

General Description

The MIC69301/2/3 is the 3A output current member of the MIC69xxx family of high current, low voltage regulators, which support currents of 1A, 1.5A, 3A, and 5A. This family operates from a single low voltage supply, yet offers high precision and ultra low dropout of 500mV under worst case conditions.

The MIC69301/2/3 operates 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. The adjustable version can support output voltages down to 0.5V.

The μ Cap design of the MIC69301/2/3 is optimized for stability with low value low-ESR ceramic output capacitors.

Features of the MIC69301/2/3 include thermal shutdown and current limit protection. Logic enable and error flag pins are also available.

The MIC69301/2/3 is offered in the space-efficient S-PAK package and the EPAD SOIC-8 package. Both packages have an operating temperature range of -40°C to $+125^{\circ}\text{C}$.

Data sheets and support documentation can be found on Micrel's web site at: www.micrel.com.

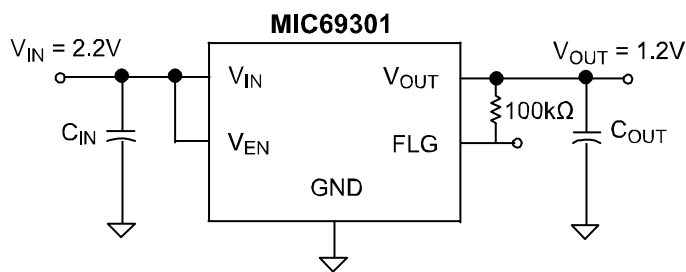
Features

- Input voltage range: V_{IN} : 1.65V to 5.5V
- Maximum dropout ($V_{IN} - V_{OUT}$) of 500mV over temperature
- Adjustable output voltage down to 0.5V
- Stable with 10 μ F ceramic output capacitor
- Excellent line and load regulation specifications
- Logic controlled shutdown
- Thermal shutdown and current limit protection
- 5-Pin S-Pak package
- EPAD SOIC-8 package
- Available -40°C to $+125^{\circ}\text{C}$ temperature junction

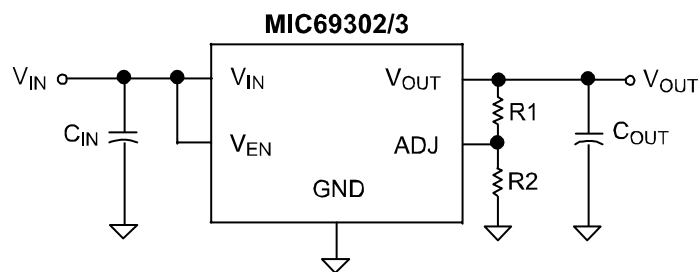
Applications

- Point-of-load applications
- Industrial power
- Sensitive RF applications

Typical Application



Fixed 1.2V Regulator w/Flag Error

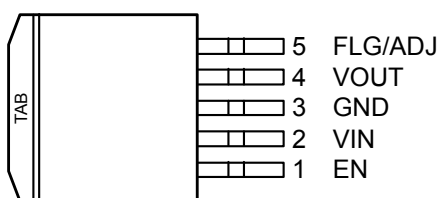


Adjustable Regulator

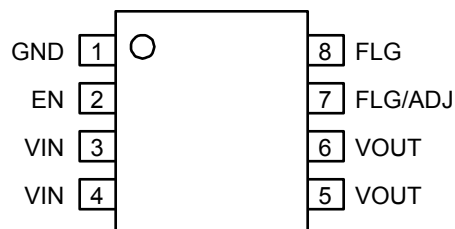
Ordering Information

Part Number	Nominal Output Voltage	Junction Temperature Range	Package	Lead Finish
MIC69301-1.2WR	1.2V	-40° to +125°C	5-Pin S-PAK	RoHS Compliant
MIC69301-1.2YME	1.2V	-40° to +125°C	8-Pin EPAD SOIC	Pb Free
MIC69303YME	Adj.	-40° to +125°C	8-Pin EPAD SOIC	Pb Free
MIC69302WR	Adj.	-40° to +125°C	5-Pin S-PAK	RoHS Compliant

Pin Configuration



5-Pin S-PAK (R)



8-Pin EPAD SOIC (ME)

Pin Description

Pin Number SPAK-5	Pin Number EPAD SOIC-8	Pin Name	Pin Function
1	2	EN	Enable (Input): CMOS compatible input. Logic high = enable, logic low = shutdown. Do not leave pin floating.
2	3, 4	VIN	Input voltage which supplies current to the output power device.
3	1	GND	Ground (TAB is connected to ground on S-Pak).
4	5, 6	VOUT	Regulator Output.
5	7	ADJ	Adjustable regulator feedback input. Connect to resistor voltage divider.
	8	FLG	Error Flag (Output): Open collector output. Active low indicates an output fault condition.

Absolute Maximum Ratings⁽¹⁾

Supply Input Voltage (V_{IN})	6V
Logic Input Voltage (V_{EN})	0V to V_{IN}
Power Dissipation (P_D)	Internally Limited ⁽³⁾
Flag	6V
Storage Temperature (T_S)	-65°C to +125°C
ESD ⁽⁴⁾	2kV

Operating Ratings⁽²⁾

Supply Voltage (V_{IN})	1.65V to 5.5V
Enable Input Voltage (V_{EN})	0V to V_{IN}
Junction Temperature (T_J)	-40°C ≤ T_J ≤ +125°C
Package Thermal Resistance	
S-PAK-5 (θ_{JC})	2°C/W
S-PAK-5 (θ_{JA})	38°C/W
EPAD SOIC-8 (θ_{JA})	41°C/W

Electrical Characteristics⁽⁴⁾

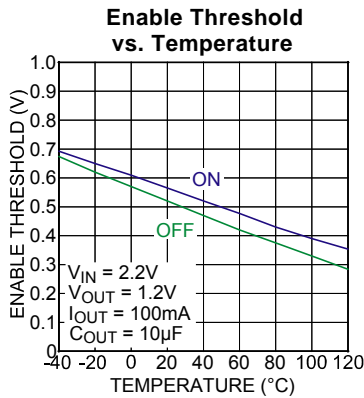
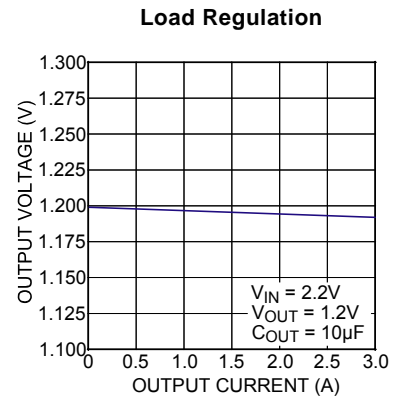
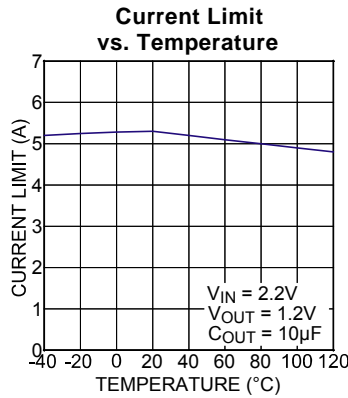
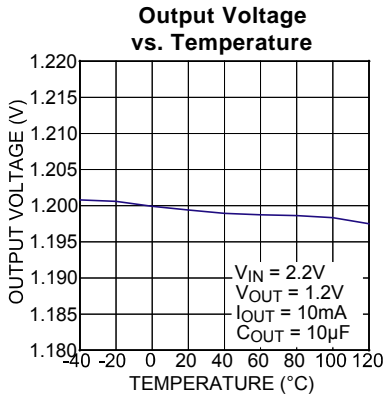
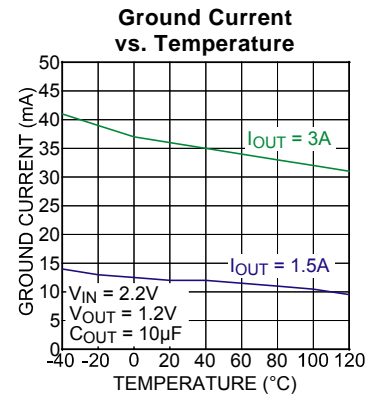
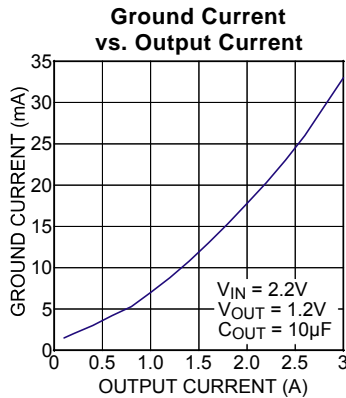
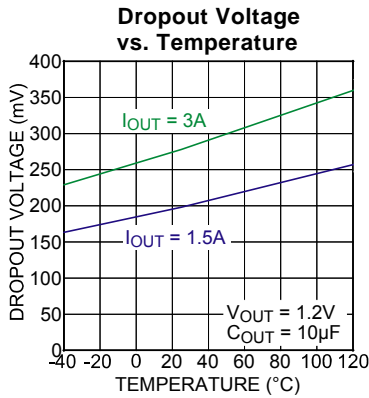
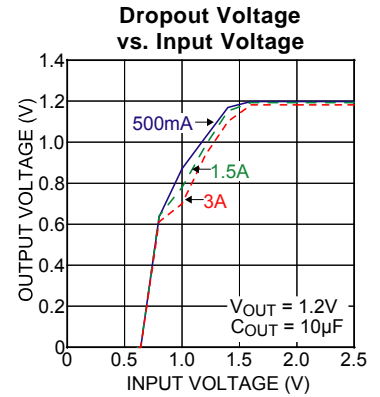
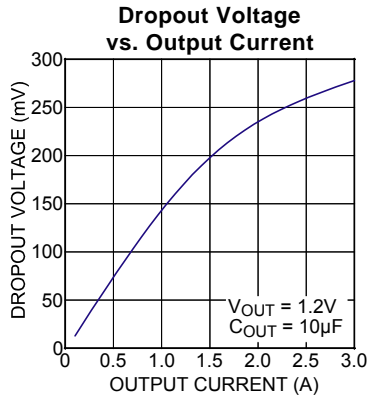
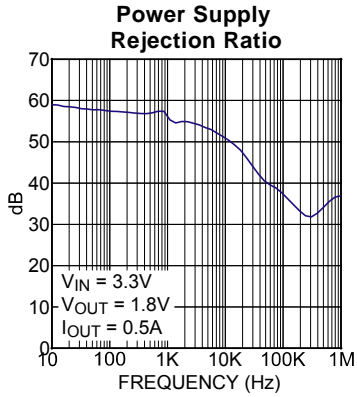
$T_A = 25^\circ\text{C}$ with $V_{IN} = V_{OUT} + 1\text{V}$; **bold** values indicate $-40^\circ\text{C} \leq T_J \leq +125^\circ\text{C}$; $I_{OUT} = 10\text{mA}$; $C_{OUT} = 10\mu\text{F}$ ceramic, unless noted.

Parameter	Conditions	Min	Typ	Max	Units
Output Voltage Accuracy	Over temperature range	-2		+2	%
Output Voltage Line Regulation (Note 5)	$V_{IN} = V_{OUT} + 1.0\text{V}$ to 5.5V For $V_{OUT} \geq 0.65\text{V}$, $V_{IN} = 1.65$ to 5.5V		±0.2	±0.3	%/V
Output Voltage Load Regulation	$I_L = 10\text{mA}$ to 3A		±0.3		%
$V_{IN} - V_O$; Dropout Voltage (Note 6)	$I_L = 1.5\text{A}$		175	300	mV
	$I_L = 3.0\text{A}$		275	500	mV
Ground Pin Current	$I_L = 10\text{mA}$		1.2	5	mA
	$I_L = 1.5\text{A}$		15	30	mA
	$I_L = 3.0\text{A}$		40	75	mA
Ground Pin Current in Shutdown	$V_{EN} = 0\text{V}$		1		μA
Current Limit	$V_{OUT} = 0\text{V}$	3.3	5		A
Start-up Time	$V_{EN} = V_{IN}$		10	150	μs
Thermal Shutdown			165		°C
Enable Input					
Enable Input Threshold	Regulator enable	0.8	0.6		V
	Regulator shutdown			0.2	V
Enable Pin Input Current	$V_{IL} \leq 0.2\text{V}$ (Regulator shutdown)		0.005		μA
	$V_{IH} \geq 0.8\text{V}$ (Regulator enable)		7		μA
Flag Output					
$I_{FLG(LEAK)}$	Flag Output Leakage Current (Flag Off)		0.05		μA
$V_{FLG(LO)}$	Output Logic-Low Voltage (undervoltage condition), $I_L = 5\text{mA}$		150		mV
V_{FLG}	Threshold, % of V_{OUT} below nominal (falling)	7.5	10	14	%
	Hysteresis		2		%
Feedback Pin Current			0.25	1	μA

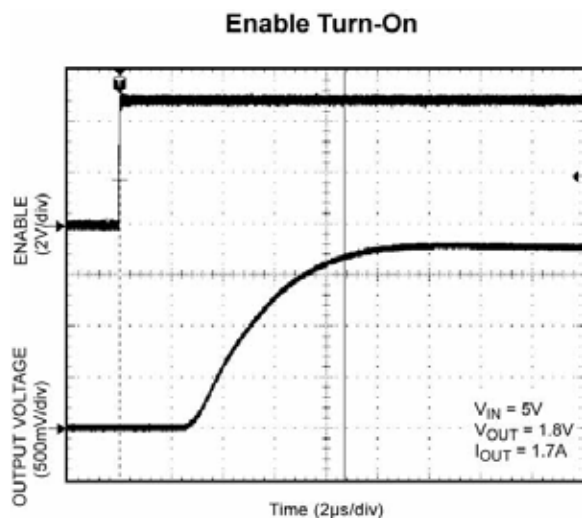
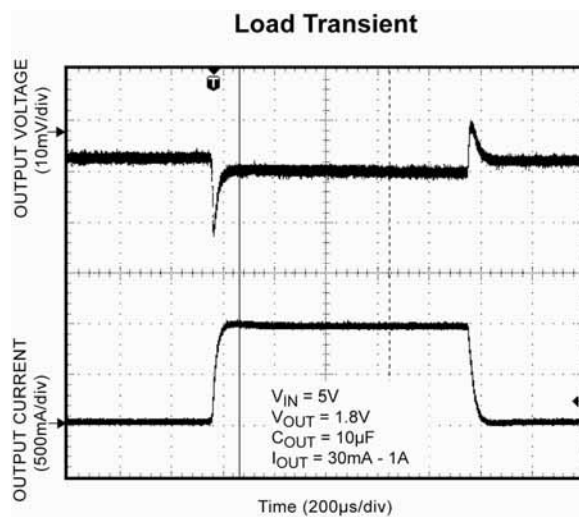
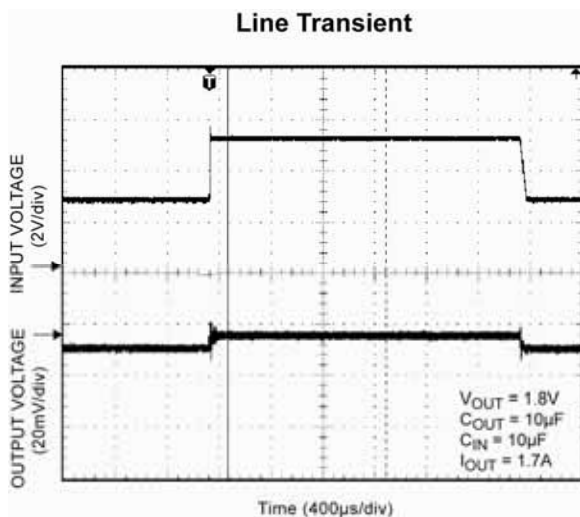
Notes:

- Exceeding the absolute maximum rating may damage the device.
- The device is not guaranteed to function outside its operating rating.
- 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.
- Specification for packaged product only.
- Minimum input for line regulation test is set to $V_{OUT} + 1\text{V}$ relative to the highest output voltage.
- 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.

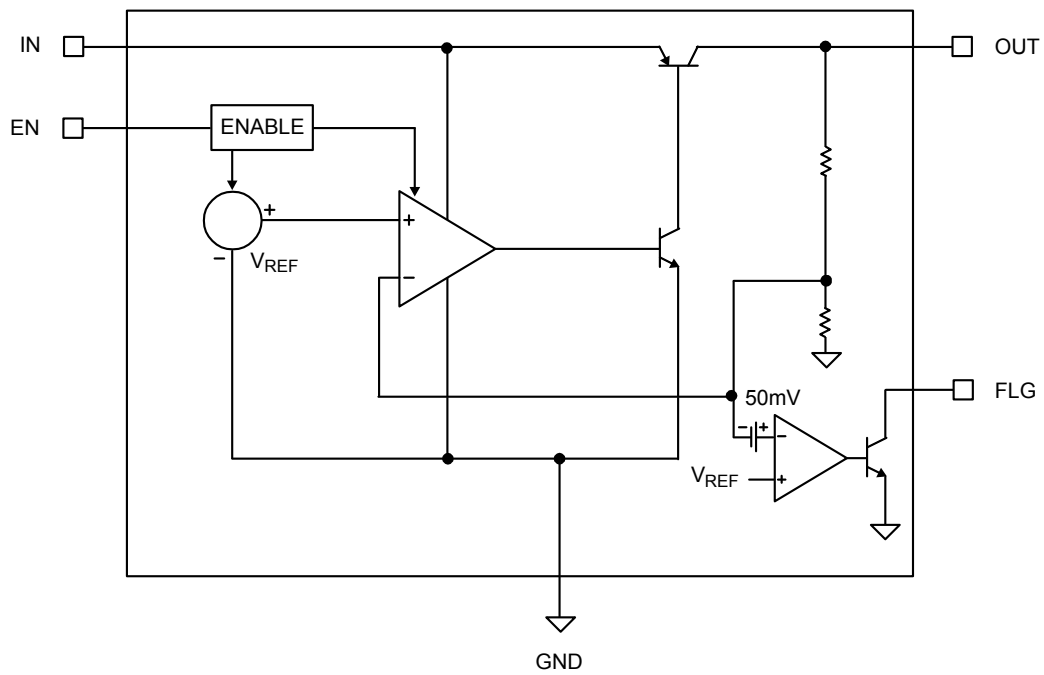
Typical Characteristics



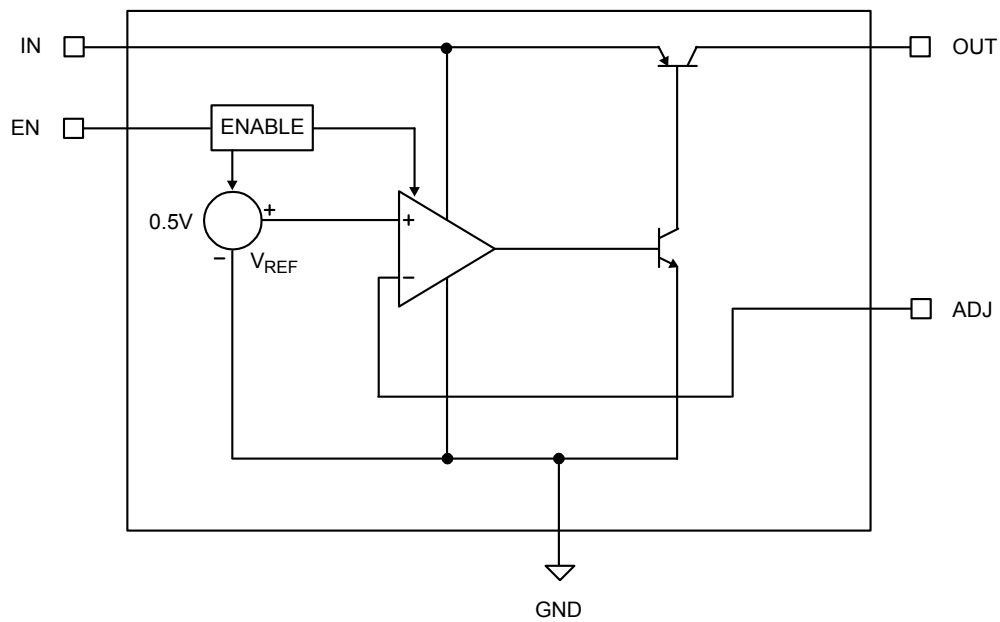
Functional Characteristics



Functional Diagram



Fixed Output Regulator



Adjustable Output Regulator

Application Information

The MIC69301/2/3 is an ultra-high performance low dropout linear regulator designed for high current applications requiring a fast transient response. It utilizes a single input supply and has a very low dropout voltage perfect for low-voltage DC-to-DC conversion. The MIC69301/2/3 requires a minimum number of external components.

The MIC69301/2/3 regulator is fully protected from damage due to fault conditions offering constant current limiting and thermal shutdown.

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.

Output Capacitor

The MIC69301/2/3 requires a minimum of output capacitance to maintain stability. However, proper capacitor selection is important to ensure desired transient response. The MIC69301/2/3 is specifically designed to be stable with low ESR ceramic chip capacitors. A 10 μ F 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.

Input Capacitor

An input capacitor of 1 μ F or greater is recommended when the device is more than 4 inches away from the bulk supply capacitance or when the supply is a battery. Small, surface mount, ceramic chip capacitors can be used for the 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.

Minimum Load Current

The MIC69301/2/3 regulator is specified between finite loads. If the output current is too small, leakage currents dominate and the output voltage rises. A 10mA minimum load current is necessary for proper operation.

Adjustable Regulator Design

The MIC69302 and MIC69303 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 10k Ω . Larger values can cause instability. The resistor values are calculated by:

$$V_{OUT} = 0.5 * \left(\frac{R_1}{R_2} + 1 \right)$$

Where V_{OUT} is the desired output voltage.

Enable

The fixed output voltage versions of the MIC69301 feature 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. The EN input has TTL/CMOS compatible thresholds for simple logic interfacing. EN may be directly tied to V_{IN} and pulled up to the maximum supply voltage.

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.

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

where the ground current is approximated by using numbers from the "Electrical Characteristics" or "Typical Characteristics" sections. The heat sink thermal resistance is then determined with this formula:

$$\theta_{SA} = ((T_J(\max) - T_A) / P_D) - (\theta_{JC} + \theta_{CS})$$

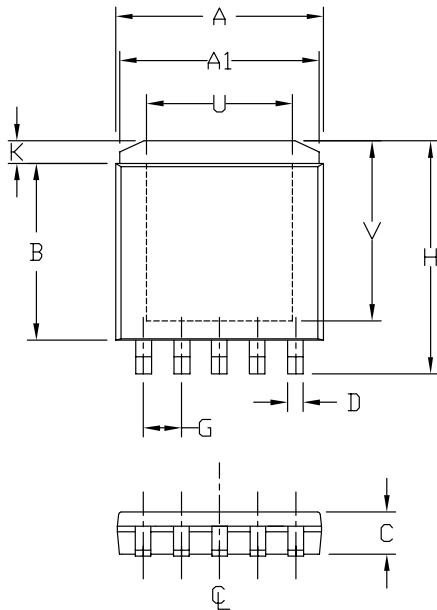
Where $T_J(\max) \leq 125^\circ\text{C}$ and θ_{CS} is between 0°C and 2°C/W .

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 Micrel 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 μ 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.

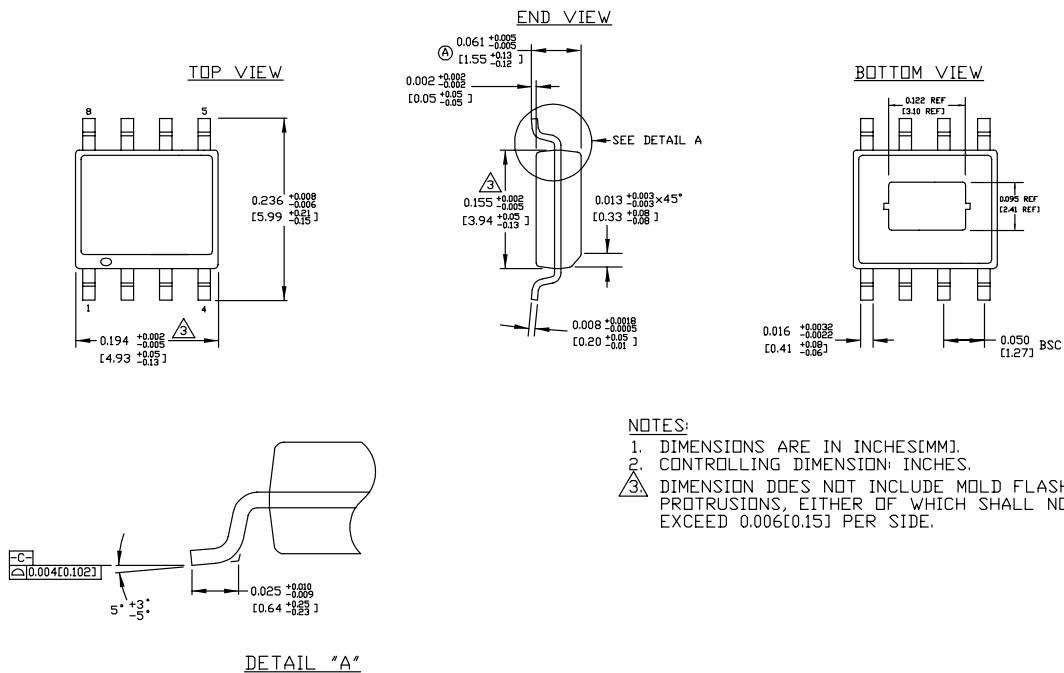
Package Information



	INCHES		MILLIMETERS	
A	0.365	0.375	9.27	9.52
A1	0.350	0.360	8.89	9.14
B	0.310	0.320	7.87	8.13
C	0.070	0.080	1.78	2.03
D	0.025	0.031	0.63	0.79
E	0.010	BSC	0.25	BSC
G	0.067	BSC	1.70	BSC
H	0.410	0.420	10.41	10.67
K	0.030	0.050	0.76	1.27
L	0.001	0.005	0.03	0.13
M	0.035	0.045	0.89	1.14
N	0.010	BSC	0.25	BSC
P	0.031	0.041	0.79	1.04
R	0°	6°	0°	6°
U	0.256	BSC	6.50	BSC
V	0.316	BSC	8.03	BSC

- 1. DIMENSION DOES NOT INCLUDE MOLD FLASH OR PROTRUSIONS.
- 2. DIMENSION INCLUDES PLATING THICKNESS

5-Pin S-PAK (R)



- 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 0.006[0.15] PER SIDE.

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