

3A, Low Voltage μ Cap LDO Regulator

Features

- 3A Minimum Ensured Output Current
- 600 mV Maximum Dropout Voltage over Temperature
 - Ideal for 3.0V to 2.5V Conversion
 - Ideal for 2.5V to 1.8V, 1.65V, or 1.5V Conversion
- Stable with Ceramic or Tantalum Capacitor
- Wide Input Voltage Range
 - V_{IN} : 2.25V to 6.0V
- $\pm 1.0\%$ Initial Output Tolerance
- Excellent Line and Load Regulation Specifications
- Logic-Controlled Shutdown
- Thermal Shutdown and Current Limit Protection
- Reverse Leakage Protection
- -40°C to $+125^{\circ}\text{C}$ Junction Temperature
- Power D-Pak Package (TO-252)

Applications

- LDO Linear Regulator for Low-Voltage Digital IC
- PC Add-In Cards
- High Efficiency Linear Power Supplies
- SMPS Post Regulator
- Battery Charger

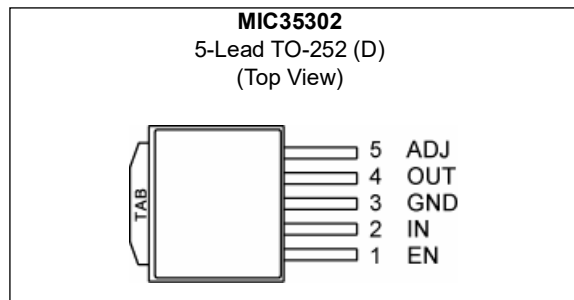
General Description

The MIC35302 is a 3A low-dropout linear voltage regulator that provides a low voltage, high current output with a minimum of external components. It offers high precision, ultra-low dropout (600 mV over temperature), and low ground current.

The MIC35302 operates from an input of 2.25V to 6.0V. It is designed to drive digital circuits that require low voltage at high currents (i.e., PLDs, DSPs, micro-controllers, etc.), providing an adjustable output voltage from 1.24V to 5.4V.

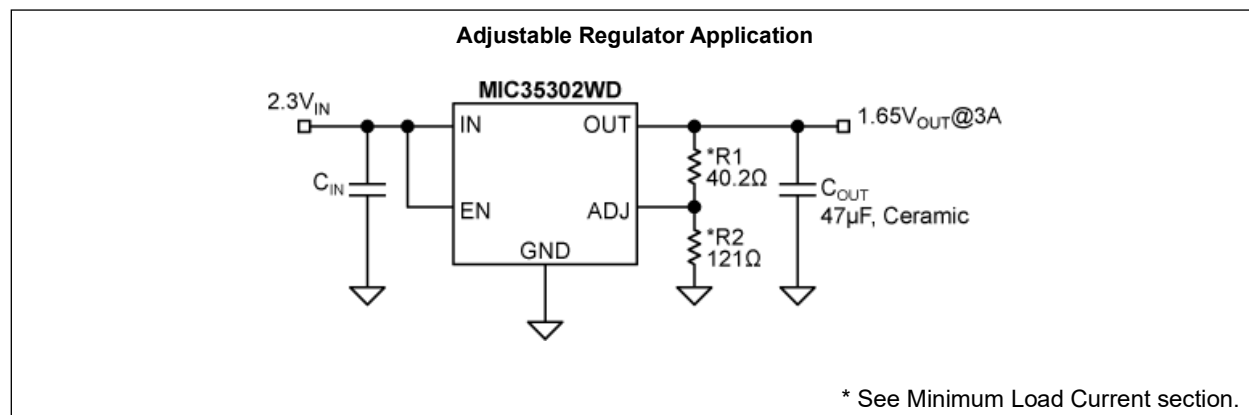
Features of the MIC35302 LDO include current limiting and thermal protection, as well as reverse current and reverse battery protection. Also a logic (active-high) enable pin is included. The MIC35302 is available in a 5-pin power D-Pak package (TO-252) with an operating temperature range of -40°C to $+125^{\circ}\text{C}$.

Package Type



MIC35302

Typical Application Circuit



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN})	–0.3V to +6.5V
Enable Input Voltage (V_{EN})	–0.3V to +6.5V
Power Dissipation	Internally Limited
ESD Rating (Note 1)	2 kV

Operating Ratings ‡

Supply Voltage (V_{IN})	+2.25V to +6.0V
Enable Input Voltage (V_{EN})	0V to +6.0V
Maximum Power Dissipation	Note 2

† **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: Device is ESD sensitive. Handling precautions are recommended. 200V Machine Model.

2: $P_{D(MAX)} = (T_{J(MAX)} - T_A)/\theta_{JA}$, where θ_{JA} depends upon the printed circuit layout. See the Applications Information section.

ELECTRICAL CHARACTERISTICS

$T_J = +25^\circ\text{C}$ with $V_{IN} = V_{EN} = V_{OUT} + 1\text{V}$; $I_{OUT} = 10\text{ mA}$; **Bold** values valid for $-40^\circ\text{C} < T_J < +125^\circ\text{C}$, unless otherwise noted. Note 1

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Line Regulation		—	0.02	0.5	%	$V_{IN} = V_{OUT} + 1.0V$ to 6.0V
Output Voltage Load Regulation		—	0.2	1	%	$I_{OUT} = 10\text{ mA}$ to 3A
Dropout Voltage (Note 2)	$V_{IN} - V_{OUT}$	—	250	450	mV	$I_{OUT} = 1.5A$
		—	370	600	mV	$I_{OUT} = 3A$
Ground Pin Current	I_{GND}	—	20	50	mA	Note 3, $I_{OUT} = 3A$
Ground Pin Current in Shutdown		—	1.0	—	μA	$V_{IL} \leq 0.5V$, $V_{IN} = V_{OUT} + 1V$
Current Limit	I_{LIM}	3.5	6	8.5	A	$V_{OUT} = 0V$
Start-Up Time	t_{SU}	—	35	150	μs	$V_{EN} = V_{IN}$, $I_{OUT} = 10\text{ mA}$, $C_{OUT} = 47\text{ }\mu F$
Enable Input						
Enable Input Threshold		2.25	—	—	V	Regulator enable
		—	—	0.8	V	Regulator shutdown
Enable Pin Input Current		—	—	4	μA	$V_{IL} \leq 0.8V$ (regulator shutdown)
		1	15	75	μA	$V_{IH} \geq 2.25V$ (regulator enabled)
Adjust Pin						
Reference Voltage	V_{REF}	1.228	1.240	1.252	V	—
		1.215	—	1.265	V	
Reference Voltage Temperature Coefficient		—	20	—	ppm/°C	Note 4

ELECTRICAL CHARACTERISTICS (CONTINUED)

$T_J = +25^\circ\text{C}$ with $V_{IN} = V_{EN} = V_{OUT} + 1\text{V}$; $I_{OUT} = 10\text{ mA}$; **Bold** values valid for $-40^\circ\text{C} < T_J < +125^\circ\text{C}$, unless otherwise noted. [Note 1](#)

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Adjust Pin Bias Current	I_{BIAS}	—	40	80	nA	—
		—	—	120		
Adjust Pin Bias Current Temperature Coefficient		—	0.1	—	nA/°C	—

Note 1: Specifications for packaged product only.

- 2: $V_{DO} = V_{IN} - V_{OUT}$ when V_{OUT} decreased to 98% of its nominal output voltage with $V_{IN} = V_{OUT} + 1\text{V}$. For output voltages below 1.75V, dropout voltage specification does not apply due to a minimum input operating voltage of 2.25V.
- 3: I_{GND} is the quiescent current. $I_{IN} = I_{GND} + I_{OUT}$.
- 4: 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 $V_{IN} = 6\text{V}$ for $t = 10\text{ ms}$.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Temperature Range	T_J	-40	—	+125	°C	—
Storage Temperature Range	T_S	-65	—	+150	°C	—
Lead Temperature	T_{LEAD}	—	—	260	°C	Soldering, 5 sec.
Package Thermal Resistances						
Thermal Resistance, TO-252 5-Ld	θ_{JC}	—	3	—	°C/W	—
	θ_{JA}	—	56	—	°C/W	—

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.

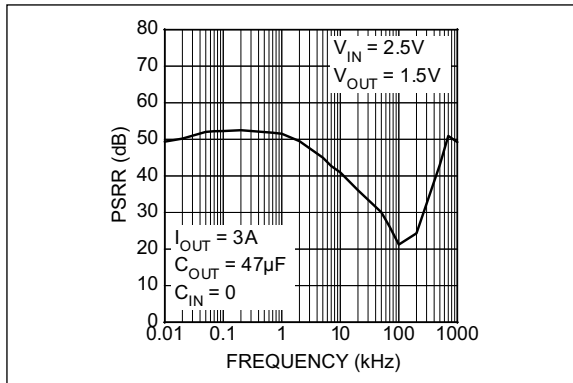


FIGURE 2-1: Power Supply Rejection Ratio.

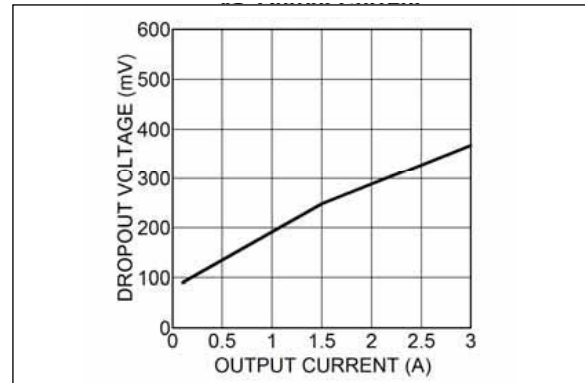


FIGURE 2-4: Dropout Voltage vs. Output Current.

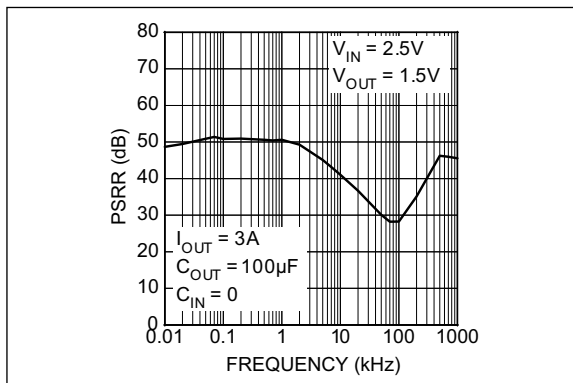


FIGURE 2-2: Power Supply Rejection Ratio.

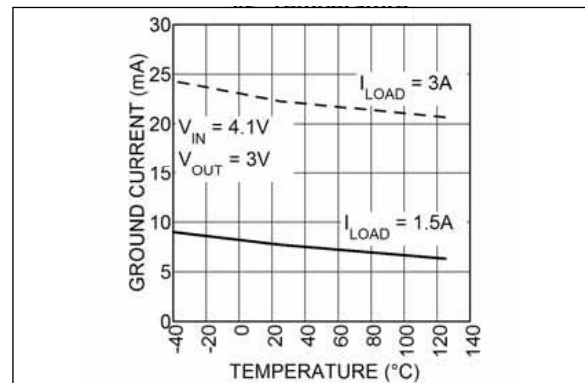


FIGURE 2-5: Ground Current vs. Temperature.

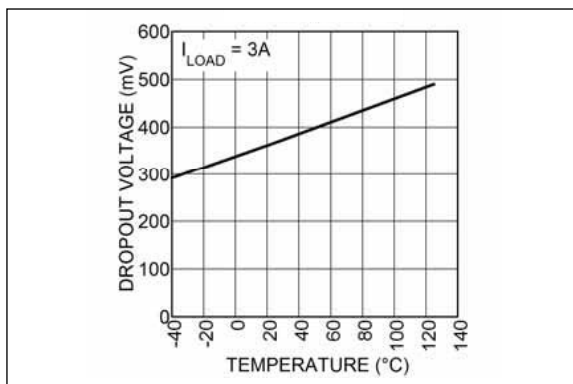


FIGURE 2-3: Dropout Voltage vs. Temperature.

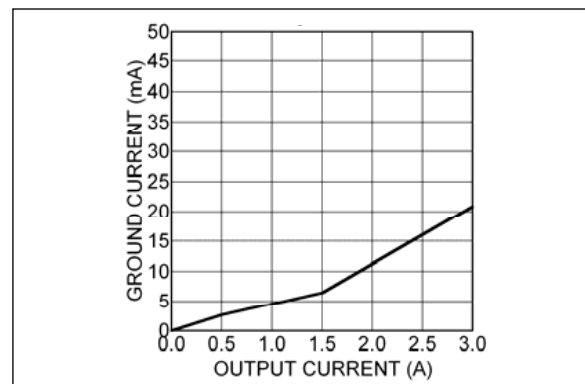


FIGURE 2-6: Ground Current vs. Output Current.

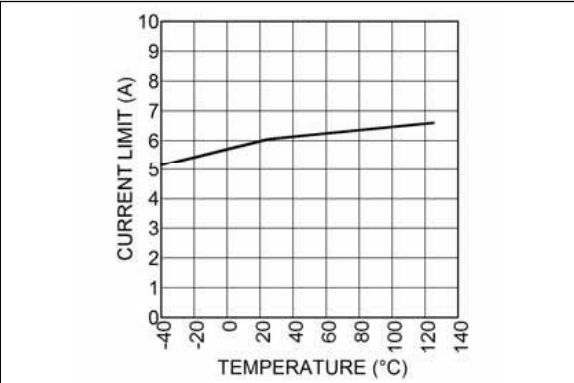


FIGURE 2-7: Current Limit vs. Temperature.

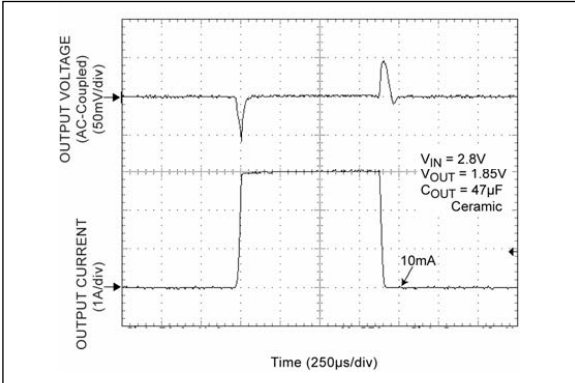


FIGURE 2-10: Load Transient Response.

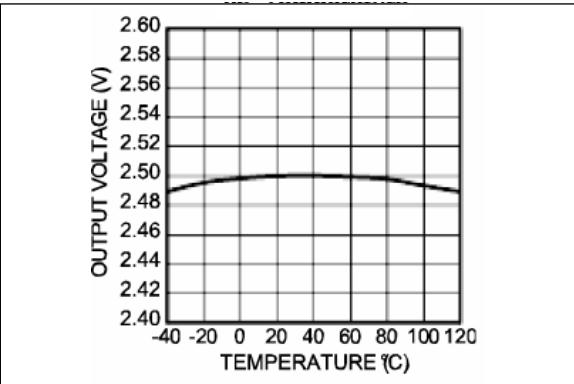


FIGURE 2-8: Output Voltage vs. Temperature.

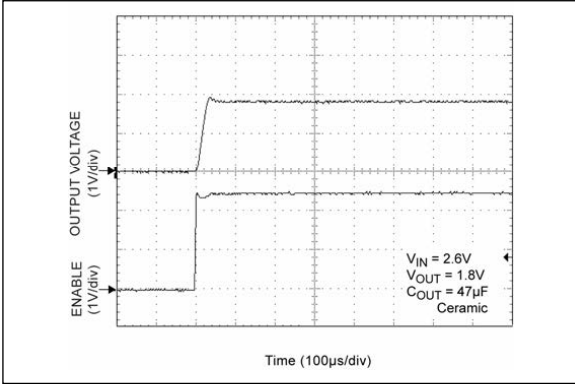


FIGURE 2-11: Enable Turn-On Response.

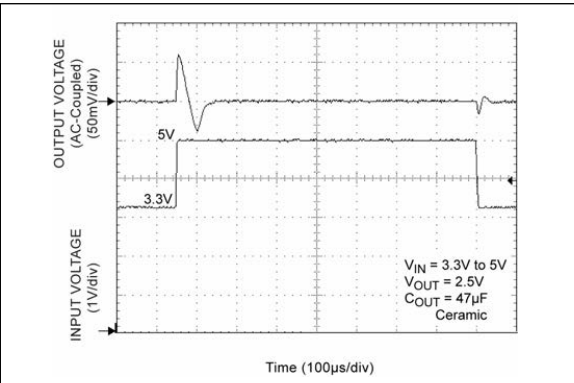


FIGURE 2-9: Line Transient Response.

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	EN	Enable (Input): CMOS compatible input. Logic high = enable, logic low = shutdown.
2	IN	Input Voltage: Supplies the current to the output power device.
3	GND, TAB	Ground: TAB is also connected internally to the IC's ground on D-PAK.
4	OUT	Regulator Output: The output voltage is set by the resistor divider connected from OUT to GND (with the divided connection tied to ADJ). A minimum value capacitor must be used to maintain stability. See the Functional Description section.
5	ADJ	Adjustable Regulator Feedback Input: Connect to the resistor voltage divider that is placed from OUT to GND in order to set the output voltage.

4.0 FUNCTIONAL DESCRIPTION

The MIC35302 is a high-performance low-dropout voltage regulator suitable for moderate to high-current regulator applications. Its 600 mV dropout voltage at full load and over temperature makes it especially valuable in battery-powered systems and as high-efficiency noise filters in post-regulator applications. Unlike older NPN-pass transistor designs, the minimum dropout voltage is limited by the base-to-emitter voltage drop and collector-to-emitter saturation voltage. Dropout performance of the PNP output of these devices is limited only by the low V_{CE} saturation voltage.

A trade-off for the low dropout voltage is a varying base drive requirement. Microchip's Super β PNP process reduces this drive requirement to only 2% to 5% of the load current.

The MIC35302 regulator is fully protected from damage due to fault conditions. Current limiting is provided. This limiting is linear; output current during overload conditions is constant. Thermal shutdown disables the device when the die temperature exceeds the maximum safe operating temperature. Transient protection allows device (and load) survival even when the input voltage spikes above and below nominal. The output structure of these regulators allows voltages in excess of the desired output voltage to be applied without reverse current flow.

4.1 Thermal Design

Linear regulators are simple to use. The most complicated design parameters to consider are thermal characteristics. Thermal design requires the following application-specific parameters:

- Maximum ambient temperature (T_A)
- Output current (I_{OUT})
- Output voltage (V_{OUT})
- Input voltage (V_{IN})
- Ground current (I_{GND})

First, calculate the power dissipation of the regulator from these numbers and the device parameters from this data sheet.

EQUATION 4-1:

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

The ground current is approximated by using numbers from the "Electrical Characteristics" or "Typical Characteristics."

Then, the heat sink thermal resistance is determined with this formula:

EQUATION 4-2:

$$\theta_{SA} = [(T_{J(MAX)} - T_A) / P_D] - (\theta_{JC} - \theta_{CS})$$

Where:

$T_{J(MAX)} \leq 125^\circ\text{C}$.

θ_{CS} = Between 0°C/W and 2°C/W .

The heat sink may be significantly reduced in applications where the minimum input voltage is known and is large compared with the dropout voltage. Use a series input resistor to drop excessive voltage and distribute the heat between this resistor and the regulator. The low dropout properties of the Super β PNP regulators allow significant reductions in regulator power dissipation and the associated heat sink without compromising performance. When this technique is employed, a capacitor of at least $1.0 \mu\text{F}$ is needed directly between the input and regulator ground.

Refer to [Application Note 9](#) for further details and examples on thermal design and heat sink applications.

With no heat sink in the application, calculate the junction temperature to determine the maximum power dissipation that will be allowed before exceeding the maximum junction temperature of the MIC35302. The maximum power allowed can be calculated using the thermal resistance (θ_{JA}) of the D-Pak adhering to the following criteria for the PCB design: 2 oz. copper and 100 mm^2 copper area for the MIC35302.

As an example, given an expected maximum ambient temperature (T_A) of 75°C with $V_{IN} = 2.25\text{V}$, $V_{OUT} = 1.75\text{V}$, and $I_{OUT} = 2.5\text{A}$, first calculate the expected P_D using [Equation 4-1](#):

EQUATION 4-3:

$$P_D = (2.25\text{V} - 1.75\text{V}) \times 2.5\text{A} + 2.25\text{V} \times 0.027\text{A} = 1.31\text{W}$$

Next, calculate the junction temperature for the expected power dissipation.

EQUATION 4-4:

$$T_J = (\theta_{JA} \times P_D) + T_A$$

$$T_J = (56^\circ\text{C/W} \times 1.31\text{W}) + 75^\circ\text{C} = 148.4^\circ\text{C}$$

Now determine the maximum power dissipation allowed that would not exceed the IC's maximum junction temperature (125°C) without the use of a heat sink by using the following calculation:

EQUATION 4-5:

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

$$P_{D(MAX)} = (125^{\circ}\text{C} - 75^{\circ}\text{C}) / 56^{\circ}\text{C/W} = 0.893\text{W}$$

4.2 Output Capacitor

The MIC35302 requires an output capacitor for stable operation. As a μCap LDO, the MIC35302 can operate with ceramic output capacitors as long as the amount of capacitance is 47 μF or greater. For values of output capacitance lower than 47 μF , the recommended ESR range is 200 m Ω to 2 Ω . The minimum value of output capacitance recommended for the MIC35302 is 10 μF .

For 47 μF or greater, the ESR range recommended is less than 1 Ω . Ultra-low ESR ceramic capacitors are recommended for output capacitance of 47 μF or greater to help improve transient response and noise reduction at high frequency. 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 Input Capacitor

An input capacitor of 1.0 μF or greater is recommended when the device is more than 4 inches away from the bulk and supply capacitance, or when the supply is a battery. Small, surface-mount chip capacitors can be used for the bypassing. The capacitor should be placed within 1" of the device for optimal performance. Larger values will help to improve ripple rejection by bypassing the input to the regulator, further improving the integrity of the output voltage.

4.4 Transient Response and Voltage Conversions

The MIC35302 has excellent transient response to variations in input voltage and load current. The device has been designed to respond quickly to load current variations and input voltage variations. Large output capacitors are not required to obtain this performance. A standard 10 μF tantalum capacitor, is all that is required. Larger values help to improve performance even further.

By virtue of its low dropout voltage, this device does not saturate into dropout as readily as similar NPN-based designs. When converting from 3.3V to 2.5V, 2.5V to 1.8V or 1.65V, or 2.5V to 1.5V, the NPN-based regulators are already operating in dropout, with typical dropout requirements of 1.2V or greater. To convert down to 2.5V without operating in dropout, NPN-based regulators require an input voltage of 3.7V at the very least. The MIC35302 regulator will provide excellent performance with an input as low as 3.0V or 2.25V, respectively. This gives the PNP-based regulators a distinct advantage over older, NPN-based linear regulators.

4.5 Minimum Load Current

The MIC35302 regulator is specified between finite loads. If the output current is too small, leakage currents dominate and the output voltage rises. A 10 mA minimum load current is necessary for proper operation.

4.6 Enable Input

The MIC35302 also features an enable input for on/off control of the device. Its shutdown state draws "zero" current (only microamperes of leakage). The enable input is TTL/CMOS compatible for simple logic interface, but can be connected to up to V_{IN} . When enabled, it draws approximately 15 μA .

4.7 Adjustable Regulator Design

The MIC35302 allows programming the output voltage anywhere between 1.24V and 5.4V. Two resistors are used. The resistor values are calculated by:

EQUATION 4-6:

$$R1 = R2 \times \left(\frac{V_{OUT}}{1.240} - 1 \right)$$

Where:

V_{OUT} = The desired output voltage.

MIC35302

Figure 4-1 shows component definition. Applications with widely varying load currents may scale the resistors to draw the minimum load current required for proper operation (see the Minimum Load Current section).

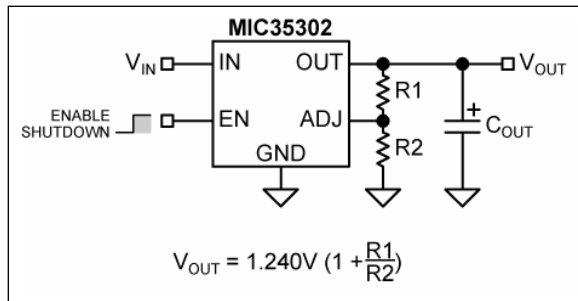


FIGURE 4-1: Adjustable Regulator with Resistors.

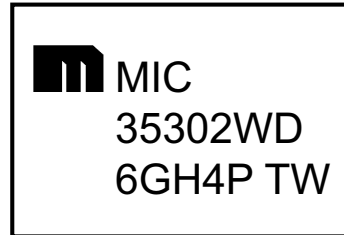
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

5-Lead TO-252*



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.	

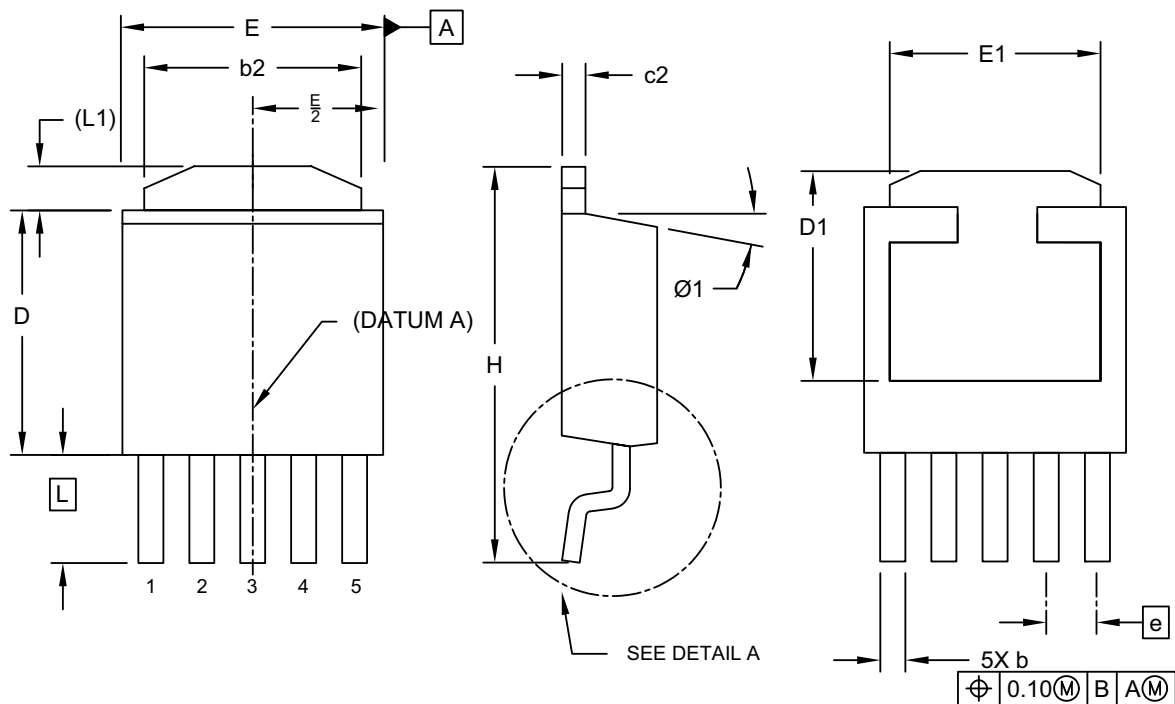
Note: If the full seven-character YYWWNNN code cannot fit on the package, the following truncated codes are used based on the available marking space:
 6 Characters = YWWNNN; 5 Characters = WWNNN; 4 Characters = WNNN; 3 Characters = NNN;
 2 Characters = NN; 1 Character = N

MIC35302

5-Lead Transistor Outline (9EA) - [TO-252]

Option "A"

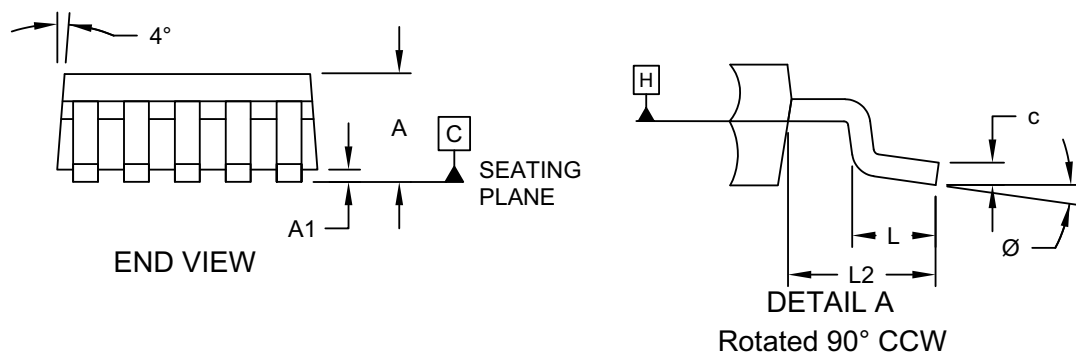
Note: For the most current package drawings, please see the Microchip Packaging Specification located at <http://www.microchip.com/packaging>



TOP VIEW

SIDE VIEW

BOTTOM VIEW



END VIEW

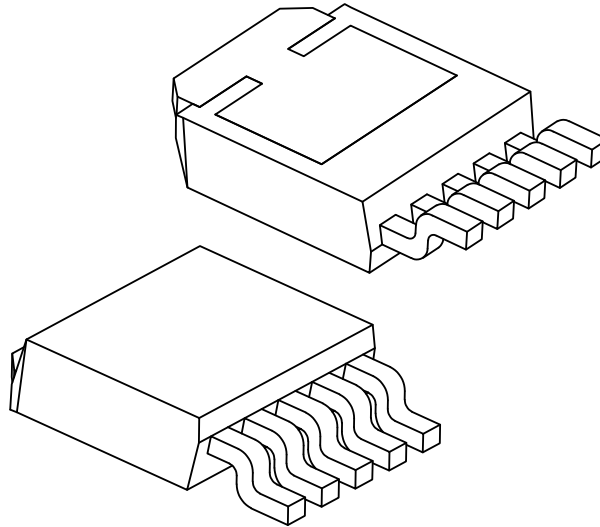
DETAIL A

Rotated 90° CCW

Microchip Technology Drawing C04-1168 Rev A Sheet 1 of 2

5-Lead Transistor Outline (9EA) - [TO-252] Option "A"

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



		MILLIMETERS		
Dimension Limits		Min	Nom	Max
Number of Leads	N	5		
Pitch	e	1.27 BSC		
Overall Height	A	2.18	—	2.38
Seating Plane Height	A1	—	—	0.127
Lead Width	b	0.508	—	0.771
Thermal Pad Width	b2	4.95	—	5.46
Lead Thickness	c	0.46	—	0.61
Thermal Pad Thickness	c2	0.46	—	0.89
Molded Body Length	D	5.97	—	6.22
Thermal Pad Length	D1	5.21	—	—
Total Width	E	6.35	—	6.73
Thermal Pad Width	E1	4.32	—	—
Overall Length	H	9.39	—	10.41
Foot Length	L	1.39	—	1.78
Tab Length	L1	1.067 REF		
Lead Length	L2	2.74 BSC		
Foot Angle	θ	0°	—	10°
Mold Draft Angle	θ1	0°	—	15°

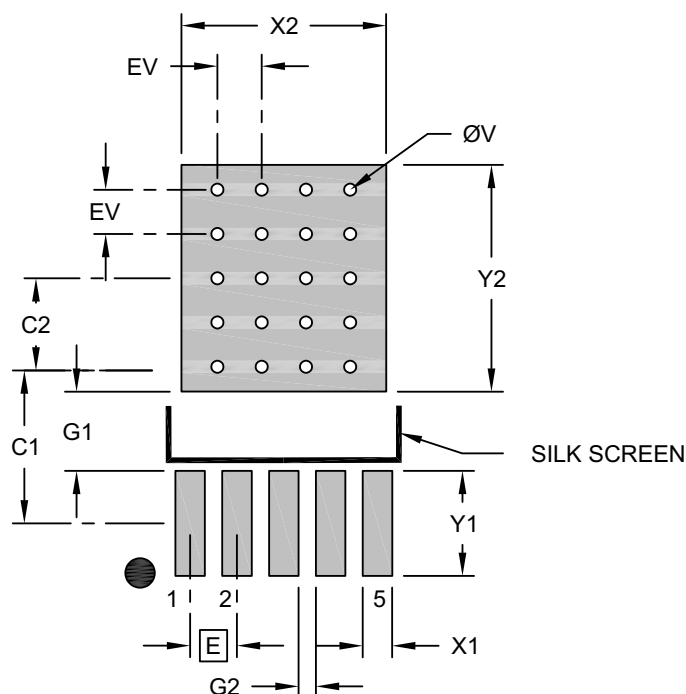
Notes:

- 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 C04-1168 Rev A Sheet 2 of 2

5-Lead Transistor Outline (9EA) - [TO-252] Option "A"

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



RECOMMENDED LAND PATTERN

Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Contact Pitch	E	1.27 BSC		
Center Pad Width	X2			5.55
Center Pad Length	Y2			6.15
Contact Pad Spacing	C1		4.15	
Contact Pad Spacing	C2		2.50	
Contact Pad Width (X5)	X1			0.80
Contact Pad Length (X5)	Y1			2.85
Contact Pad to Center Pad (X5)	G1	2.15		
Contact Pad to Contact Pad (X4)	G2	0.47		
Thermal Via Diameter	V		0.33	
Thermal Via Pitch	EV		1.20	

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
BSC: Basic Dimension. Theoretically exact value shown without tolerances.
2. For best soldering results, thermal vias, if used, should be filled or tented to avoid solder loss during reflow process

Microchip Technology Drawing C04-3168 Rev A

APPENDIX A: REVISION HISTORY

Revision A (March 2026)

- Converted Micrel document MIC35302 to Microchip data sheet DS20007057A.
- Minor text changes throughout.

MIC35302

NOTES:

PRODUCT IDENTIFICATION SYSTEM

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

<u>Part Number</u>	<u>X</u>	<u>X</u>	<u>-XX</u>
Device	Temp. Range	Package	Media Type
Device:	MIC35302:	3A, Low Voltage μ Cap LDO Regulator	
Temperature Range:	W	=	-40°C to +125°C
Package:	D	=	5-Lead TO-252
Media Type:	<blank>	=	80/Tube
	TR	=	2,500/Reel

Examples:

a) MIC35302WD:

MIC35302, -40°C to +125°C Temp. Range, 5-Lead TO-252, 80/Tube

b) MIC35302WD-TR:

MIC35302, -40°C to +125°C Temp. Range, 5-Lead TO-252, 2,500/Reel

Note: 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.

MIC35302

NOTES:

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