A-12 and MIC29201-12 only |
| | | **–3** | — | **3** | | |
| | | **–4** | — | **4** | | 1 mA ≤ $I_L$ ≤ 400 mA, across temp range |
| Output Voltage Temperature Coefficient | $\Delta V_O/\Delta T$ | — | 20 | **100** | ppm/°C | Note 2 |
| | | — | 80 | **350** | | $V_{OUT}$ > 10V only |
| Line Regulation | $\Delta V_O/V_O$ | — | 0.03 | 0.10 | % | $V_{IN}$ = $V_{OUT}$ + 1V to 26V |
| | | — | — | **0.40** | | |
| Load Regulation | $\Delta V_O/V_O$ | — | 0.04 | 0.16 | % | $I_L$ = 1 mA to 250 mA (Note 3) |
| | | — | — | **0.30** | | |
| Dropout Voltage (Note 4) | $V_{IN} - V_O$ | — | 100 | 150 | mV | $I_L$ = 1 mA |
| | | — | — | **180** | | |
| | | — | 250 | — | | $I_L$ = 100 mA |
| | | — | 350 | — | | $V_{OUT}$ > 10V only |
| | | — | 370 | — | | $I_L$ = 250 mA |
| | | — | 500 | — | | $V_{OUT}$ > 10V only |
| | | — | 400 | 600 | | $I_L$ = 400 mA |
| | | — | — | **750** | | |
| Ground Pin Current (Note 5) | $I_{GND}$ | — | 140 | 200 | µA | $I_L$ = 1 mA |
| | | — | — | **300** | | |
| | | — | 1.3 | 2 | mA | $I_L$ = 100 mA |
| | | — | — | **2.5** | | |
| | | — | 5 | 9 | | $I_L$ = 250 mA |
| | | — | — | **12** | | |
| | | — | 13 | 15 | | $I_L$ = 400 mA |
| Ground Pin Current at Dropout (Note 5) | $I_{GNDDO}$ | — | 180 | **400** | µA | $V_{IN}$ = 0.5V less than designed $V_{OUT}$, ($V_{OUT}$ = 3.3V), $I_O$ = 1 mA |
| Current Limit | $I_{LIMIT}$ | — | 425 | 100 | mA | $V_{OUT}$ = 0V |
| | | — | — | **1200** | | Note 6 |
| Thermal Regulation | $\Delta V_O/\Delta P_D$ | — | 0.05 | 0.2 | %/W | Note 7 |
| Output Noise Voltage (10 Hz to 100 kHz), $I_L$ = 100 mA | $e_n$ | — | 400 | — | $\mu V_{RMS}$ | $C_L$ = 10 µF |
| | | — | 260 | — | | CL = 100 µF |

## ELECTRICAL CHARACTERISTICS (CONTINUED)

**Electrical Characteristics:** Limits in standard typeface are for $T_J$ = +25°C and limits in **boldface** apply over the full operating temperature range. Unless otherwise specified, $V_{IN} = V_{OUT}$ + 1V, $I_L$ = 1 mA, $C_L$ = 10 µF. Adjustable versions are set for an output of 5V. The MIC29202 $V_{SHUTDOWN}$ ≤ 0.7V. The 8-lead MIC29204 is configured with the Adjust pin tied to the 5V Tap, the Output is tied to Output Sense ($V_{OUT}$ = 5V), and $V_{SHUTDOWN}$ ≤ 0.7V. (Note 1)

| Parameter | Symbol | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| **MIC29202, MIC29204** | | | | | | |
| Reference Voltage | $V_{REF}$ | 1.223 | 1.235 | 1.247 | V | MIC29202 |
| | | **1.210** | — | **1.260** | | |
| Reference Voltage | $V_{REF}$ | **1.204** | — | **1.266** | V | MIC29202, Note 8 |
| Reference Voltage | $V_{REF}$ | 1.210 | 1.235 | 1.260 | V | MIC29204 |
| | | **1.200** | — | **1.270** | | |
| Reference Voltage | $V_{REF}$ | **1.185** | — | **1.285** | V | MIC29204, Note 8 |
| Adjust Pin Bias Current | $I_{BIAS}$ | — | 20 | 40 | nA | — |
| | | — | — | **60** | | |
| Reference Voltage Temperature Coefficient | $\Delta V_{REF}/\Delta T$ | — | 20 | — | ppm/°C | Note 7 |
| Adjust Pin Bias Current Temperature Coefficient | $\Delta I_{BIAS}/\Delta T$ | — | 0.1 | — | nA/°C | — |
| **Error Comparator MIC29201, MIC29204** | | | | | | |
| Output Leakage Current | — | — | 0.01 | 1.00 | µA | $V_{OH}$ = 26V |
| | | — | — | **2.00** | | |
| Output Low Voltage | $V_{OL}$ | — | 150 | 250 | mV | $V_{IN}$ = 4.5V, $I_{OL}$ = 250 µA |
| | | — | — | **400** | | |
| Upper Threshold Voltage | $V_{UTH}$ | 40 | 60 | — | mV | Note 9 |
| | | **25** | — | — | | |
| Lower Threshold Voltage | $V_{LTH}$ | — | 75 | 95 | mV | Note 9 |
| | | — | — | **140** | | |
| Hysteresis | HYS | — | 15 | — | mV | Note 9 |

## ELECTRICAL CHARACTERISTICS (CONTINUED)

**Electrical Characteristics:** Limits in standard typeface are for $T_J$ = +25°C and limits in **boldface** apply over the full operating temperature range. Unless otherwise specified, $V_{IN} = V_{OUT}$ + 1V, $I_L$ = 1 mA, $C_L$ = 10 µF. Adjustable versions are set for an output of 5V. The MIC29202 $V_{SHUTDOWN} \le 0.7V$. The 8-lead MIC29204 is configured with the Adjust pin tied to the 5V Tap, the Output is tied to Output Sense ($V_{OUT}$ = 5V), and $V_{SHUTDOWN} \le 0.7V$. (Note 1)

| Parameter | Symbol | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| **Shutdown Input MIC29201, MIC29202, MIC29204** | | | | | | |
| Input Logic Voltage | — | — | 1.3 | — | V | — |
| | | — | — | **0.7** | | Low (ON) |
| | | **2.0** | — | — | | High (OFF) |
| Shutdown Pin Input Current | $I_{IN(SHDN)}$ | — | 30 | 50 | µA | $V_{SHUTDOWN}$ = 2.4V |
| | | — | — | **100** | | |
| | | — | 450 | 600 | | $V_{SHUTDOWN}$ = 26V |
| | | — | — | **750** | | |
| Regulator Output Current in Shutdown | — | — | 3 | 10 | µA | Note 10 |
| | | — | — | **20** | | |

**Note 1:** Devices are ESD protected. However, handling precautions are recommended.

**2:** Output voltage temperature coefficient is defined as the worst case voltage change divided by the total temperature range.

**3:** 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.

**4:** Dropout Voltage is defined as the input to output differential at which the output voltage drops 100 mV below its nominal value measured at 1V differential. At low values of programmed output voltage, the minimum input supply voltage of 4.3V over temperature must be taken into account. The MIC2920A operates down to 2V of input at reduced output current at 25°C.

**5:** 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.

**6:** The MIC2920A features fold-back current limiting. The short circuit ($V_{OUT}$ = 0V) current limit is less than the maximum current with normal output voltage.

**7:** Thermal regulation is defined as the change in output voltage at a time "t" after a change in power dissipation is applied, excluding load or line regulation effects. Specifications are for a 200 mA load pulse at $V_{IN}$ = 20V (a 4W pulse) for t = 10 ms.

**8:** $V_{REF} \le V_{OUT} \le (V_{IN} - 1V)$, $4.3V \le V_{IN} \le 26V$, $1\text{ mA} < I_L \le 400\text{ mA}$, $T_J \le T_{J(MAX)}$.

**9:** Comparator thresholds are expressed in terms of a voltage differential at the Adjust terminal below the nominal reference voltage measured at 6V input. To express these thresholds in terms of output voltage change, multiply by the error amplifier gain = $V_{OUT}/V_{REF}$ = (R1 + R2)/R2. For example, at a programmed output voltage of 5V, the Error output is guaranteed to go low when the output drops by 95 mV x 5V/1.235V = 384 mV. Thresholds remain constant as a percent of $V_{OUT}$ as $V_{OUT}$ is varied, with the dropout warning occurring at typically 5% below nominal, 7.7% ensured.

**10:** $V_{SHUTDOWN} \ge 2V$, $V_{IN} \le 26V$, $V_{OUT}$ = 0, with the Adjust pin tied to 5V Tap or to the R1, R2 junction (see the MIC29202/29204 Adjustable Regulator in Typical Application Circuits) with R1 ≥ 150 kΩ.

**11:** When used in dual supply systems where the regulator load is returned to a negative supply, the output voltage must be diode clamped to ground.

**12:** Maximum positive supply voltage of 60V must be of limited duration (<100 ms) and duty cycle (≤1%). The maximum continuous supply voltage is 26V.

## TEMPERATURE SPECIFICATIONS (Note 1)

| Parameters | Sym. | Min. | Typ. | Max. | Units | Conditions |
|---|---|---|---|---|---|---|
| **Temperature Ranges** | | | | | | |
| Junction Temperature Range | $T_J$ | –40 | — | +125 | °C | — |
| Lead Temperature | — | — | — | +260 | °C | Soldering, 5 sec. |
| **Package Thermal Resistance** | | | | | | |
| Thermal Resistance, SOT-223 | $\theta_{JC}$ | — | 15 | — | °C/W | — |
| Thermal Resistance, TO-220 | $\theta_{JC}$ | — | 3 | — | °C/W | — |
| Thermal Resistance, TO-263 | $\theta_{JC}$ | — | 3 | — | °C/W | — |
| Thermal Resistance, 8-Ld SOIC | $\theta_{JA}$ | — | 160 | — | °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.

## 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.

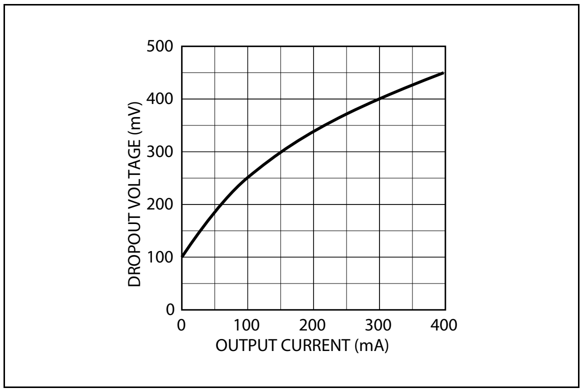



***FIGURE 2-1:*** *Dropout Voltage vs. Output Current.*

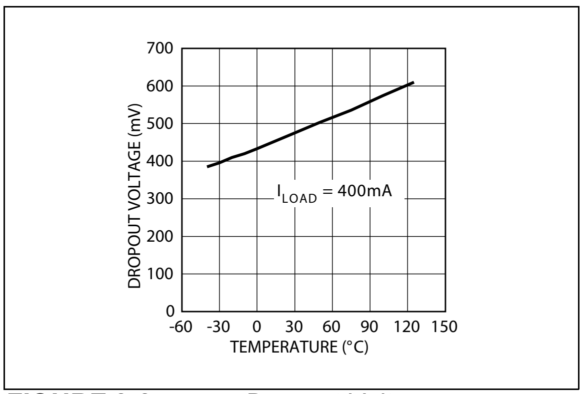



***FIGURE 2-2:*** *Dropout Voltage vs. Temperature.*

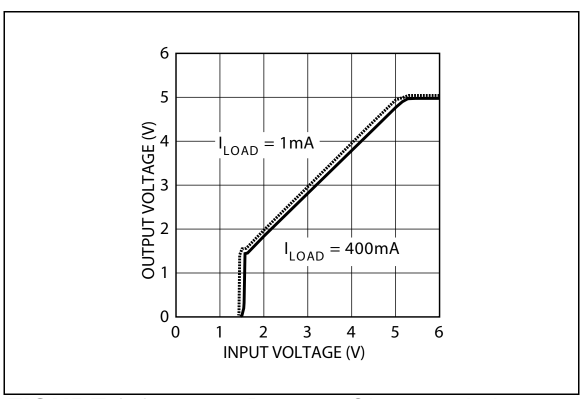



***FIGURE 2-3:*** *Dropout Characteristics.*

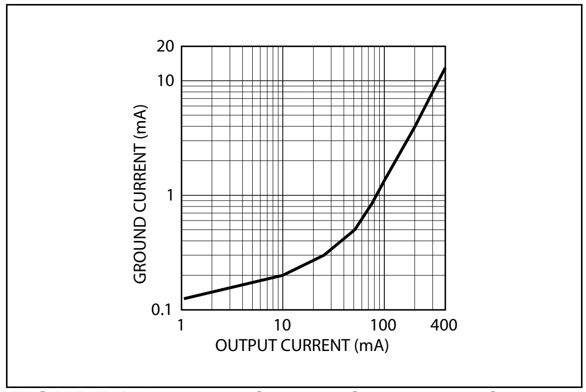



***FIGURE 2-4:*** *Ground Current vs. Output Current.*

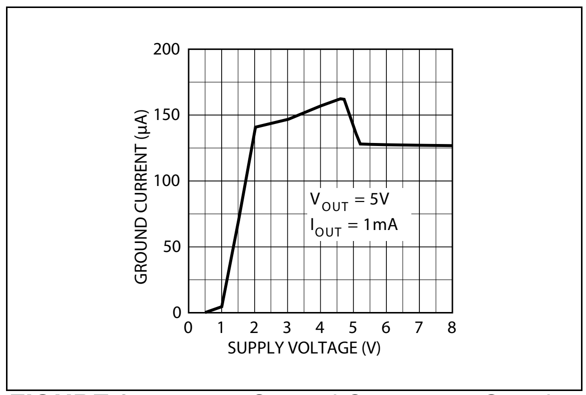



***FIGURE 2-5:*** *Ground Current vs. Supply Voltage.*

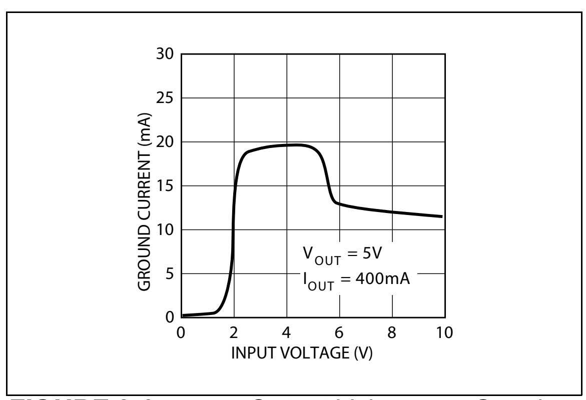



***FIGURE 2-6:*** *Output Voltage vs. Supply Voltage.*

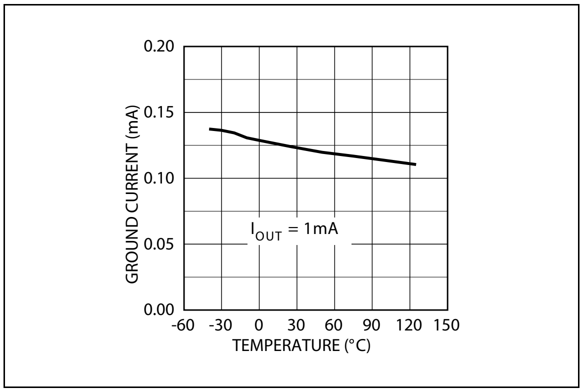



***FIGURE 2-7:*** *Ground Current vs. Temperature.*

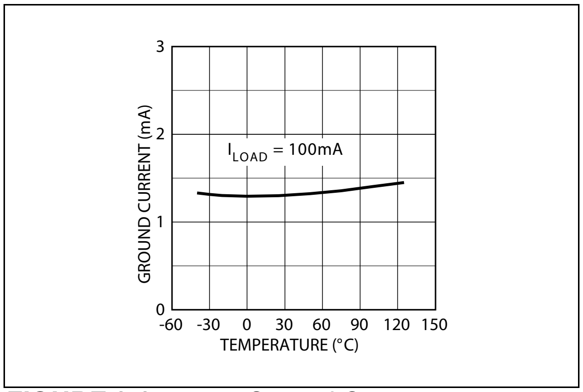



***FIGURE 2-8:*** *Ground Current vs. Temperature.*

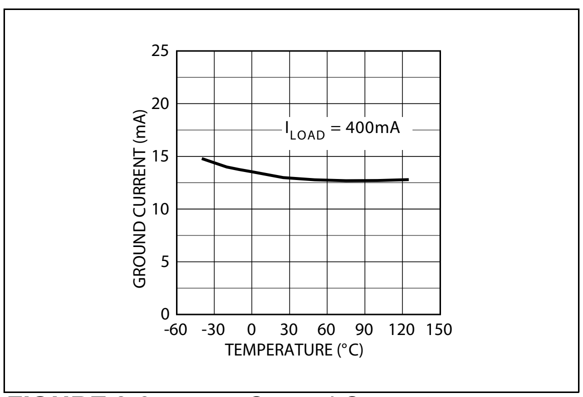



***FIGURE 2-9:*** *Ground Current vs. Temperature.*

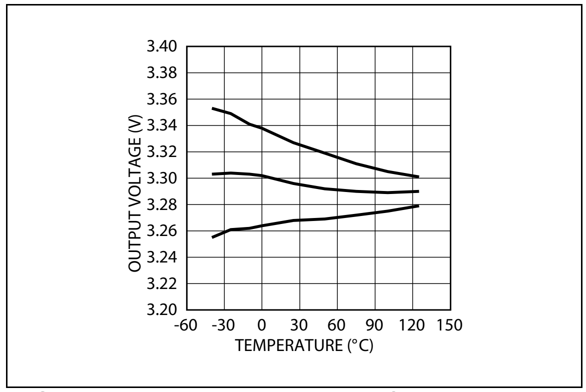



***FIGURE 2-10:*** *Fixed 3.3V Output Voltage vs. Temperature.*

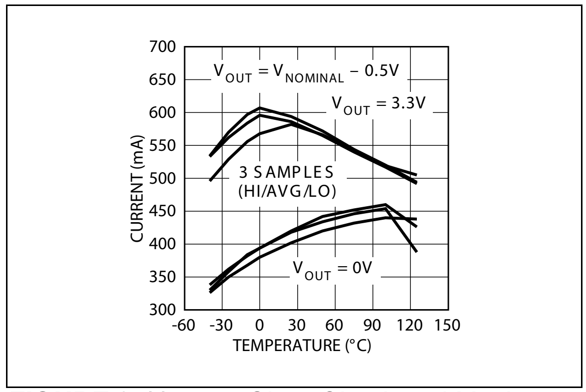



***FIGURE 2-11:*** *Short Circuit and Maximum Current vs. Temperature.*

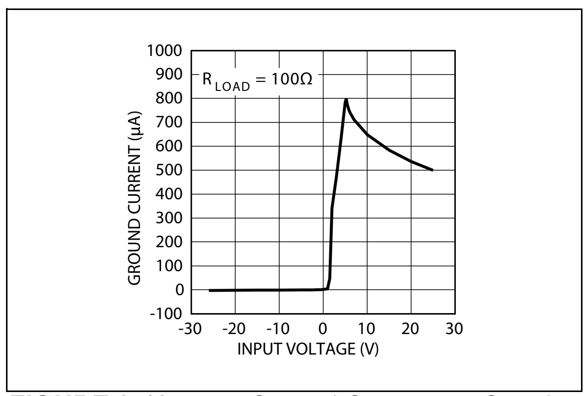



***FIGURE 2-12:*** *Ground Current vs. Supply Voltage.*

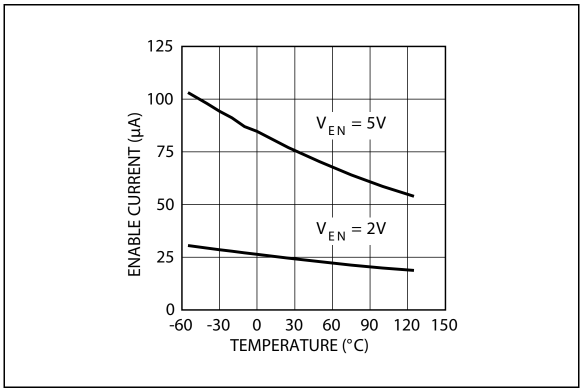



***FIGURE 2-13:*** *MIC29201/2 Shutdown Current vs. Temperature.*

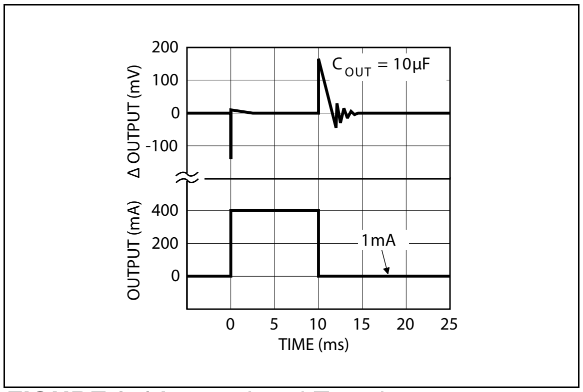



***FIGURE 2-14:*** *Load Transient.*

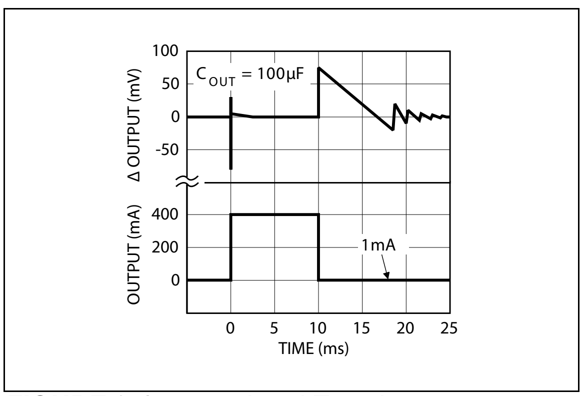



***FIGURE 2-15:*** *Load Transient.*

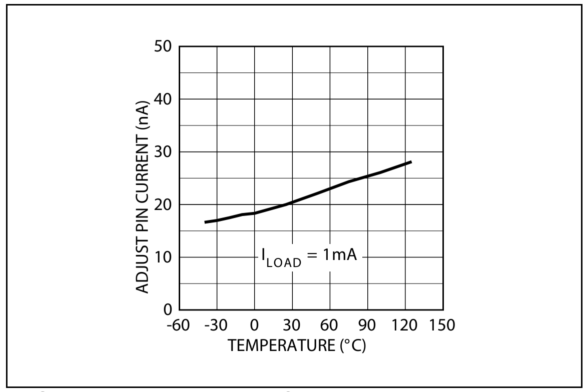



***FIGURE 2-16:*** *MIC29202 Adjust Pin Current vs. Temperature.*

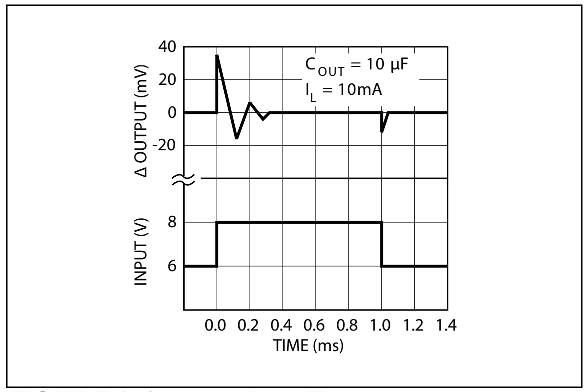



***FIGURE 2-17:*** *Line Transient.*

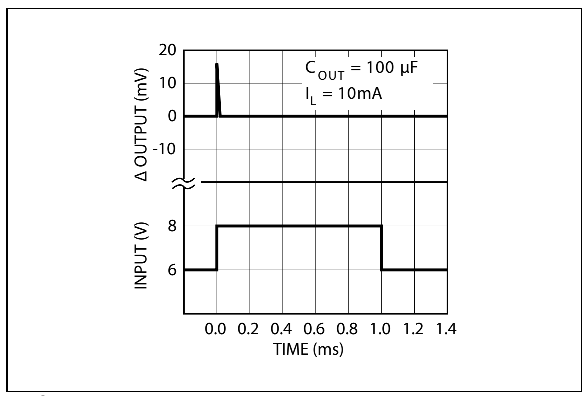



***FIGURE 2-18:*** *Line Transient.*

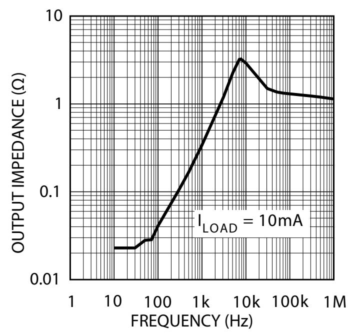



***FIGURE 2-19:*** *Output Impedance vs. Frequency.*

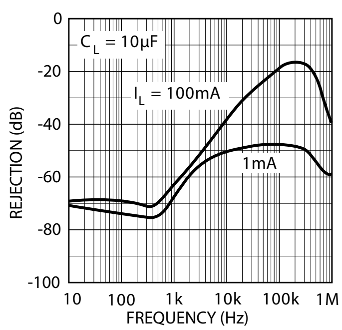



***FIGURE 2-20:*** *Ripple Rejection.*

## 3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1 through Table 3-4.

**TABLE 3-1: MIC2920A PIN FUNCTION TABLE**

| Pin Number SOT-223/TO-220 | Pin Name | Description |
|---|---|---|
| 1 | INPUT | Input Voltage Pin. $V_{IN}$ between 2V and 26V at +25°C and between 4.3V and 26V across the full operating temperature range. |
| 2 | GROUND | Ground Pin. |
| 3 | OUTPUT | Output Voltage Pin. Can be 3.3V, 4.85V, 5V, and 12V depending of the variant of MIC2920A-x.x. |

**TABLE 3-2: MIC29201 PIN FUNCTION TABLE**

| Pin Number Fixed SOIC-8 | Pin Number TO-220/TO-263 | Pin Name | Description |
|---|---|---|---|
| 1 | 4 | OUTPUT | Output Voltage Pin. Can be 3.3V, 4.85V, 5V, and 12V depending of the variant of MIC29201-x.x. |
| 2 | — | SENSE | Input Pin. Must be connected to $V_{OUT}$ (Pin 1) to ensure proper operation. The connection is not made internally. |
| 3 | 5 | SHUTDOWN | Shutdown Pin. Offers a logic-compatible ON/OFF input. |
| 4 | 3 | GROUND | Ground Pin. |
| 5 | 1 | $\overline{\text{ERROR}}$ | Error Pin. An output pin used as an error flag output. Can be used also as a power-on reset signal. |
| 6 | — | NC | Not connected. |
| 7 | — | NC | Not connected. |
| 8 | 2 | INPUT | Input Voltage Pin. $V_{IN}$ between 2V and 26V at +25°C and between 4.3V and 26V across the full operating temperature range. |

**TABLE 3-3: MIC29202 PIN FUNCTION TABLE**

| Pin Number TO-263-5 | Pin Number TO-220-5 | Pin Name | Description |
|---|---|---|---|
| 1 | 1 | ADJUST | ADJUST is an input pin used to set the output voltage $V_{OUT}$ from 1.24V to 26V using two external resistors. |
| 2 | 2 | SHUTDOWN | Shutdown Pin. Offers a logic-compatible ON/OFF input. |
| 3 | 3 | GROUND | Ground Pin. |
| 4 | 4 | INPUT | Input Voltage Pin. $V_{IN}$ between 2V and 26V at +25°C and between 4.3V and 26V across the full operating temperature range. |
| 5 | 5 | OUTPUT | Output Pin. Programmable from 1.24V to 26V using two external resistors. |

**TABLE 3-4: MIC29204 PIN FUNCTION TABLE**

| Pin Number Adj. SOIC-8 | Pin Name | Description |
|---|---|---|
| 1 | OUTPUT | Output Pin. Programmable from 1.24V to 26V using two external resistors. |
| 2 | SENSE | Input Pin. Must be connected to $V_{OUT}$ (Pin 1) to ensure proper operation. The connection is not made internally. It is used for connecting the internal resistor divider (which is not connected internally) necessary to set output to 5V by using 5V TAP (Pin 6). |
| 3 | SHUTDOWN | Shutdown Pin. Offers a logic-compatible ON/OFF input. |
| 4 | GROUND | Ground Pin. |
| 5 | $\overline{\text{ERROR}}$ | Error Pin. An output pin used as an error flag output. Can be used also as a power-on reset signal. |
| 6 | 5V TAP | Input pin used to set the output voltage to 5V by using internal resistor divider by tying Pin 1 (Output) to Pin 2 (Sense) and Pin 7 (Adjust) to Pin 6 (5V Tap). |
| 7 | ADJUST | ADJUST is an input pin used to set the output voltage $V_{OUT}$ from 1.24V to 26V using two external resistors. |
| 8 | INPUT | Input Voltage Pin. $V_{IN}$ between 2V and 26V at +25°C and between 4.3V and 26V across the full operating temperature range. |

# 4.0 APPLICATIONS INFORMATION

## 4.1 External Capacitors

A 10 µF (or greater) capacitor is required between the MIC2920A output and ground to prevent oscillations due to instability. Most types of tantalum or aluminum electrolytics will be adequate; film types will work, but are costly and therefore not recommended. Many aluminum electrolytics have electrolytes that freeze at about –30°C, so solid tantalums are recommended for operation below –25°C. The important parameters of the capacitor are an effective series resistance of about 5Ω or less and a resonant frequency above 500 kHz. The value of this capacitor may be increased without limit.

At lower values of output current, less output capacitance is required for output stability. The capacitor can be reduced to 2.2 µF for current below 10 mA or 1 µF for currents below 1 mA. Adjusting the MIC29202/29204 to voltages below 5V runs the error amplifier at lower gains so that more output capacitance is needed. For the worst-case situation of a 500 mA load at 1.23V output (Output shorted to Adjust) a 47 µF (or greater) capacitor should be used.

The MIC2920A/29201 will remain in regulation with a minimum load of 1 mA. When setting the output voltage of the MIC29202/29204 versions with external resistors, the current through these resistors may be included as a portion of the minimum load.

A 0.1 µF capacitor should be placed from the MIC2920A input to ground if there is more than 10 inches of wire between the input and the AC filter capacitor or if a battery is used as the input.

## 4.2 Error Detection Comparator Output (MIC29201/MIC29204)

A logic low output will be produced by the comparator whenever the MIC29201/29204 output falls out of regulation by more than approximately 5%. This figure is the comparator's built-in offset of about 75 mV divided by the 1.235V reference voltage. This trip level remains 5% below normal regardless of the programmed output voltage of the MIC29201/29204. For example, the error flag trip level is typically 4.75V for a 5V output or 11.4V for a 12V output. The out of regulation condition may be due either to low input voltage, extremely high input voltage, current limiting, or thermal limiting.

Figure 4-1 is a timing diagram depicting the $\overline{\text{ERROR}}$ signal and the regulated output voltage as the MIC29201/29204 input is ramped up and down. The $\overline{\text{ERROR}}$ signal becomes valid (low) at about 1.3V input. It goes high at about 5V input (the input voltage at which $V_{OUT}$ = 4.75). Because the MIC29201/29204's dropout voltage is load-dependent (see curve in Typical Performance Characteristics), the input voltage trip point (about 5V) will vary with the load current. The output voltage trip point (approximately 4.75V) does not vary with load.

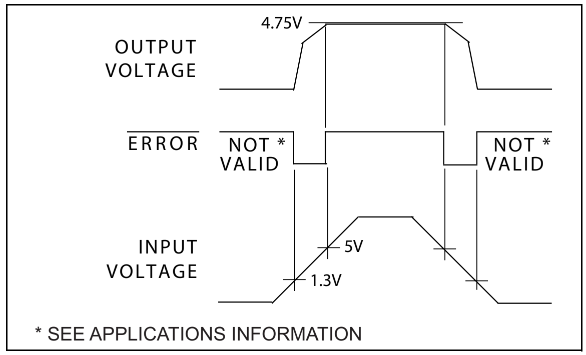



***FIGURE 4-1:*** *$\overline{\text{ERROR}}$ Output Timing.*

The error comparator has an NPN open-collector output that requires an external pull-up resistor. Depending on system requirements, this resistor may be returned to the 5V output or some other supply voltage. In determining a value for this resistor, note that while the output is rated to sink 250 µA, this sink current adds to battery drain in a low battery condition. Suggested values range from 100 kΩ to 1 MΩ. The resistor is not required if this output is unused.

## 4.3 Programming the Output Voltage (MIC29202/MIC29204)

The MIC29202/29204 may be programmed for any output voltage between its 1.235V reference and its 26V maximum rating, using an external pair of resistors, as shown in the Typical Application Circuits.

The complete equation for the output voltage is:

**EQUATION 4-1:**

$$V_{OUT} = V_{REF} \times \left(1 + \frac{R1}{R2}\right) - |I_{FB}| \times R1$$

Where:
$V_{REF}$ = The nominal 1.235V reference voltage.
$I_{FB}$ = The Adjust pin bias current, nominally 20 nA.

The minimum recommended load current of 1 µA forces an upper limit of 1.2 MΩ on the value of R2, if the regulator must work with no load (a condition often found in CMOS in standby), $I_{FB}$ will produce a –2% typical error in $V_{OUT}$ that may be eliminated at room temperature by trimming R1. For better accuracy, choosing R2 = 100 kΩ reduces this error to 0.17% while increasing the resistor program current to 12 µA. Because the MIC29202/29204 typically draws 110 µA at no load with SHUTDOWN open-circuited, this is a negligible addition. The MIC29204 may be pin-strapped for 5V using the internal voltage divider by tying Pin 1 (Output) to Pin 2 (Sense) and Pin 7 (Adjust) to Pin 6 (5V Tap).

## 4.4 Configuring the MIC29201-3.3YM

For the MIC29201-3.3YM, Output (Pin 1) and Sense (Pin 2), must be connected to ensure proper operation. They are not connected internally.

## 4.5 Reducing Output Noise

In reference applications, it may be advantageous to reduce the AC noise present at the output. One method is to reduce the regulator bandwidth by increasing the size of the output capacitor. This is relatively inefficient, as increasing the capacitor from 1 µF to 220 µF only decreases the noise from 430 $\mu V_{RMS}$ to 160 $\mu V_{RMS}$ for a 100 kHz bandwidth at 5V output. Noise can be reduced fourfold by a bypass capacitor across R1 because it reduces the high frequency gain from 4 to unity. Pick

**EQUATION 4-2:**

$$C_{BYPASS} = \frac{1}{2\pi R1 \times 200Hz}$$

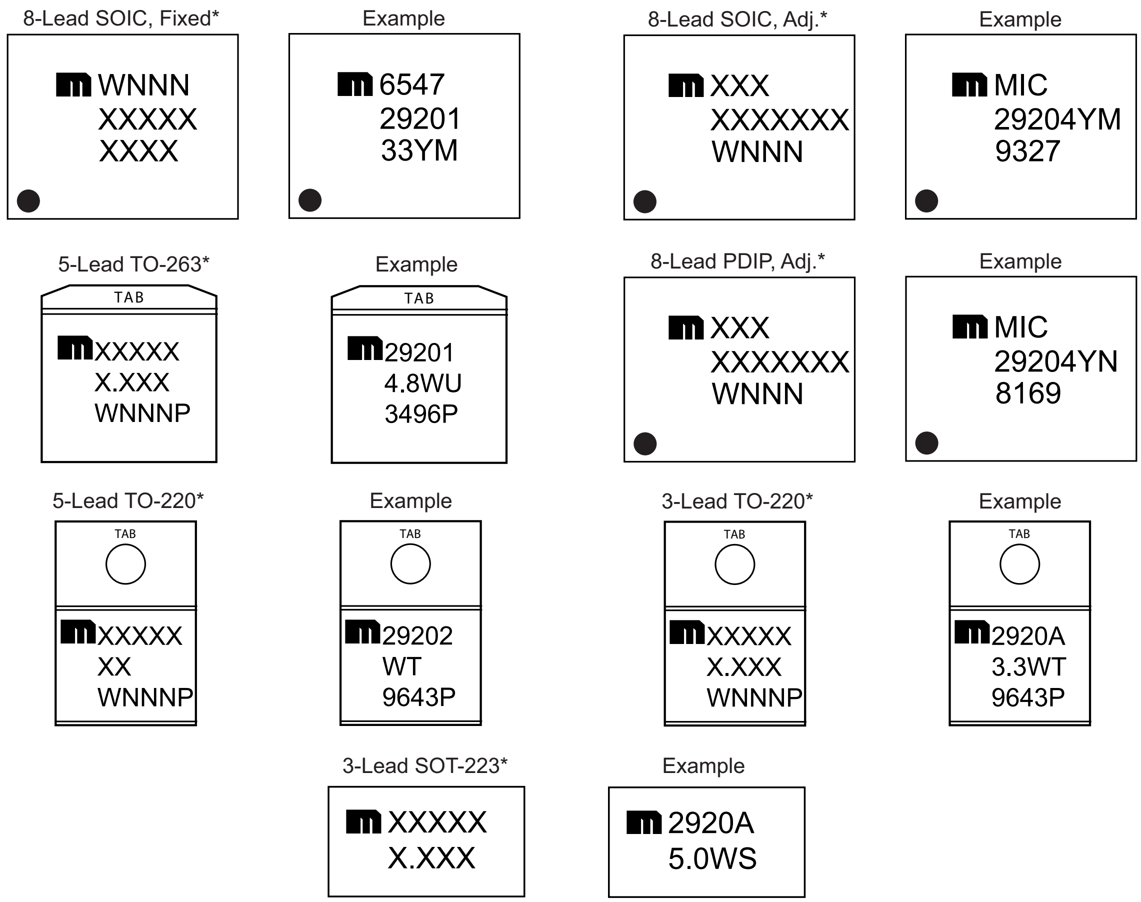
or about 0.01 µF. When doing this, the output capacitor must be increased to 10 µF to maintain stability. These changes reduce the output noise from 430 $\mu V_{RMS}$ to 100 $\mu V_{RMS}$ for a 100 kHz bandwidth at 5V output. With the bypass capacitor added, noise no longer scales with output voltage so that improvements are more dramatic at higher output voltages.

## 4.6 Automotive Applications

The MIC2920A is ideally suited for automotive applications for a variety of reasons. It will operate over a wide range of input voltages with very low dropout voltages (40 mV at light loads), and very low quiescent currents (100 µA typical). These features are necessary for use in battery-powered systems, such as automobiles. It is a robust device with the ability to survive both reverse battery (negative transients up to 20V below ground), and load dump (positive transients up to 60V) conditions. A wide operating temperature range with low temperature coefficients is yet another reason to use these versatile regulators in automotive designs.

# 5.0 PACKAGING INFORMATION

## 5.1 Package Marking Information




Some of the examples above have both fixed and adjustable versions. For the full list of fixed and adjustable options for these parts, be sure to see the Product Identification System.

| | | |
|---|---|---|
| **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). |

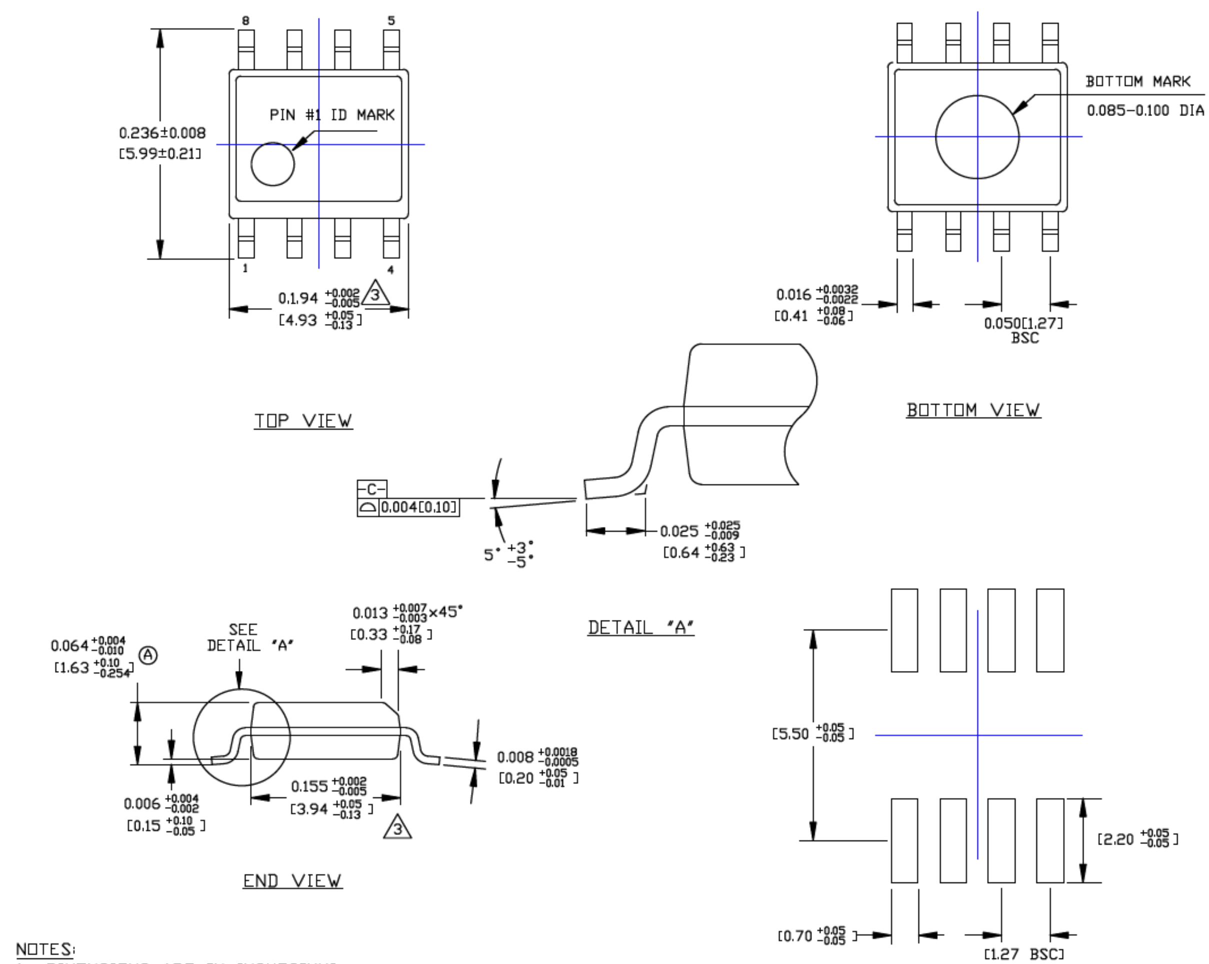
**Note:** In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

Underbar (_) and/or Overbar (‾) symbol may not be to scale.

## 8-Lead SOIC Package Outline and Recommended Land Pattern

**TITLE**
8 LEAD SOICN PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

| **DRAWING #** | SOICN-8LD-PL-1 | **UNIT** | INCH [MM] |
|---|---|---|---|



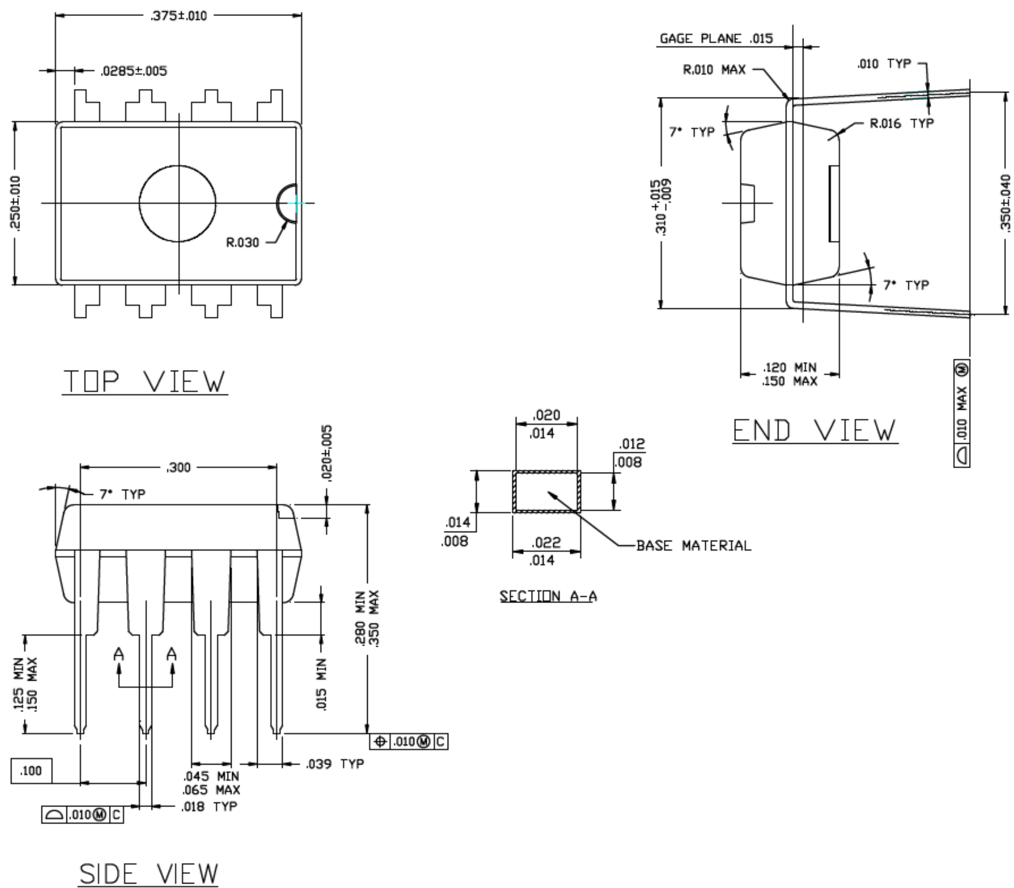

NOTES:
1. DIMENSIONS ARE IN INCHES[MM].
2. CONTROLLING DIMENSION: INCHES.
3. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS, EITHER OF WHICH SHALL NOT EXCEED 0.010[0.25] PER SIDE.

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

## 8-Lead PDIP Package Outline and Recommended Land Pattern

**TITLE**
8 LEAD PDIP PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

| | | | |
|---|---|---|---|
| **DRAWING #** | PDIP-8LD-PL-1 | **UNIT** | INCH |
| **Lead Frame** | Copper | **Lead Finish** | Matte Tin |

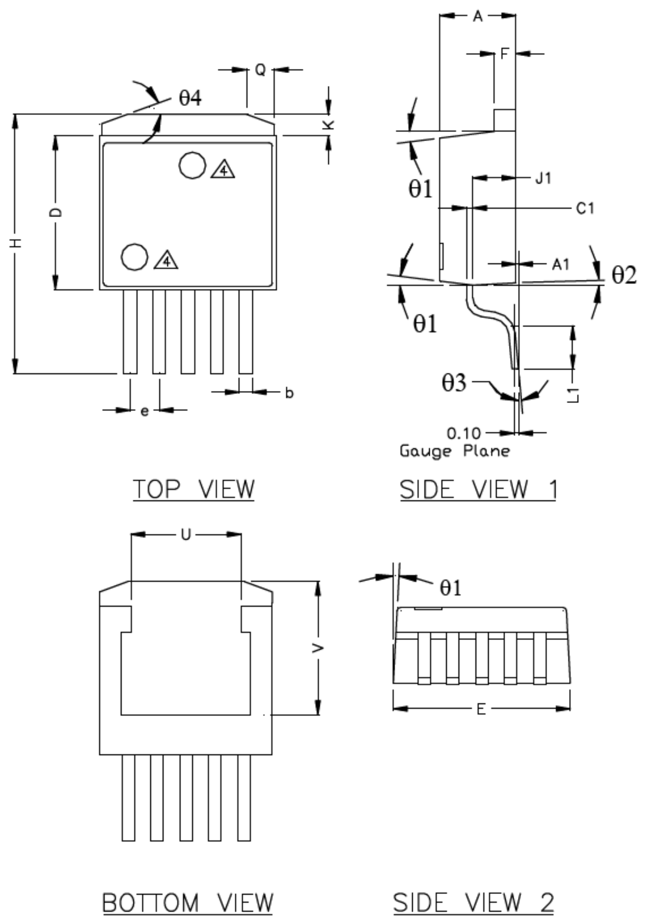



| Note: | For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging. |
|---|---|

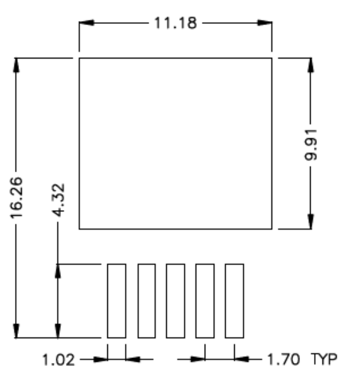
## 5-Lead TO-263 Package Outline and Recommended Land Pattern

**TITLE**
5 LEAD T0263 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

| DRAWING # | T0263-5LD-PL-1 | UNIT | INCH/MM |
|---|---|---|---|




| POS | INCH | | MM | |
|---|---|---|---|---|
| | MIN | MAX | MIN | MAX |
| A | 0.170 | 0.181 | 4.318 | 4.597 |
| A1 | 0.000 | 0.012 | 0.000 | 0.305 |
| b | 0.026 | 0.036 | 0.660 | 0.914 |
| C1 | 0.012 | 0.023 | 0.305 | 0.584 |
| D | 0.330 | 0.361 | 8.392 | 9.169 |
| E | 0.396 | 0.420 | 10.058 | 10.668 |
| e | 0.062 | 0.072 | 1.575 | 1.829 |
| F | 0.045 | 0.055 | 1.143 | 1.397 |
| H | 0.575 | 0.625 | 14.605 | 15.875 |
| J1 | 0.080 | 0.120 | 2.032 | 3.048 |
| K | 0.045 | 0.066 | 1.143 | 1.676 |
| L1 | 0.090 | 0.110 | 2.286 | 2.794 |
| θ1 | 3° | 10° | 3° | 10° |
| θ2 | 1° | 7° | 1° | 7° |
| θ3 | 0° | 8° | 0° | 8° |
| θ4 | 18° | 22° | 18° | 22° |
| Q | 0.055 | 0.075 | 1.397 | 1.905 |
| U | 0.256 Ref. | | 6.502 Ref. | |
| V | 0.305 Ref. | | 7.747 Ref. | |




RECOMMENDED LAND PATTERN
(UNIT : mm)

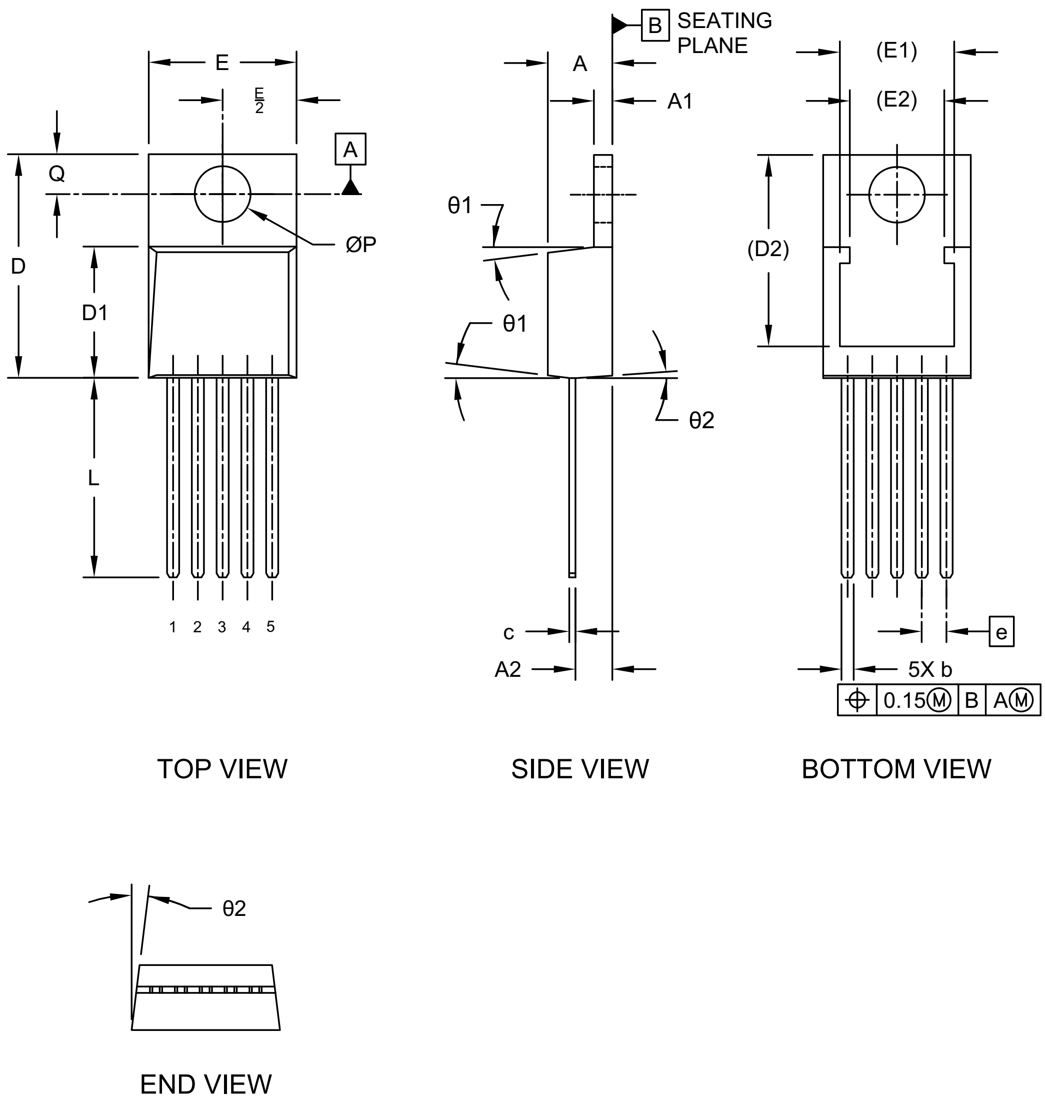
NOTE:
1. PACKAGE OUTLINE EXCLUSIVE OF MOLD FLASH & METAL BURR.
2. PACKAGE OUTLINE INCLUSIVE OF PLATING THICKNESS.
3. FOOT LENGTH USING GAUGE PLANE METHOD MEASUREMENT 0.010"
4. PACKAGE TOP MARK MAY BE IN TOP CENTER OR LOWER LEFT CORNER
5. ALL DIMENSIONS ARE IN INCHES/MILLIMETERS.

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

## 5-Lead TO-220 Package Outline and Recommended Land Pattern

**5-Lead Transistor Outline Type LB03 (B8X) - [TO-220]**
**Micrel Legacy Package TO220-LB03-5LD-PL-1**

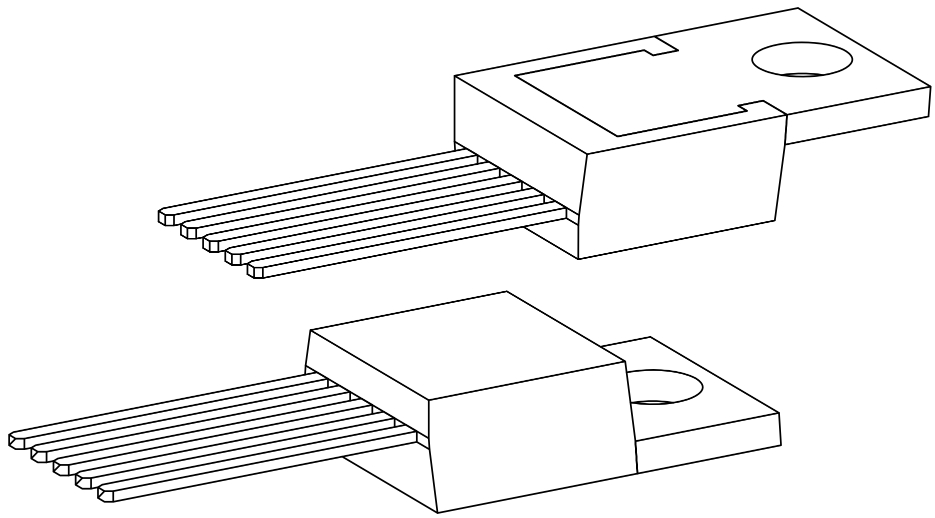
| **Note:** | For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging |
|---|---|




Microchip Technology Drawing C04-036 Rev D Sheet 1 of 2

**5-Lead Transistor Outline Type LB03 (B8X) - [TO-220]**
**Micrel Legacy Package TO220-LB03-5LD-PL-1**

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



| | | INCHES | | |
|---|---|---|---|---|
| Dimension Limits | | Min | Nom | Max |
| Number of Leads | N | 5 | | |
| Pitch | e | .067 BSC | | |
| Overall Height | A | .160 | .175 | .190 |
| Tab Height | A1 | .045 | .050 | .055 |
| Seating Plane to Lead | A2 | .080 | .098 | .115 |
| Lead Width | b | .025 | .033 | .040 |
| Lead Thickness | c | .012 | .016 | .020 |
| Lead Length | L | .500 | .540 | .580 |
| Total Body Length Including Tab | D | .542 | .580 | .619 |
| Molded Body Length | D1 | .348 | .354 | .360 |
| Total Width | E | .380 | .400 | .420 |
| Pad Width | E1 | 0.256 REF | | |
| Pad Length | D2 | 0.486 REF | | |
| Hole Diameter | ØP | .146 | .151 | .156 |
| Hole Center to Tab Edge | Q | .103 | .108 | .113 |
| Molded Body Draft Angle | θ1 | 3 | 7 | 10 |
| Molded Body Draft Angle | θ2 | 1 | 4 | 7 |

Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.
   REF: Reference Dimension, usually without tolerance, for information purposes only.

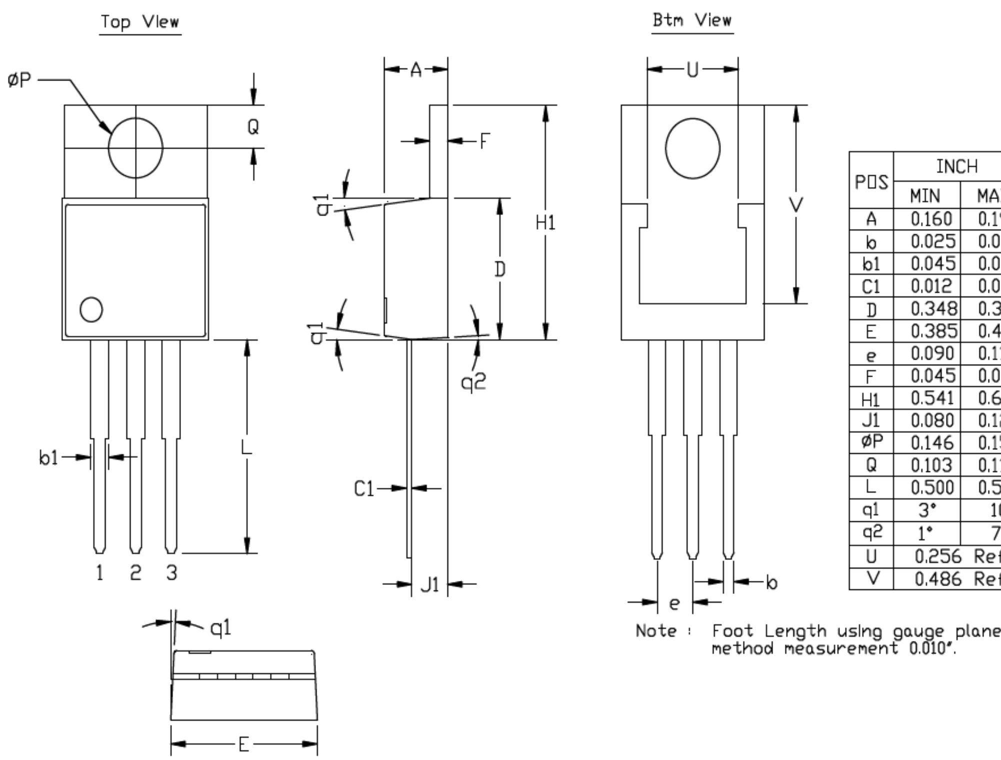
Microchip Technology Drawing C04-036 Rev D Sheet 2 of 2

## 3-Lead TO-220 Package Outline and Recommended Land Pattern

**TITLE**
3 LEAD TO220 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

| **DRAWING #** | TO220-3LD-PL-1 | **UNIT** | INCH |
|---|---|---|---|
| **Lead Frame** | Copper Alloy | **Lead Finish** | Matte Tin |



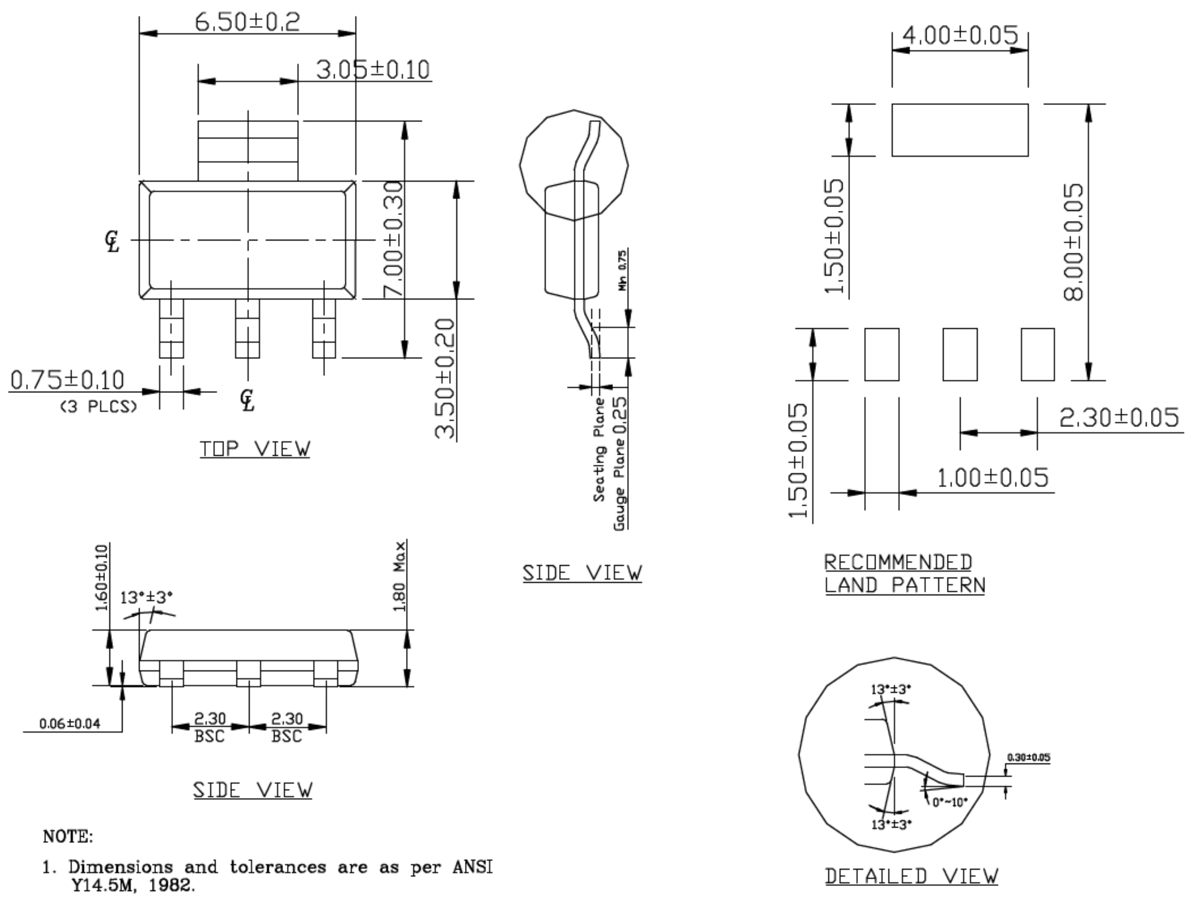

| POS | INCH | |
|---|---|---|
| | MIN | MAX |
| A | 0.160 | 0.190 |
| b | 0.025 | 0.040 |
| b1 | 0.045 | 0.060 |
| C1 | 0.012 | 0.022 |
| D | 0.348 | 0.360 |
| E | 0.385 | 0.420 |
| e | 0.090 | 0.110 |
| F | 0.045 | 0.055 |
| H1 | 0.541 | 0.619 |
| J1 | 0.080 | 0.120 |
| øP | 0.146 | 0.156 |
| Q | 0.103 | 0.113 |
| L | 0.500 | 0.580 |
| q1 | 3° | 10° |
| q2 | 1° | 7° |
| U | 0.256 Ref. | |
| V | 0.486 Ref. | |

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

## 3-Lead SOT-223 Package Outline and Recommended Land Pattern

**TITLE**
3 LEAD SOT223 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

| **DRAWING #** | SOT223-3LD-PL-1 | **UNIT** | MM |
|---|---|---|---|




NOTE:

1. Dimensions and tolerances are as per ANSI Y14.5M, 1982.
2. Controlling dimension: Millimeters.
3. Dimensions are exclusive of mold flash and gate burr.
4. All specification comply to Jedec spec TO261 Issue C.

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

# APPENDIX A: REVISION HISTORY

## Revision A (October 2021)

- Converted Micrel document MIC2920x to Microchip data sheet DS20006601A.
- Minor text changes throughout.
- Removed all reference to discontinued leaded parts.

**NOTES:**

## PRODUCT IDENTIFICATION SYSTEM

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

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

| | | |
|---|---|---|
| **Device:** | MIC2920A: | 400 mA Low Dropout Voltage Regulator |
| | MIC29201: | 400 mA Low Dropout Voltage Regulator with Logic-Compatible Shutdown & Error Flag |
| | MIC29202: | 400 mA Low Dropout Voltage Regulator with Logic-Compatible Shutdown |
| | MIC29204: | 400 mA Low Dropout Voltage Regulator with Logic-Compatible Shutdown & Error Flag |
| **Output Voltage:** | (blank) = | Adjustable (MIC29202 & MIC29204 only) |
| | 3.3 = | 3.3V |
| | 4.8 = | 4.85V |
| | 5.0 = | 5.0V |
| | 12 = | 12V |
| **Junction Temperature Range:** | W = | –40°C to +125°C |
| | Y = | –40°C to +125°C |
| **Package:** | M = | 8-Lead SOIC |
| | N = | 8-Lead PDIP |
| | S = | 3-Lead SOT-223 |
| | T = | 3- or 5-Lead TO-220 |
| | U = | 5-Lead TO-263 |
| **Media Type:** | (blank)= | 50/Tube (TO-220, TO-263, & PDIP options) |
| | (blank)= | 78/Tube (SOT-223 option) |
| | (blank)= | 95/Tube (SOIC option) |
| | TR = | 750/Reel (TO-263 option) |
| | TR = | 2,500/Reel (SOT-223, SOIC, & PDIP options) |

**Examples:**

a) MIC2920A-4.8WT: 400 mA Low Dropout Regulator 4.85V Output Voltage, –40°C to +125°C Temp. Range, 3-Lead TO-220, 50/Tube

b) MIC29201-3.3YM-TR: 400 mA Low Dropout Regulator 3.3V Output Voltage, –40°C to +125°C Temp. Range, 8-Lead SOIC, 2,500/Reel

c) MIC29202WU: 400 mA Low Dropout Regulator Adjustable Output Voltage, –40°C to +125°C Temp. Range, 5-Lead TO-263, 50/Tube

d) MIC29204YN-TR: 400 mA Low Dropout Regulator Adjustable Output Voltage, –40°C to +125°C Temp. Range, 8-Lead PDIP, 2,500/Reel

e) MIC2920A-12WS-TR: 400 mA Low Dropout Regulator 12V Output Voltage, –40°C to +125°C Temp. Range, 3-Lead SOT-223, 2,500/Reel

f) MIC29201-5.0WT: 400 mA Low Dropout Regulator 5.0V Output Voltage, –40°C to +125°C Temp. Range, 5-Lead TO-220, 50/Tube

g) MIC29202WU-TR: 400 mA Low Dropout Regulator Adjustable Output Voltage, –40°C to +125°C Temp. Range, 5-Lead TO-263, 750/Reel

h) MIC29204YM: 400 mA Low Dropout Regulator Adjustable Output Voltage, –40°C to +125°C Temp. Range, 8-Lead SOIC, 95/Tube

**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.

**NOTES:**

**Note the following details of the code protection feature on Microchip products:**

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
- Microchip values and aggressively protects its intellectual property rights. Attempts to breach the code protection features of Microchip product is strictly prohibited and may violate the Digital Millennium Copyright Act.
- Neither Microchip nor any other semiconductor manufacturer can guarantee the security of its code. Code protection does not mean that we are guaranteeing the product is “unbreakable”. Code protection is constantly evolving. Microchip is committed to continuously improving the code protection features of our products.

This publication and the information herein may be used only with Microchip products, including to design, test, and integrate Microchip products with your application. Use of this information in any other manner violates these terms. Information regarding device applications is provided only for your convenience and may be superseded by updates. It is your responsibility to ensure that your application meets with your specifications. Contact your local Microchip sales office for additional support or, obtain additional support at https://www.microchip.com/en-us/support/design-help/client-support-services.

THIS INFORMATION IS PROVIDED BY MICROCHIP "AS IS". MICROCHIP MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND WHETHER EXPRESS OR IMPLIED, WRITTEN OR ORAL, STATUTORY OR OTHERWISE, RELATED TO THE INFORMATION INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF NON-INFRINGEMENT, MERCHANTABILITY, AND FITNESS FOR A PARTICULAR PURPOSE, OR WARRANTIES RELATED TO ITS CONDITION, QUALITY, OR PERFORMANCE.

IN NO EVENT WILL MICROCHIP BE LIABLE FOR ANY INDIRECT, SPECIAL, PUNITIVE, INCIDENTAL, OR CONSEQUENTIAL LOSS, DAMAGE, COST, OR EXPENSE OF ANY KIND WHATSOEVER RELATED TO THE INFORMATION OR ITS USE, HOWEVER CAUSED, EVEN IF MICROCHIP HAS BEEN ADVISED OF THE POSSIBILITY OR THE DAMAGES ARE FORESEEABLE. TO THE FULLEST EXTENT ALLOWED BY LAW, MICROCHIP'S TOTAL LIABILITY ON ALL CLAIMS IN ANY WAY RELATED TO THE INFORMATION OR ITS USE WILL NOT EXCEED THE AMOUNT OF FEES, IF ANY, THAT YOU HAVE PAID DIRECTLY TO MICROCHIP FOR THE INFORMATION.

Use of Microchip devices in life support and/or safety applications is entirely at the buyer's risk, and the buyer agrees to defend, indemnify and hold harmless Microchip from any and all damages, claims, suits, or expenses resulting from such use. No licenses are conveyed, implicitly or otherwise, under any Microchip intellectual property rights unless otherwise stated.

*For information regarding Microchip’s Quality Management Systems, please visit www.microchip.com/quality.*

**Trademarks**

The Microchip name and logo, the Microchip logo, Adaptec, AnyRate, AVR, AVR logo, AVR Freaks, BesTime, BitCloud, CryptoMemory, CryptoRF, dsPIC, flexPWR, HELDO, IGLOO, JukeBlox, KeeLoq, Kleer, LANCheck, LinkMD, maXStylus, maXTouch, MediaLB, megaAVR, Microsemi, Microsemi logo, MOST, MOST logo, MPLAB, OptoLyzer, PIC, picoPower, PICSTART, PIC32 logo, PolarFire, Prochip Designer, QTouch, SAM-BA, SenGenuity, SpyNIC, SST, SST Logo, SuperFlash, Symmetricom, SyncServer, Tachyon, TimeSource, tinyAVR, UNI/O, Vectron, and XMEGA are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

AgileSwitch, APT, ClockWorks, The Embedded Control Solutions Company, EtherSynch, Flashtec, Hyper Speed Control, HyperLight Load, IntelliMOS, Libero, motorBench, mTouch, Powermite 3, Precision Edge, ProASIC, ProASIC Plus, ProASIC Plus logo, Quiet-Wire, SmartFusion, SyncWorld, Temux, TimeCesium, TimeHub, TimePictra, TimeProvider, TrueTime, WinPath, and ZL are registered trademarks of Microchip Technology Incorporated in the U.S.A.

Adjacent Key Suppression, AKS, Analog-for-the-Digital Age, Any Capacitor, AnyIn, AnyOut, Augmented Switching, BlueSky, BodyCom, CodeGuard, CryptoAuthentication, CryptoAutomotive, CryptoCompanion, CryptoController, dsPICDEM, dsPICDEM.net, Dynamic Average Matching, DAM, ECAN, Espresso T1S, EtherGREEN, GridTime, IdealBridge, In-Circuit Serial Programming, ICSP, INICnet, Intelligent Paralleling, Inter-Chip Connectivity, JitterBlocker, Knob-on-Display, maxCrypto, maxView, memBrain, Mindi, MiWi, MPASM, MPF, MPLAB Certified logo, MPLIB, MPLINK, MultiTRAK, NetDetach, NVM Express, NVMe, Omniscient Code Generation, PICDEM, PICDEM.net, PICkit, PICtail, PowerSmart, PureSilicon, QMatrix, REAL ICE, Ripple Blocker, RTAX, RTG4, SAM-ICE, Serial Quad I/O, simpleMAP, SimpliPHY, SmartBuffer, SmartHLS, SMART-I.S., storClad, SQI, SuperSwitcher, SuperSwitcher II, Switchtec, SynchroPHY, Total Endurance, TSHARC, USBCheck, VariSense, VectorBlox, VeriPHY, ViewSpan, WiperLock, XpressConnect, and ZENA are trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.

SQTP is a service mark of Microchip Technology Incorporated in the U.S.A.

The Adaptec logo, Frequency on Demand, Silicon Storage Technology, Symmcom, and Trusted Time are registered trademarks of Microchip Technology Inc. in other countries.

GestIC is a registered trademark of Microchip Technology Germany II GmbH & Co. KG, a subsidiary of Microchip Technology Inc., in other countries.

All other trademarks mentioned herein are property of their respective companies.



ISBN: 978-1-5224-9209-2

# Worldwide Sales and Service

## AMERICAS

**Corporate Office**
2355 West Chandler Blvd.
Chandler, AZ 85224-6199
Tel: 480-792-7200
Fax: 480-792-7277
Technical Support:
http://www.microchip.com/support
Web Address:
www.microchip.com

**Atlanta**
Duluth, GA
Tel: 678-957-9614
Fax: 678-957-1455

**Austin, TX**
Tel: 512-257-3370

**Boston**
Westborough, MA
Tel: 774-760-0087
Fax: 774-760-0088

**Chicago**
Itasca, IL
Tel: 630-285-0071
Fax: 630-285-0075

**Dallas**
Addison, TX
Tel: 972-818-7423
Fax: 972-818-2924

**Detroit**
Novi, MI
Tel: 248-848-4000

**Houston, TX**
Tel: 281-894-5983

**Indianapolis**
Noblesville, IN
Tel: 317-773-8323
Fax: 317-773-5453
Tel: 317-536-2380

**Los Angeles**
Mission Viejo, CA
Tel: 949-462-9523
Fax: 949-462-9608
Tel: 951-273-7800

**Raleigh, NC**
Tel: 919-844-7510

**New York, NY**
Tel: 631-435-6000

**San Jose, CA**
Tel: 408-735-9110
Tel: 408-436-4270

**Canada - Toronto**
Tel: 905-695-1980
Fax: 905-695-2078

## ASIA/PACIFIC

**Australia - Sydney**
Tel: 61-2-9868-6733

**China - Beijing**
Tel: 86-10-8569-7000

**China - Chengdu**
Tel: 86-28-8665-5511

**China - Chongqing**
Tel: 86-23-8980-9588

**China - Dongguan**
Tel: 86-769-8702-9880

**China - Guangzhou**
Tel: 86-20-8755-8029

**China - Hangzhou**
Tel: 86-571-8792-8115

**China - Hong Kong SAR**
Tel: 852-2943-5100

**China - Nanjing**
Tel: 86-25-8473-2460

**China - Qingdao**
Tel: 86-532-8502-7355

**China - Shanghai**
Tel: 86-21-3326-8000

**China - Shenyang**
Tel: 86-24-2334-2829

**China - Shenzhen**
Tel: 86-755-8864-2200

**China - Suzhou**
Tel: 86-186-6233-1526

**China - Wuhan**
Tel: 86-27-5980-5300

**China - Xian**
Tel: 86-29-8833-7252

**China - Xiamen**
Tel: 86-592-2388138

**China - Zhuhai**
Tel: 86-756-3210040

## ASIA/PACIFIC

**India - Bangalore**
Tel: 91-80-3090-4444

**India - New Delhi**
Tel: 91-11-4160-8631

**India - Pune**
Tel: 91-20-4121-0141

**Japan - Osaka**
Tel: 81-6-6152-7160

**Japan - Tokyo**
Tel: 81-3-6880- 3770

**Korea - Daegu**
Tel: 82-53-744-4301

**Korea - Seoul**
Tel: 82-2-554-7200

**Malaysia - Kuala Lumpur**
Tel: 60-3-7651-7906

**Malaysia - Penang**
Tel: 60-4-227-8870

**Philippines - Manila**
Tel: 63-2-634-9065

**Singapore**
Tel: 65-6334-8870

**Taiwan - Hsin Chu**
Tel: 886-3-577-8366

**Taiwan - Kaohsiung**
Tel: 886-7-213-7830

**Taiwan - Taipei**
Tel: 886-2-2508-8600

**Thailand - Bangkok**
Tel: 66-2-694-1351

**Vietnam - Ho Chi Minh**
Tel: 84-28-5448-2100

## EUROPE

**Austria - Wels**
Tel: 43-7242-2244-39
Fax: 43-7242-2244-393

**Denmark - Copenhagen**
Tel: 45-4485-5910
Fax: 45-4485-2829

**Finland - Espoo**
Tel: 358-9-4520-820

**France - Paris**
Tel: 33-1-69-53-63-20
Fax: 33-1-69-30-90-79

**Germany - Garching**
Tel: 49-8931-9700

**Germany - Haan**
Tel: 49-2129-3766400

**Germany - Heilbronn**
Tel: 49-7131-72400

**Germany - Karlsruhe**
Tel: 49-721-625370

**Germany - Munich**
Tel: 49-89-627-144-0
Fax: 49-89-627-144-44

**Germany - Rosenheim**
Tel: 49-8031-354-560

**Israel - Ra'anana**
Tel: 972-9-744-7705

**Italy - Milan**
Tel: 39-0331-742611
Fax: 39-0331-466781

**Italy - Padova**
Tel: 39-049-7625286

**Netherlands - Drunen**
Tel: 31-416-690399
Fax: 31-416-690340

**Norway - Trondheim**
Tel: 47-7288-4388

**Poland - Warsaw**
Tel: 48-22-3325737

**Romania - Bucharest**
Tel: 40-21-407-87-50

**Spain - Madrid**
Tel: 34-91-708-08-90
Fax: 34-91-708-08-91

**Sweden - Gothenberg**
Tel: 46-31-704-60-40

**Sweden - Stockholm**
Tel: 46-8-5090-4654

**UK - Wokingham**
Tel: 44-118-921-5800
Fax: 44-118-921-5820