MIC69101/103

Single Supply V_{IN}, LOW V_{IN}, LOW V_{OUT}, 1A LDO

Features

- Single Input Voltage Range: V_{IN} 1.65V to 5.5V
- Maximum Dropout (V_{IN} – V_{OUT}) of 500 mV over Temperature
- Adjustable Output Voltage Down to 0.5V
- Stable with 4.7 µF Ceramic Output Capacitor
- Excellent Line and Load Regulation Specifications
- Logic-Controlled Shutdown
- Thermal Shutdown and Current-Limit Protection
- 10-Pin 3 mm x 3 mm DFN Package
- –40°C to +125°C Junction Temperature Range

Applications

- Point-of-Load Applications
- Industrial Power
- Sensitive RF Applications

General Description

The MIC69101/103 are the 1A output current member of the MIC69xxx family of high current, low voltage regulators, that support currents of 1A, 1.5A, 3A, and 5A. The MIC69101/103 operates from a single low voltage supply, yet offers high precision and ultra-low dropout of 500 mV under worst case conditions.

The MIC69101/103 operate from an input voltage of 1.65V to 5.5V. It is designed to drive digital circuits requiring low voltage at high currents (i.e. PLDs, DSP, microcontroller, etc.). These regulators are available in adjustable and fixed output voltages including 1.8V. The adjustable version can support output voltages down to 0.5V.

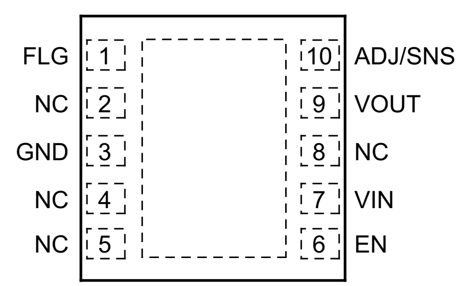
The µCap design of the MIC69101/103 is optimized for stability with low value low-ESR ceramic output capacitors.

Features of the MIC69101/103 include thermal shutdown and current limit protection. Logic enable and error flag pins are also available.

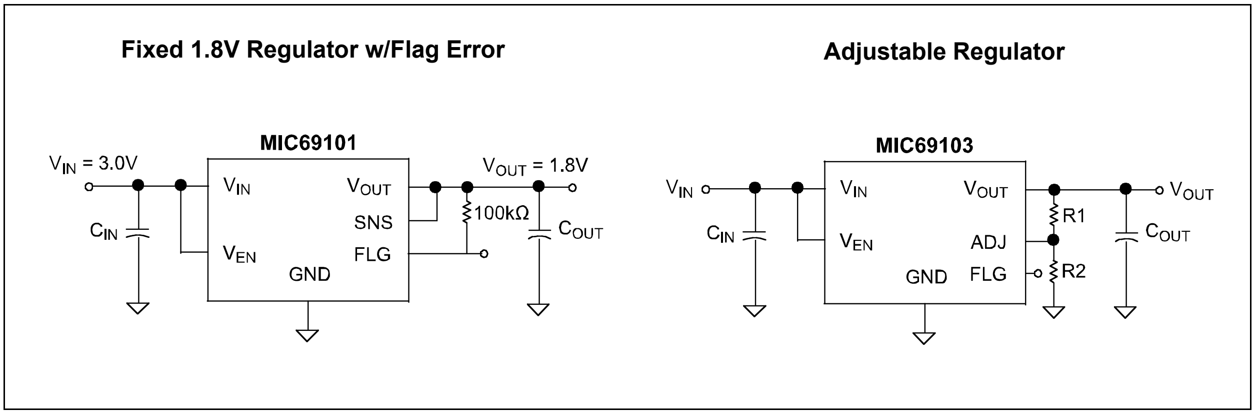
The MIC69101/103 are offered in a tiny 10-pin 3 mm x 3 mm DFN package and has an operating temperature range of –40°C to +125°C.

Package Type

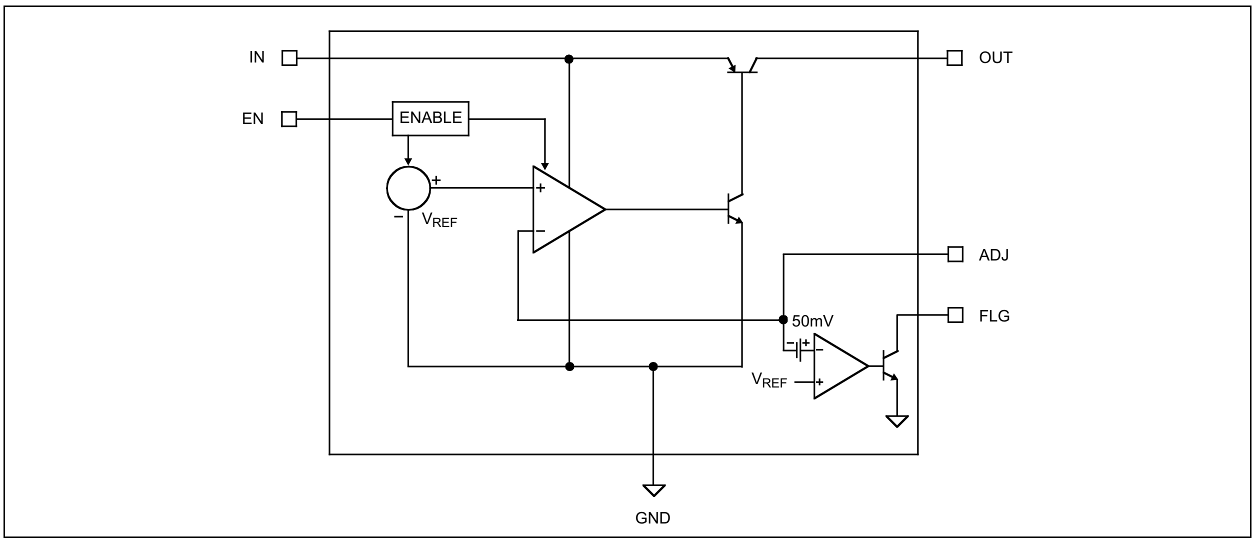
MIC69101/03
10-Pin 3 mm x 3 mm DFN (ML)



Typical Application Circuits



Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Input Voltage (V_{IN}) .... +6V
Logic Input Voltage (V_{EN}) .... 0V to V_{IN}
Power Dissipation (P_D) (Note 1) .... Internally Limited
Flag Pin (FLG) .... +6V
ESD Rating (Note 1) .... 2 kV

Operating Ratings ‡

Supply Voltage (V_{IN}) .... +1.65V to +5.5V
Enable Input 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. Specifications are for packaged product only.

‡ 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: T_A = 25°C with $V_{IN} = V_{OUT}$ + 0.5V; **Bold** values indicate –40°C ≤ T_J ≤ +125°C; I_{OUT} = 10 mA; C_{OUT} = 4.7 µF ceramic, unless otherwise noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy (Fixed)	V_{OUT}	**–2**	—	**+2**	%	Over temperature range
Output Voltage Accuracy (Adj)		**0.49**	0.5	**0.51**	V	—
Feedback Pin Current	I_{FB}	—	0.21	1	µA	—
Output Voltage Line Regulation (Note 1)	$\Delta V_{OUT}/\Delta V_{IN}$	—	±0.1	±0.3	%/V	$V_{IN} = V_{OUT}$ +1.0V to 5.5V
						For V_{OUT} ≥ 0.65V, V_{IN} = 1.65 to 5.5V
Output Voltage Load Regulation	$\Delta V_{OUT}/V_{OUT}$	—	±0.25	—	%	I_L = 10 mA to 1A
$V_{IN} – V_{OUT}$; Dropout Voltage (Note 2)	V_{DO}	—	150	**300**	mV	I_L = 0.5A
			215	**500**	mV	I_L = 1.0A
Ground Pin Current	I_{GND}	—	1.1	—	mA	I_L = 10 mA
			4.7	—	mA	I_L = 0.5A
			11	**20**	mA	I_L = 1.0A
Ground Pin Current in Shutdown	I_{SHDN}	—	1	—	µA	V_{EN} = 0V
Current Limit	I_{LIM}	**1.2**	1.95	—	A	V_{OUT} = 0V
Start-up Time	t_{START}	—	10	**150**	µs	$V_{EN} = V_{IN}$
Thermal Shutdown	Th_{SHDN}	—	165	—	°C	—
Enable Input						
Enable Input Threshold	V_{EN}	**0.8**	0.6	—	V	Regulator enable
		—	—	**0.2**	V	Regulator shutdown
Enable Pin Input Current	I_{EN}	—	0.005	—	µA	V_{IL} ≤ 0.2V (Regulator shutdown)
		—	7	—	µA	V_{IH} ≥ 0.8V (Regulator enable)

Electrical Characteristics: T_A = 25°C with V_{IN} = V_{OUT} + 0.5V; **Bold** values indicate –40°C ≤ T_J ≤ +125°C; I_{OUT} = 10 mA; C_{OUT} = 4.7 µF ceramic, unless otherwise noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Flag Output						
Flag Output Leakage Current	$I_{FLG(LEAK)}$	—	0.05	—	µA	Flag off
Output Logic-Low Voltage (Undervoltage condition)	$V_{FLG(LO)}$	—	150	—	mV	I_L = 5 mA
Flag Threshold	V_{FLG}	7.5	10	14	%	% of V_{OUT} below nominal (falling)
Hysteresis	—	—	2	—	%	—

1: Minimum input for line regulation test is set to V_{OUT} + 1V relative to the highest output voltage.

2: 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 1.65V, dropout voltage is considered the input-to-output voltage differential with the minimum input voltage of 1.65V. Minimum input operating voltage is 1.65V.

TEMPERATURE SPECIFICATIONS (Note 1)

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	–65	—	+125	°C	—
Junction Temperature Range	T_J	–40	—	+125	°C	—
Package Thermal Resistances						
Thermal Resistance (3 mm x 3 mm DFN-10)	θ_{JA}	—	60	—	°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, θ_{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.

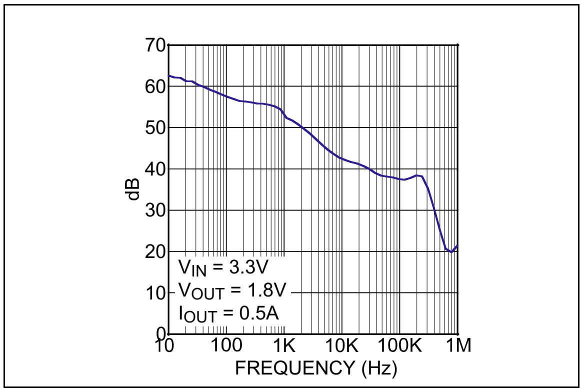


FIGURE 2-1: *Power Supply Rejection Ratio.*

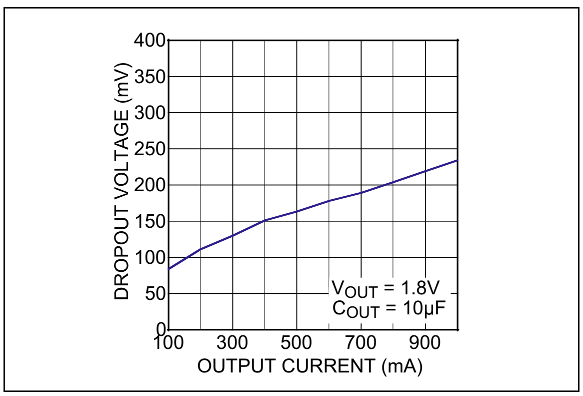


FIGURE 2-2: *Dropout Voltage vs. Output Current.*

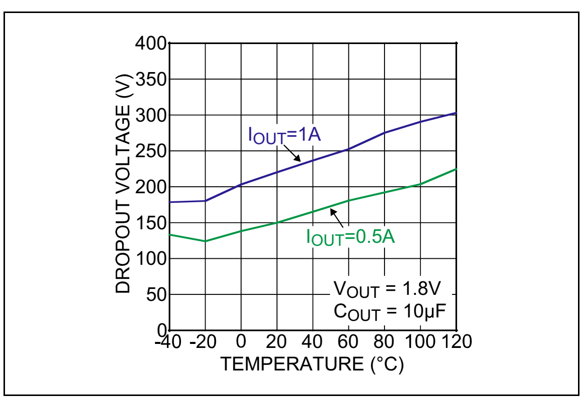


FIGURE 2-3: *Dropout Voltage vs. Temperature.*

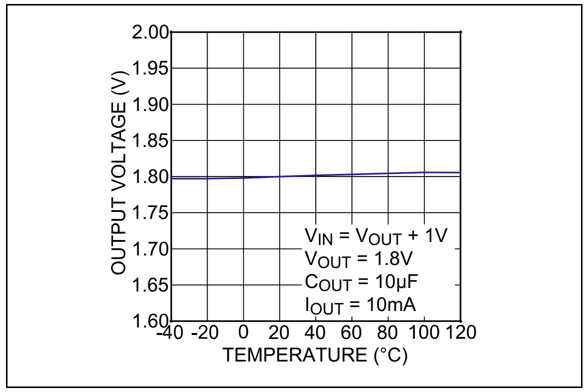


FIGURE 2-4: *Output Voltage vs. Temperature.*

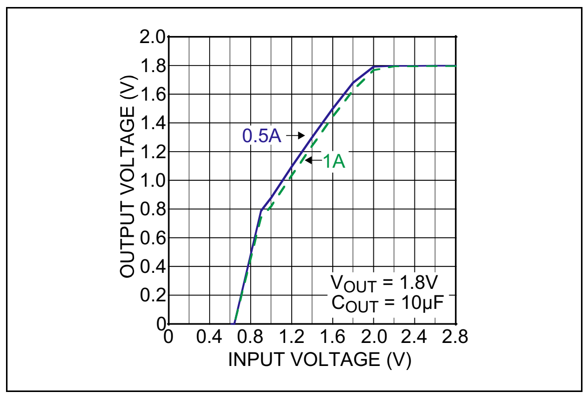


FIGURE 2-5: *Output Voltage vs. Input Voltage.*

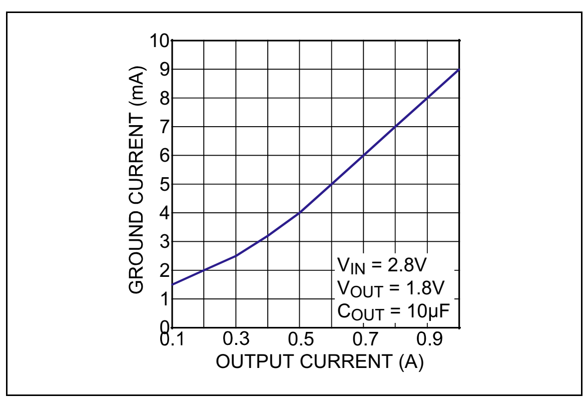


FIGURE 2-6: *Ground Current vs. Output Current.*

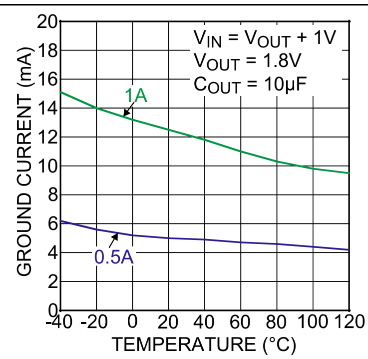


FIGURE 2-7: *Ground Current vs. Temperature.*

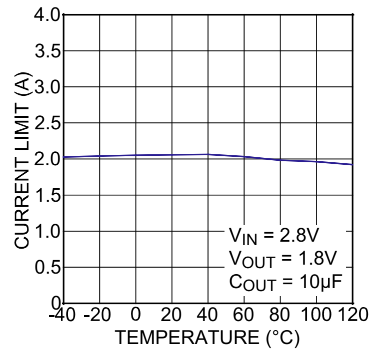


FIGURE 2-10: *Current-Limit vs. Temperature.*

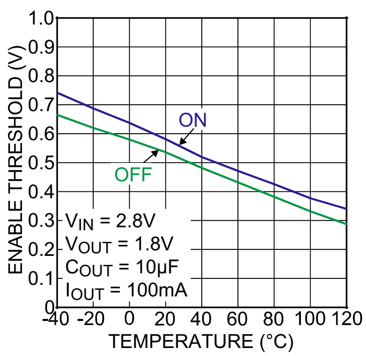


FIGURE 2-8: *Enable Threshold vs. Temperature.*

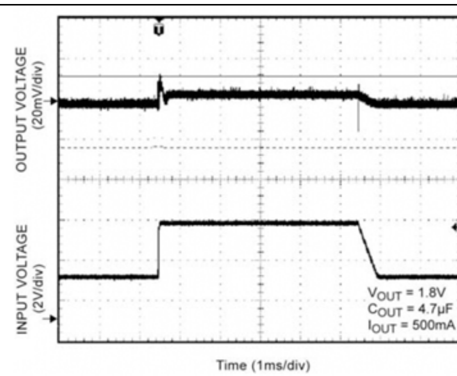


FIGURE 2-11: *Line Transient.*

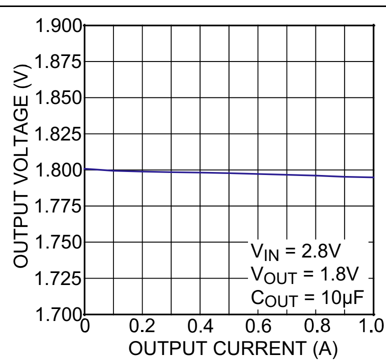


FIGURE 2-9: *Load Regulation.*

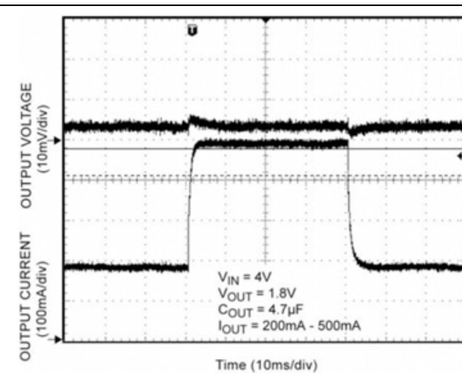


FIGURE 2-12: *Load Transient.*

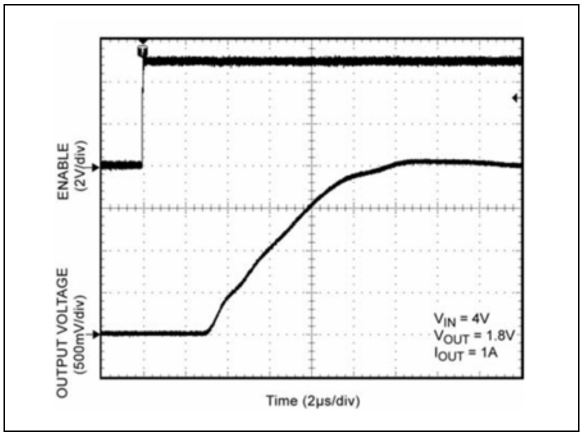


FIGURE 2-13: *Enable Turn-On.*

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	FLG	Error Flag (Output): Open collector output. Active low indicates an output fault condition.
2, 4, 5, 8	NC	Not internally connected.
3 (EP)	GND	Ground (exposed pad is recommended to connect to ground on DFN).
6	EN	Enable (Input): CMOS compatible input. Logic high = enable, logic low = shutdown. Do not leave pin floating.
7	VIN	Input voltage that supplies current to the output power device.
9	VOUT	Regulator Output.
10 (ADJ)	ADJ	Adjustable regulator feedback input. Connect to resistor voltage divider.
10 (FIXED)	SNS	Sense pin, connect to output for improved voltage regulation.

4.0 APPLICATION INFORMATION

The MIC69101/103 are ultra-high performance low dropout linear regulators designed for high current applications requiring a fast transient response. They utilize a single input supply, perfect for low-voltage DC-to-DC conversion. The MIC69101/103 require a minimum number of external components. The MIC69101/103 regulators are fully protected from damage due to fault conditions offering constant current limiting and thermal shutdown.

4.1 Input Supply Voltage

V_{IN} provides a high current to the collector of the pass transistor. The minimum input voltage is 1.65V allowing conversion from low voltage supplies.

4.2 Input Capacitor

An input capacitor of 1 µF or greater is recommended when the device is more than 4 inches away from the bulk AC supply capacitance or when the supply is a battery. Small, surface mount, ceramic chip capacitors can be used for bypassing. The capacitor should be placed within 1 inch 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.

4.3 Output Capacitor

The MIC69101/103 require a minimum of output capacitance to maintain stability. However, proper capacitor selection is important to ensure desired transient response. The MIC69101/103 are specifically designed to be stable with low ESR ceramic chip capacitors. A 4.7 µF ceramic chip capacitor should satisfy most applications. Output capacitor can be increased without bound. See typical characteristics for examples of load transient response.

X7R dielectric ceramic capacitors are recommended because of their temperature performance. X7R-type capacitors change capacitance by only 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 or a tantalum capacitor to ensure the same capacitance value over the operating temperature range. Tantalum capacitors have a very stable dielectric (10% over their operating temperature range) and can also be used with this device.

4.4 Minimum Load Current

The MIC69101/103 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.

4.5 Adjustable Regulator Design

The MIC69103 adjustable version allows programming the output voltage anywhere between 0.5V and 5.5V with two resistors. The resistor value between V_{OUT} and the adjust pin should not exceed 10 kΩ. Larger values can cause instability. The resistor values are calculated by:

EQUATION 4-1:

$$V_{OUT} = 0.5\left(\frac{R1}{R2} + 1\right)$$

Where:

V_{OUT} is the desired output Voltage

4.6 Enable

The MIC69101 fixed output voltage version features an active high enable input (EN) that allows on-off control of the regulator. Current drain reduces to near “zero” when the device is shutdown, with only microamperes of leakage current. EN may be directly tied to V_{IN} and pulled up to the maximum supply voltage.

4.7 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 4-2:

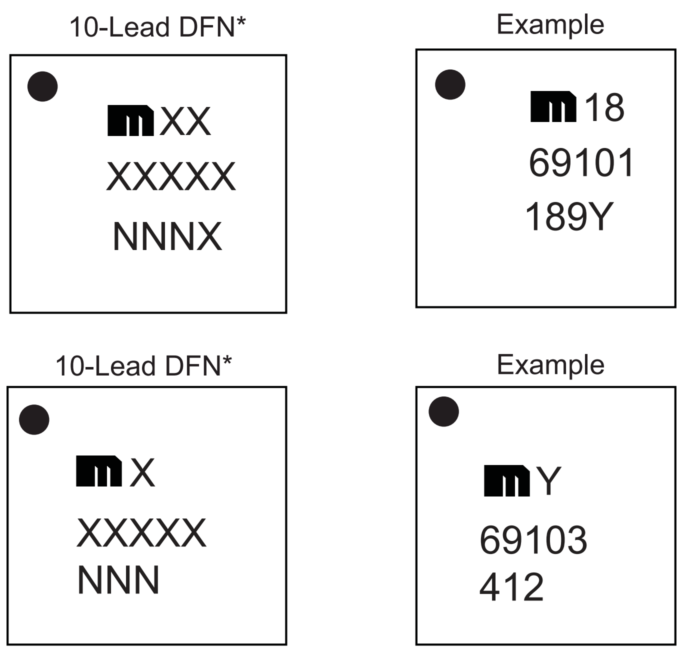
$$P_D = (V_{IN} - V_{OUT})I_{OUT} + V_{IN} \times I_{GND}$$

In Equation 4-2, the ground current is approximated by using numbers from the **Section 1.0 "Electrical Characteristics"** or **Section 2.0 "Typical Performance Curves"** sections. 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.

Refer to Application Note 9 for further details and examples on thermal design and heat sink applications.

5.0 PACKAGING INFORMATION

5.1 Package Marking Information



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).

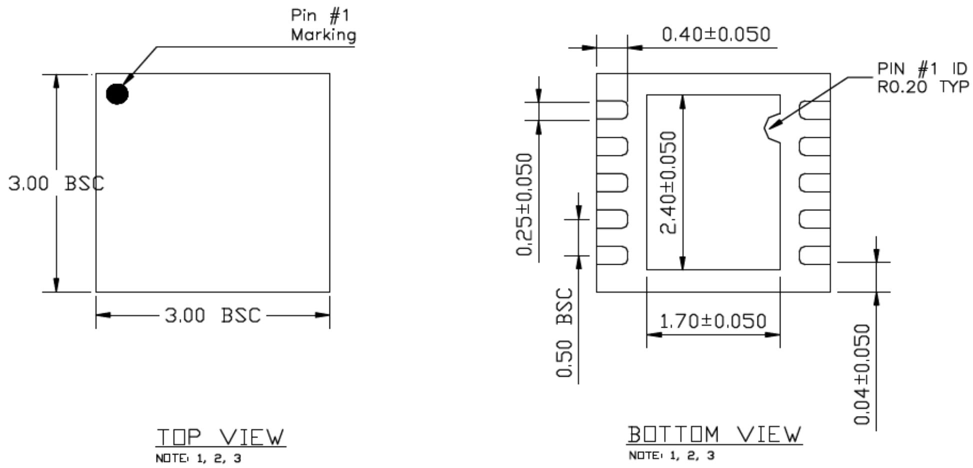
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

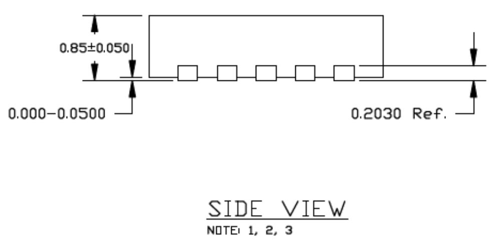
Underbar (_) and/or Overbar (‾) symbol may not be to scale.

10-Lead 3 mm x 3 mm DFN Package Outline and Recommended Land Pattern

TITLE
10 LEAD DFN 3x3mm PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

DRAWING #	DFN33-10LD-PL-1	**UNIT**	MM



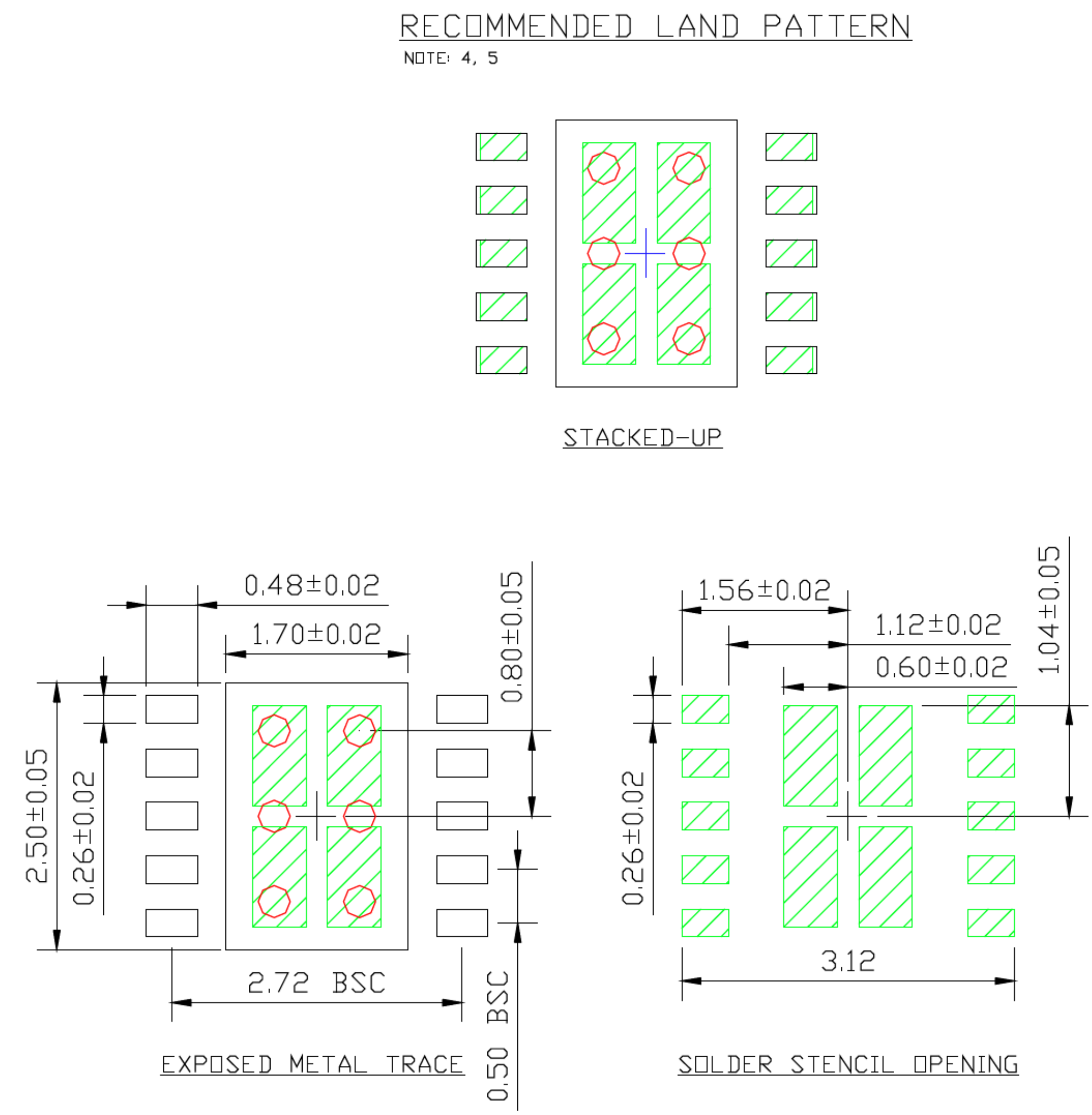


NOTE:
1. MAX PACKAGE WARPAGE IS 0.05 MM
2. MAX ALLOWABLE BURR IS 0.076MM IN ALL DIRECTIONS
3. PIN #1 IS ON TOP WILL BE LASER MARKED
4. RED CIRCLE IN LAND PATTERN INDICATE THERMAL VIA. SIZE SHOULD BE 0.30-0.35 MM IN DIAMETER AND SHOULD BE CONNECTED TO GND FOR MAX THERMAL PERFORMANCE
5. GREEN RECTANGLES (SHADED AREA) indicate SOLDER STENCIL OPENING ON EXPOSED PAD AREA. SIZE SHOULD BE 0.50x0.95 MM IN SIZE, 0.20 MM SPACING.

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

10-Lead 3 mm x 3 mm DFN Package Outline and Recommended Land Pattern

POD-Land Pattern drawing #DFN33-10LD-PL-1



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 (May 2018)

- Converted Micrel document MIC69101/103 to Microchip data sheet DS20006018A.
- Minor text changes throughout.

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	XX	–XX
Device	Output Voltage	Junction Temperature Range	Package	Media Type

Device:	MIC6910x: Single Supply V_{IN}, LOW V_{IN}, LOW V_{OUT}, 1A LDO MIC69101: Fixed Output Voltage MIC69103: Adjustable Output Voltage Down to 0.5V
Output Voltage:	1.8 = 1.8V Fixed <blank> = Adjustable
Junction Temperature Range:	Y = –40°C to +125°C, Industrial, RoHS Compliant
Package:	ML = 10-Lead DFN (3 mm x 3 mm x 0.9 mm)
Media Type:	TR = 5000/Reel

Examples:

a) MIC69101-1.8YML-TR:	Single Supply V_{IN}, LOW V_{IN}, LOW V_{OUT}, 1A LDO, 1.8 Fixed Output Voltage, –40°C to +125°C Junction Temperature Range, 10-Lead DFN Package, 5000/Reel
b) MIC69103YML-TR:	Single Supply V_{IN}, LOW V_{IN}, LOW V_{OUT}, 1A LDO, Adjustable Output Voltage, –40°C to +125°C Junction Temperature Range, 10-Lead DFN Package, 5000/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.

NOTES:

Note the following details of the code protection feature on Microchip devices:

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