MIC69502

5A, Low V_{IN}, Low V_{OUT} µCap LDO Regulator

Features

- Input Voltage Range: V_{IN}: 1.65V to 5.5V
- ± 1.0% Initial Output Tolerance
- Maximum Dropout (V_{IN} - V_{OUT}) of 500 mV Overtemperature
- Adjustable Output Voltage down to 0.5V
- Stable with 10 µF Ceramic Output Capacitor (5A)
- Excellent Line and Load Regulation Specifications
- Logic Controlled Shutdown
- Thermal Shutdown and Current Limit Protection
- 7-Pin S-Pak Package
- –40°C to +125°C Junction Temperature

Applications

- ASIC Core Voltage Regulator
- PLD/FPGA Core Power Supply
- Linear Point-of-Load Conversion
- High-Speed Post-Regulator

General Description

The MIC69502 is a 5A, low dropout linear regulator that provides low voltage high current outputs with a minimum of external components. It offers high precision and ultra low dropout of 500 mV under worst case conditions.

The MIC69502 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.). The MIC69502 output is adjustable to a minimum of 0.5V.

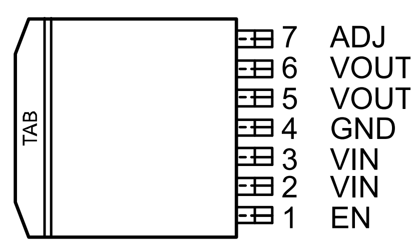
The µCap design of the MIC69502 is optimized for stability with low value low-ESR ceramic output capacitors.

Protection features of the MIC69502 include thermal shutdown and current limit protection. Logic enable and error flag pins are also available.

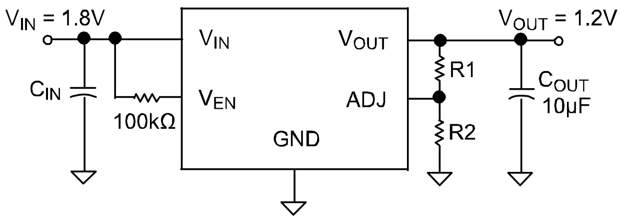
The MIC69502 is offered in the space-efficient S-PAK package. It has an operating temperature range of –40°C to +125°C.

Package Type

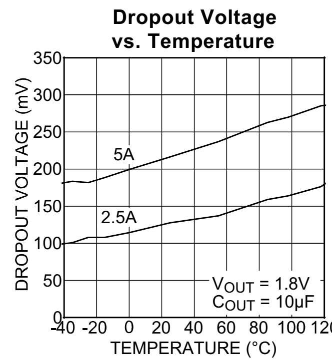
7-Pin S-PAK (R)



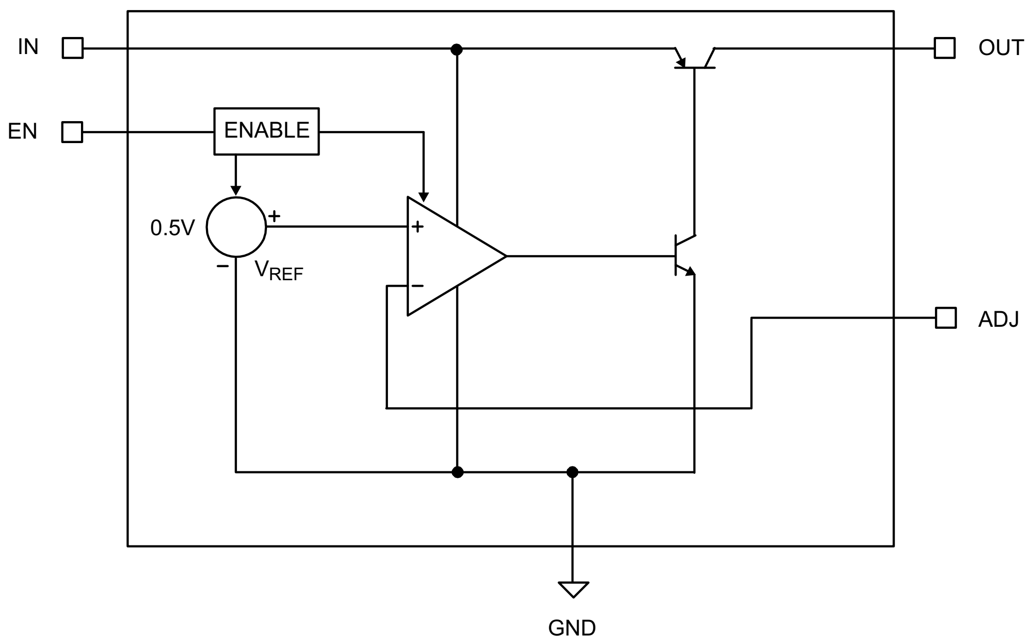
Typical Application Circuits



Adjustable Regulator



Functional Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Input Voltage (V_{IN}) .... +6.0V
Enable Input Voltage (V_{EN}) .... V_{IN}
Power Dissipation (P_D) .... Internally Limited (Note 1)
Junction Temperature (T_J) .... –40°C ≤ T_J ≤ +125°C

Operating Ratings ‡

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-7 (θ_{JC}) .... 2°C/W

† **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.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: T_A = 25°C, $V_{IN} = V_{OUT}$ + 1V. **Bold** values indicate –40°C ≤ T_J ≤ +125°C; I_{OUT} = 10 mA; unless otherwise specified. Specification for packaged product only.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Output Voltage Accuracy	—	–1	—	1	%	At 25°C
		–2	—	**+2**	%	Overtemperature range
Output Voltage Line Regulation (Note 1)	—	—	0.2	0.5	%	$V_{IN} = V_{OUT}$ +1.0V to 5.5V
Output Voltage Load Regulation	—	—	0.2	—	%	I_L = 10 mA to 5A
$V_{IN} – V_O$; Dropout Voltage (Note 2)	—	—	160	**300**	mV	I_L = 2.5A
	—	—	250	**500**		I_L = 5A
Output Voltage Line Regulation	—	—	1	**5**	mA	I_L = 10 mA
	—	—	3	**10**		I_L = 500 mA
	—	—	20	**50**		I_L = 2.5A
	—	—	54	**150**		I_L = 5A
Ground Pin Current in Shutdown	—	—	5	**10**	µA	V_{EN} = 0V
Current Limit	—	**5.5**	10	—	A	
Start-Up Time	—	—	50	**150**	µs	$V_{EN} = V_{IN}$

Note 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.

ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: T_A = 25°C, $V_{IN} = V_{OUT}$ + 1V. **Bold** values indicate –40°C ≤ T_J ≤ +125°C; I_{OUT} = 10 mA; unless otherwise specified. Specification for packaged product only.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Input						
Enable Input Threshold	—	**0.8**	0.6	—	V	Regulator enable
	—	—	—	**0.2**		Regulator shutdown
Enable Pin Input Current	—	—	1	—	µA	V_{IN} ≤ 0.2V (Regulator shutdown)
	—	—	100	—		V_{IN} ≤ 0.8V (Regulator enable)
Overtemperature Shutdown	—	—	160	—	°C	—
Overtemperature Shutdown Hysteresis	—	—	20	—	°C	—

Note 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.

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.

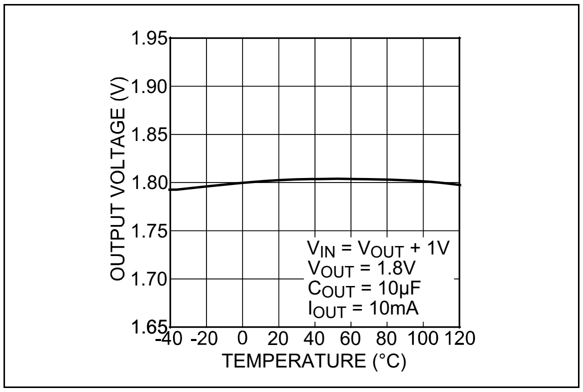


FIGURE 2-1: *Output Voltage vs. Temperature.*

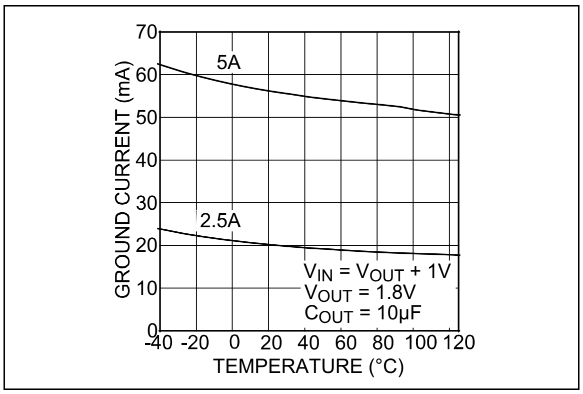


FIGURE 2-2: *Ground Current vs. Temperature.*

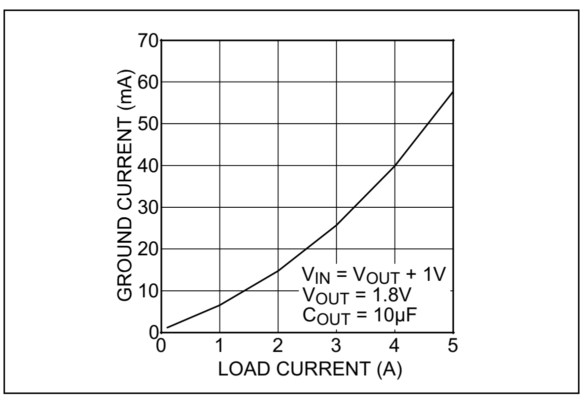


FIGURE 2-3: *Ground Current vs. Load Current.*

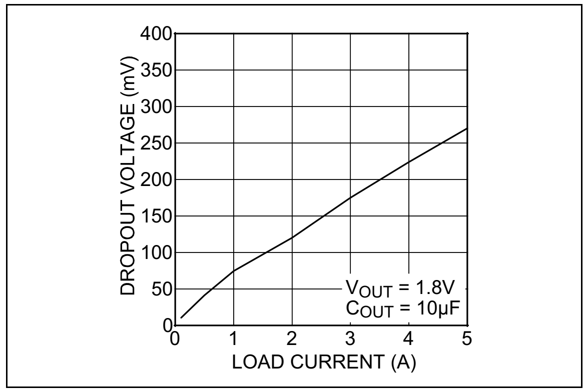


FIGURE 2-4: *Dropout Current vs. Load Current.*

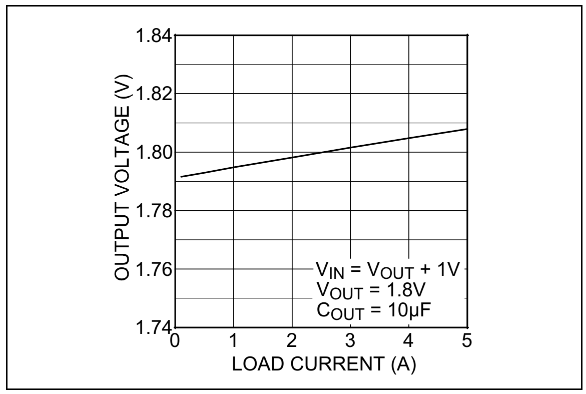


FIGURE 2-5: *Output Voltage vs. Load Current.*

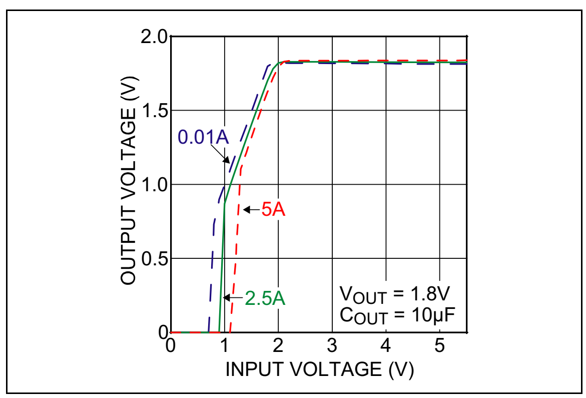


FIGURE 2-6: *Output Voltage vs. Input Voltage.*

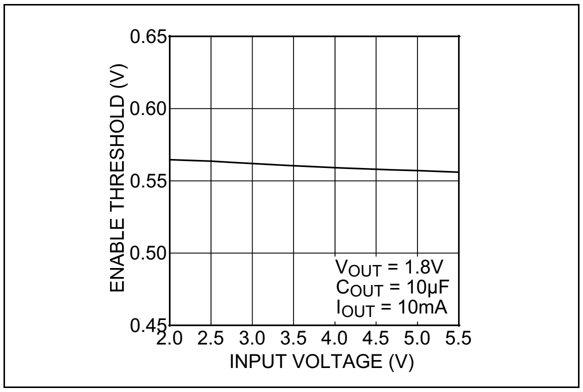


FIGURE 2-7: *Enable Threshold vs. Input Voltage.*

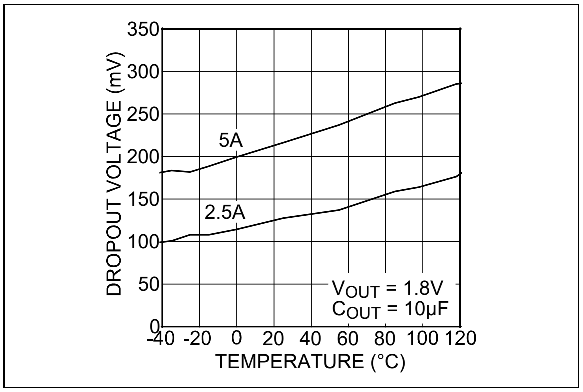


FIGURE 2-8: *Dropout Voltage vs. Temperature.*

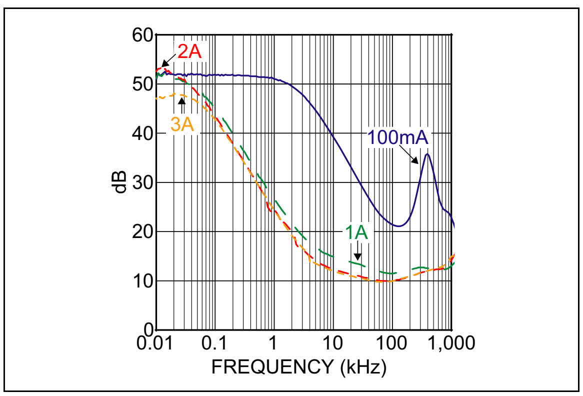


FIGURE 2-9: *Power Supply Rejection Ratio.*

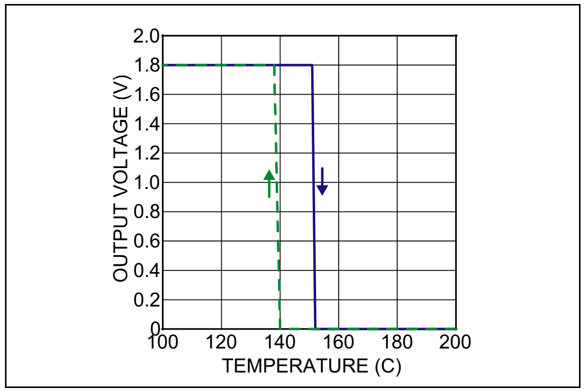


FIGURE 2-10: *Thermal Shutdown.*

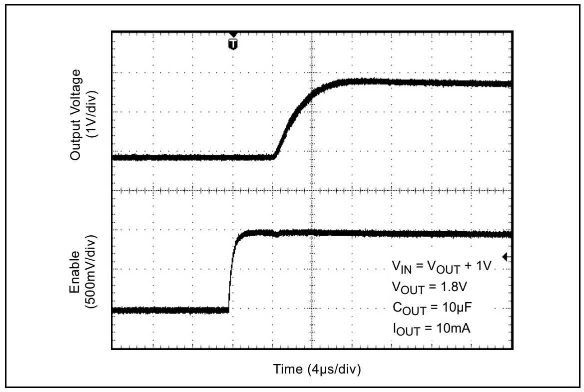


FIGURE 2-11: *Enable.*

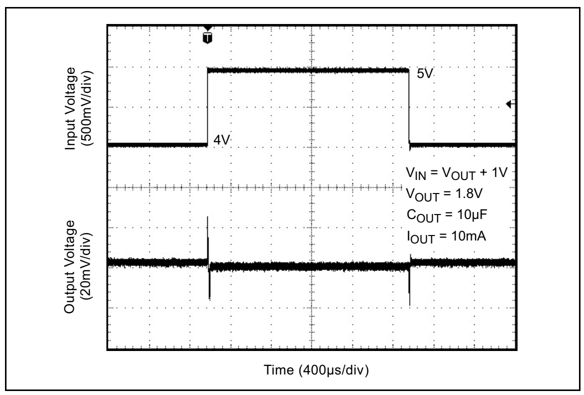


FIGURE 2-12: *Line Transient.*

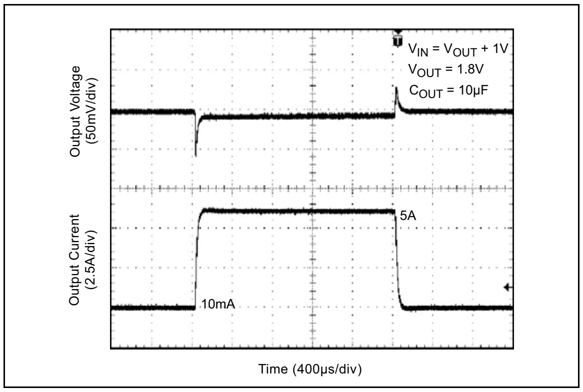


FIGURE 2-13: *Load Transient.*

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. Do not float.
2, 3	VIN	Input voltage which supplies current to the output power device.
4	GND	Ground (TAB is connected to ground on S-Pak).
5, 6	VOUT	Regulator Output.
7	ADJ	Adjustable regulator feedback input. Connect to resistor voltage divider. Applies only to adjustable output voltage parts.

4.0 APPLICATIONS INFORMATION

The MIC69502 is an ultra-high performance low dropout linear regulator designed for high current applications requiring fast transient response. It utilizes a single input supply and has very low dropout voltage perfect for lowvoltage DC-to-DC conversion. The MIC69502 requires a minimum of external components. As a µCap regulator the output is tolerant of virtually any type of capacitor including ceramic and tantalum.

The MIC69502 regulator is fully protected from damage due to fault conditions offering constant current limiting and thermal shutdown.

4.1 Input Supply Voltage

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

4.2 Output Capacitor

The MIC69502 requires a minimum of output capacitance to maintain stability. However, proper capacitor selection is important to ensure desired transient response. The MIC69502 is specifically designed to be stable with a wide range of capacitance values and ESR. A 10 µF ceramic chip capacitor should satisfy most applications. See Section 2.0, Typical Performance Curves 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.

4.3 Inductor Capacitor

An input capacitor of 1 µF 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” 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 Minimum Load Current

The MIC69502 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 MIC69502 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:

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

Where V_{OUT} is the desired output voltage.

4.6 Enable

The MIC69502 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. The EN input has TTL/CMOS compatible thresholds for simple logic interfacing. EN may be directly tied to VIN 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.

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

where the ground current is approximated by using numbers from the Electrical Characteristics or Typical Performance Curves 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 $T_{J(MAX)} \leq 125°C$ and θ_{CS} is between 0°C and 2°C/W.

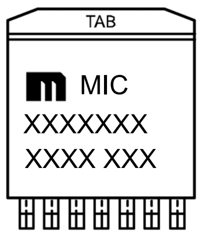
The heat sink may be significantly reduced in applications where the minimum input voltage is known and is large compared with the dropout voltage. Use a series input resistor to drop excessive voltage and distribute the heat between this resistor and the regulator. The low dropout properties of Micrel Super βeta 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 µF 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.

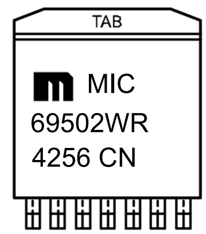
5.0 PACKAGING INFORMATION

5.1 Package Marking Information

7-Pin S-PAK



Example



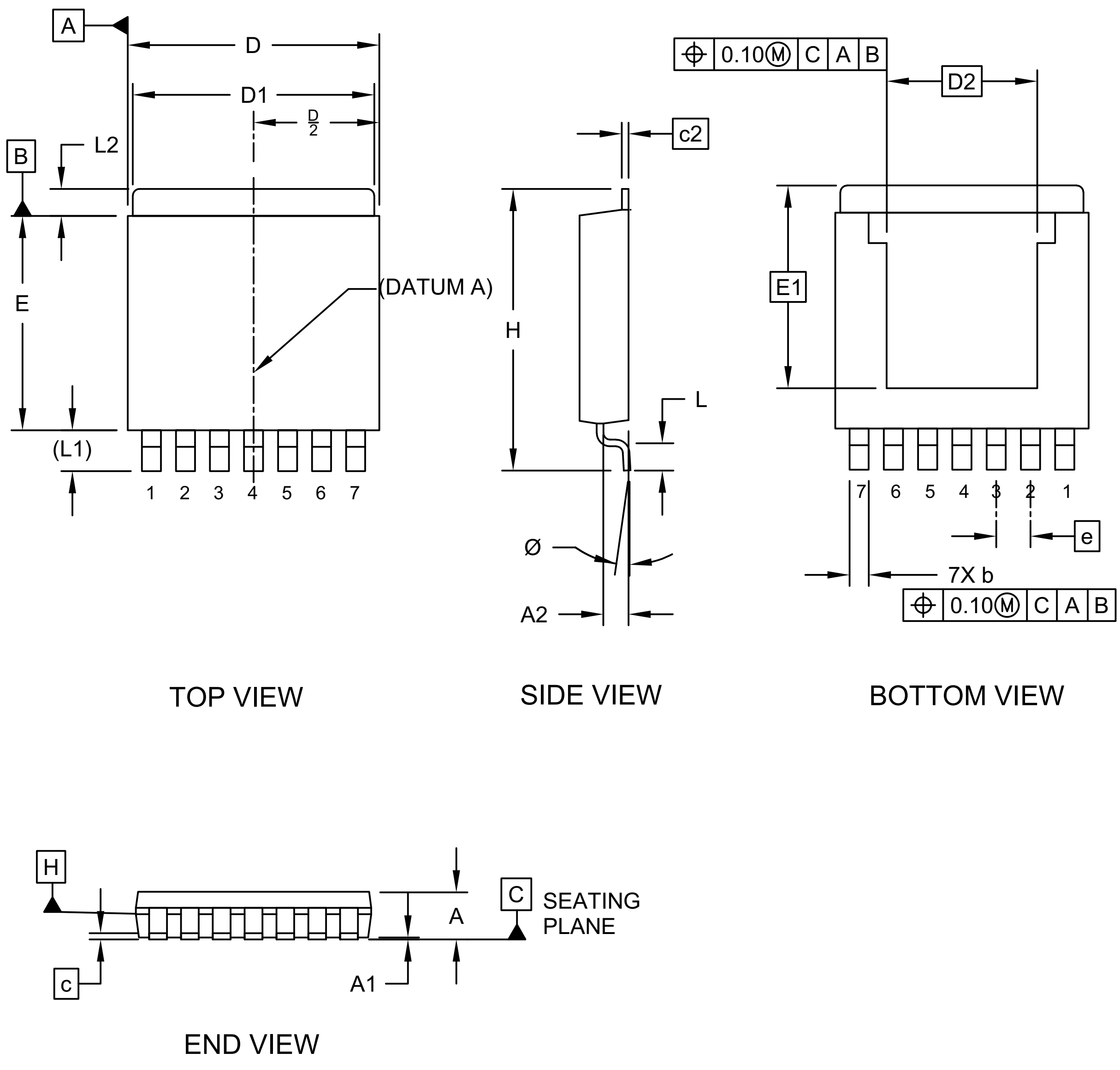
Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package 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.

7-Lead Plastic [Surface] Flange-Mount Package (8CA) - [SPAK]

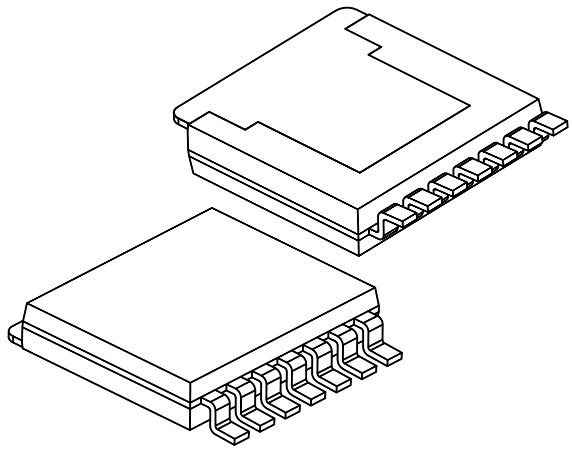
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-1143 Rev A Sheet 1 of 2

7-Lead Plastic [Surface] Flange-Mount Package (8CA) - [SPAK]

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	7		
Pitch	e	1.27 BCS		
Overall Height	A	1.78	–	2.03
Seating Plane Height	A1	0.03	–	0.13
Seating Plane to Lead	A2	0.89	–	1.14
Lead Width	b	0.63	–	0.79
Lead Thickness	c	0.25 BSC		
Thermal Pad Thickness	c2	0.25 BCS		
Foot Length	L	0.79	–	1.04
Lead Length	L1	1.53 REF		
Tab Length	L2	0.76	–	1.27
Overall Length	H	10.41	–	10.67
Molded Body Length	D	9.27	–	9.52
Thermal Pad Length	D1	8.89	–	9.14
Exposed Pad Length	D2	5.58 BSC		
Molded Body Width	E	7.87	–	8.13
Exposed Pad Width	E2	7.52 BSC		
Lead Foot Angle	Ø	0°	–	6°

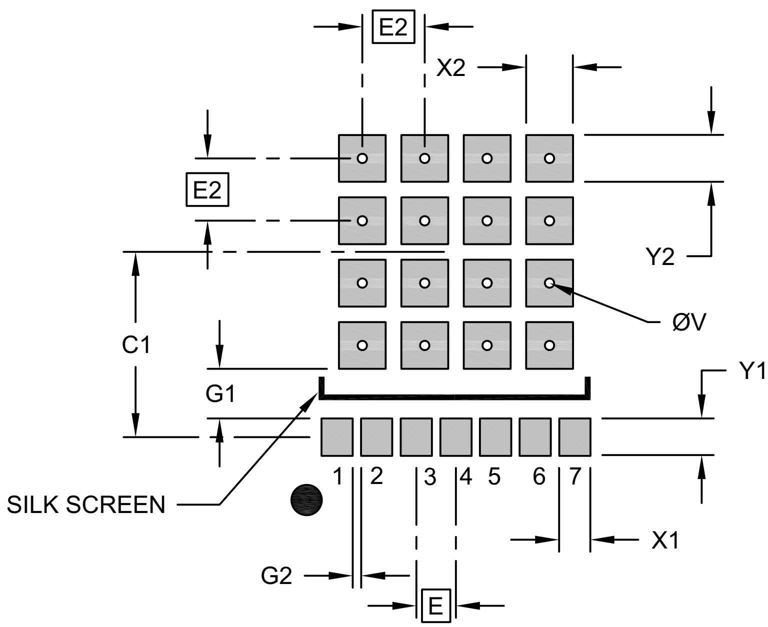
Notes:

1. 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 C04-1143 Rev A Sheet 2 of 2

7-Lead Plastic [Surface] Flange-Mount Package (8CA) - [SPAK]

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 and Via Pitch	E2	2.00 BSC		
Center Pad Width (X16)	X2			1.50
Center Pad Length (X16)	Y2			1.50
Contact Pad Spacing	C1		6.45	
Contact Pad Width (X7)	X1			1.05
Contact Pad Length (X7)	Y1			1.25
Contact Pad to Center Pad (X7)	G1	1.57		
Contact Pad to Contact Pad (X6)	G2	0.27		
Thermal Via Diameter	ØV	0.30		

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 C04-3143 Rev A

APPENDIX A: REVISION HISTORY

Revision A (December 2023)

- Converted Micrel document MIC69502 to Microchip data sheet DS20006836A.
- 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.	XX	X	XX	-XX
Device	Output Voltage	Junction Temperature Range	Package Option	Media Type

Device:	MIC69502: 5A, Low V_{IN}, Low V_{OUT} μCap LDO Regulator		
Output Voltage:	Blank	=	Adjustable
Junction Temperature Range:	W	=	–40°C to +125°C
Package:	R	=	7-Pin 9.5 mm x 8 mm x 2 mm SPAK
Media Type:	Blank TR	= =	48/Tube 750/Reel

Note: Other output voltage options are available. Contact Factory for details.

Examples:

a) MIC69502WR: 5A, Low VIN, Low VOUT μCap LDO Regulator, Adjustable Output Voltage, –40°C to +125°C Junction Temperature Range, 7-Pin SPAK Package

b) MIC69502WR-TR: 5A, Low VIN, Low VOUT μCap LDO Regulator, Adjustable Output Voltage, –40°C to +125°C Junction Temperature Range, 7-Pin SPAK Package, 750/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:

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