MIC4690

500 kHz, 1A SuperSwitcher™ Buck Regulator

Features

- SOIC-8 Package with Over 1A Output Current
- Fixed 500 kHz Operation
- Wide 4V to 34V Input Voltage Range
- Output Voltage Adjustable to 1.23V
- All Surface Mount Solution
- Internally Compensated with Fast Transient Response
- Up to 85% Efficiency
- Overcurrent Protection
- Frequency Foldback Short-Circuit Protection
- Thermal Shutdown

Applications

- Simple 1A Step-Down (Buck) Regulator
- Replacement of TO-220 and TO-263 Designs
- 12V to 5V/3.3V/2.5V/1.8V/1.5V Conversion
- 5V to 2.5V/1.8V/1.5V Conversion
- On-Card Switching Regulators
- Hard Disk Drives
- Cable Modems
- Positive-to-Negative Converters
- Simple Battery Chargers

General Description

The MIC4690 SuperSwitcher™ is an easy-to-use, 500 kHz step-down PWM voltage regulator. The MIC4690 achieves over 1A of continuous output current over a wide input voltage range in an 8-lead SOIC (small outline integrated circuit) package.

The high switching frequency of the MIC4690 allows the smallest surface-mount inductors and capacitors to be used. Internal compensation ensures fast transient response and a minimum amount of external components.

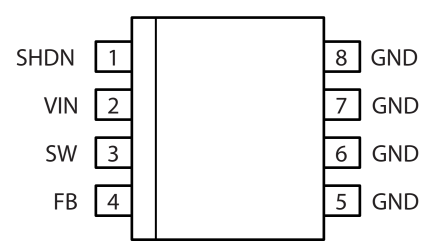
The MIC4690 features a power SOIC-8 package with a special lead frame that allows over 1A of continuous current. The MIC4690, housed in an SOIC-8, can replace larger TO-220 and TO-263 packages in many applications.

The MIC4690 allows for a high degree of safety. It has a wide input voltage range of 4V to 34V, allowing for it to be used in applications where input voltage transients may be present. Built-in safety features include overcurrent protection, frequency foldback protection, and thermal shutdown.

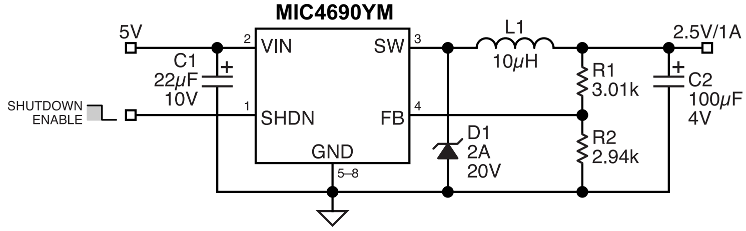
The MIC4690 is available in an 8-lead SOIC package with a junction temperature range of –40°C to +125°C.

Package Type

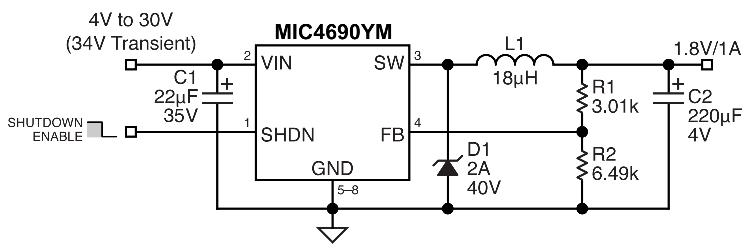
MIC4690
8-Lead SOIC (M)
(Top View)



Typical Application Circuits

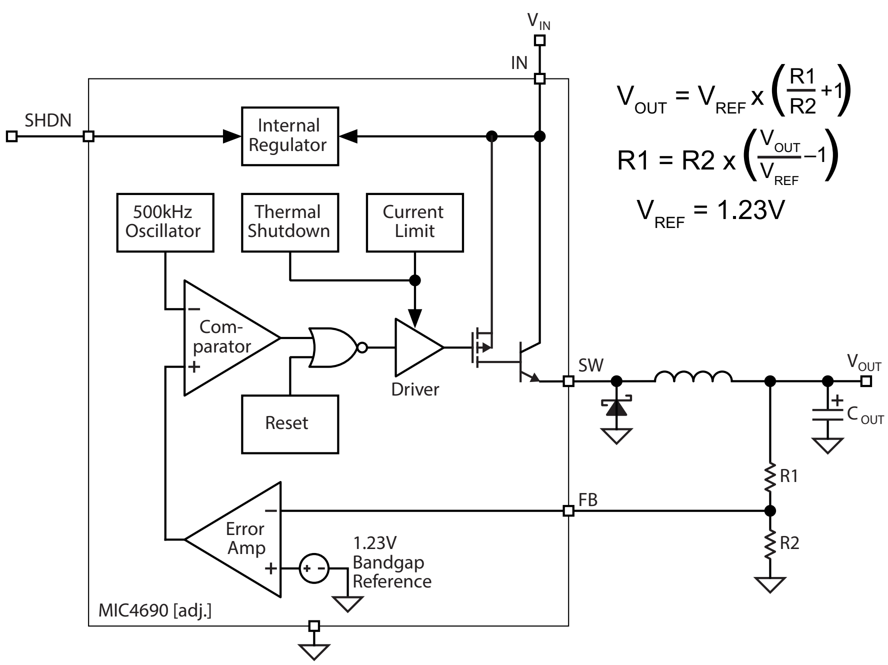


2.5V Adjustable Converter



1.8V Adjustable Converter

Functional Block Diagram



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Supply Voltage (V_{IN}, Note 1)....................+34V
Shutdown Voltage (V_{SHDN})....................–0.3V to V_{IN}
Steady-State Output Switch Voltage (V_{SW})....................–1V to V_{IN}
Feedback Voltage (V_{FB})....................+12V
ESD Rating.................... (Note 2)

Operating Ratings ‡

Supply Voltage (V_{IN}).................... +4V 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: Absolute maximum rating is intended for voltage transients only. Prolonged DC operation is not recommended.

2: Device is ESD sensitive. Handling precautions are recommended.

ELECTRICAL CHARACTERISTICS

V_{IN} = 12V, V_{OUT} = 5V; I_{LOAD} = 500 mA; V_{SHDN} = 0V, T_J = +25°C, unless otherwise noted. **Bold** values valid for –40°C ≤ T_J ≤ +125°C.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Feedback Voltage	V_{FB}	1.217	1.230	1.243	V	±1%
		1.205	—	**1.255**		±2%
		1.193	1.230	1.267		8V ≤ V_{IN} ≤ 30V, 0.1A ≤ I_{LOAD} ≤ 1A, V_{OUT} = 5V
		1.180	—	**1.280**		
Maximum Duty Cycle	DC_{MAX}	90	93	—	%	V_{FB} = 1.0V
Quiescent Current	I_Q	—	7	**12**	mA	V_{FB} = 1.5V
Standby Quiescent Current		—	30	100	µA	V_{SHDN} = 5V (regulator off)
		—	1.5	—	µA	V_{SHDN} = 12V (regulator off)
Frequency Foldback		—	220	300	kHz	V_{FB} = 0V
Oscillator Frequency	f_{OSC}	450	500	550	kHz	—
Saturation Voltage	V_{SAT}	—	1.2	—	V	I_{OUT} = 1A
Output Leakage Current	I_{LEAK}	—	50	500	µA	V_{IN} = 30V, V_{SHDN} = 5V, V_{SW} = 0V
		—	4	20	mA	V_{IN} = 30V, V_{SHDN} = 5V, V_{SW} = –1V
Short Circuit Current Limit	$I_{LIM(SC)}$	1.3	2.5	3.0	A	V_{FB} = 0V, V_{OUT} = 0V, See Figure 1-1
Shutdown Pin Input Logic Level	V_{SHDN}	**2**	1.5	—	V	Regulator off
		—	1.25	**0.8**		Regulator on
Shutdown Pin Input Current	I_{SHDN}	–10	–0.7	10	µA	V_{SHDN} = 5V (regulator off)
		–10	–1.5	10		V_{SHDN} = 0V (regulator on)
Thermal Shutdown @ T_J	T_{SHDN}	—	160	—	°C	—

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	—
Package Thermal Resistances						
Thermal Resistance, SOIC 8-Ld	θ_{JA}	—	63	—	°C/W	Note 1
	θ_{JC}	—	20	—	°C/W	—

Note 1: Measured on 1" square of 1 oz. copper FR4 printed circuit board connected to the device ground leads.

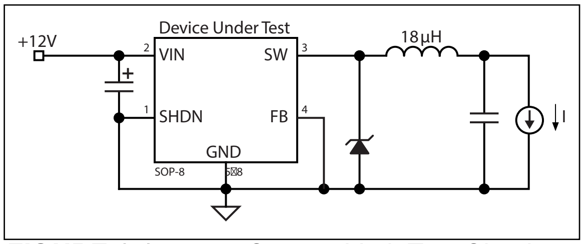


FIGURE 1-1: *Current Limit Test Circuit.*

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.

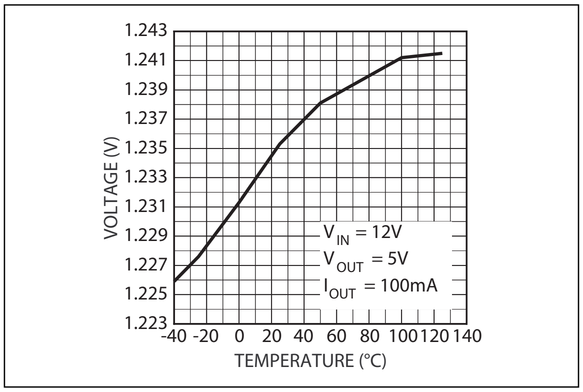


FIGURE 2-1: *Reference Voltage vs. Temperature.*

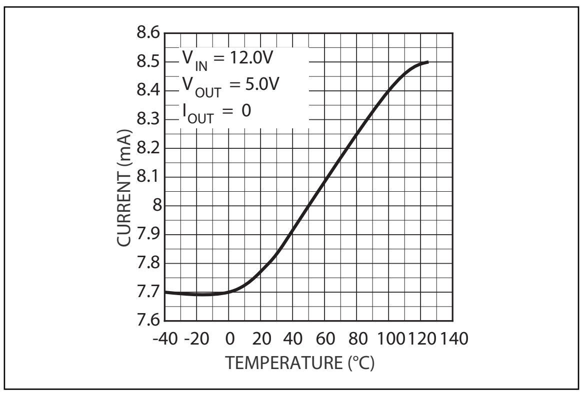


FIGURE 2-2: *Quiescent Current vs. Temperature.*

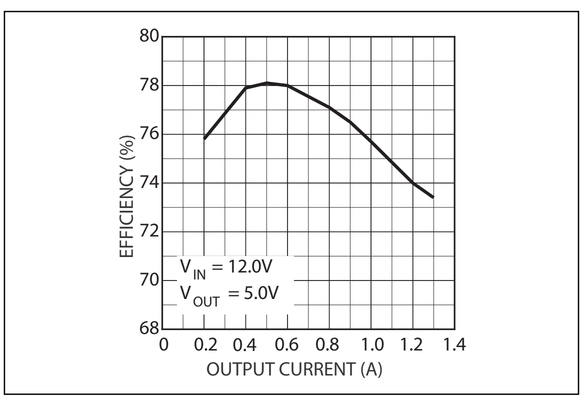


FIGURE 2-3: *Efficiency vs. Output Current.*

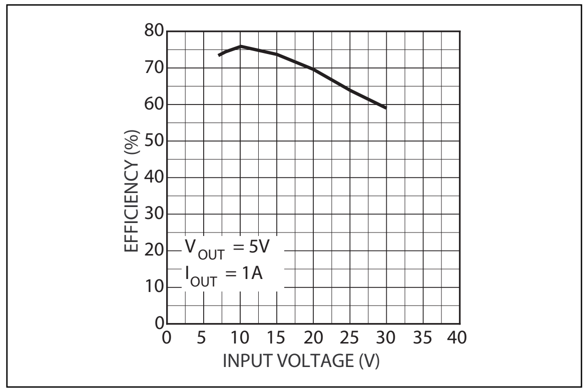


FIGURE 2-4: *Efficiency vs. Input Voltage.*

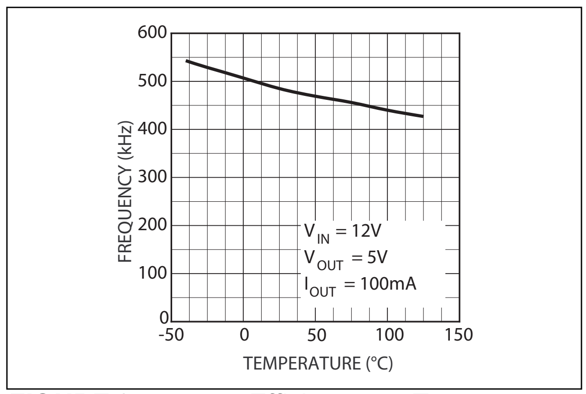


FIGURE 2-5: *Efficiency vs. Temperature.*

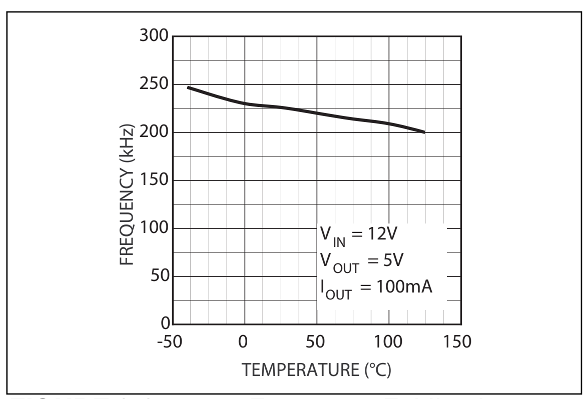


FIGURE 2-6: *Frequency Foldback vs. Temperature.*

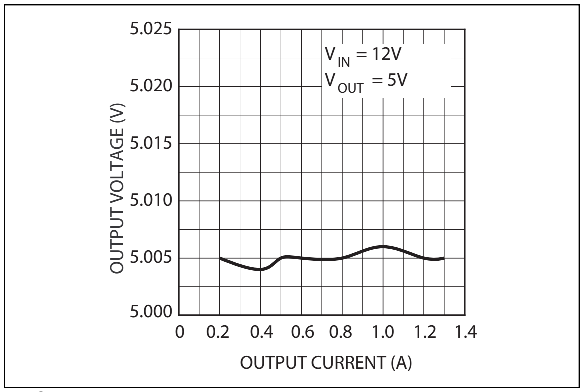


FIGURE 2-7: *Load Regulation.*

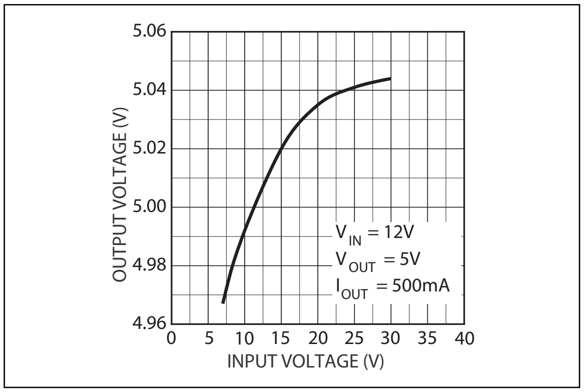


FIGURE 2-8: *Line Regulation.*

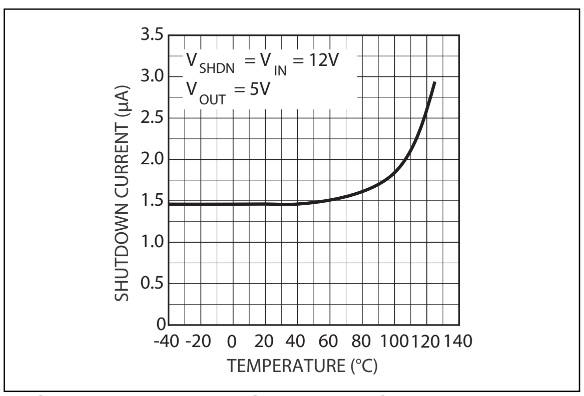


FIGURE 2-9: *Shutdown Current vs. Temperature.*

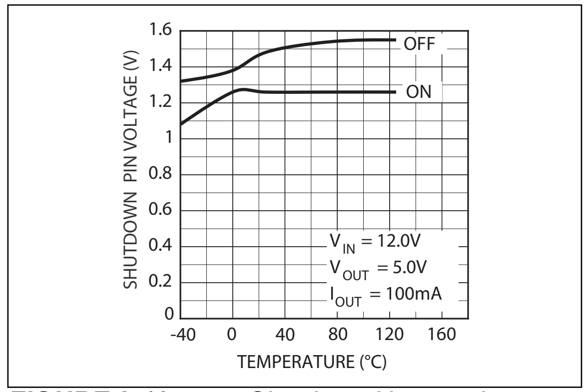


FIGURE 2-10: *Shutdown Hysteresis vs. Temperature.*

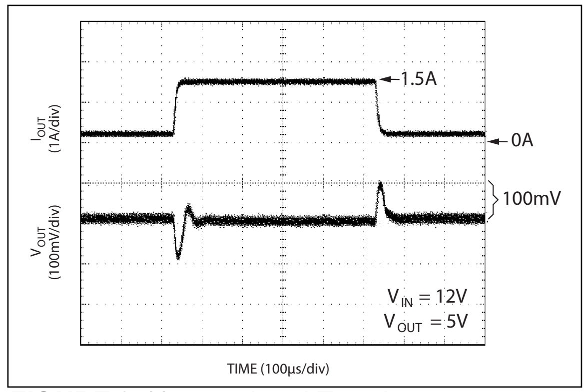


FIGURE 2-11: *Load Transient.*

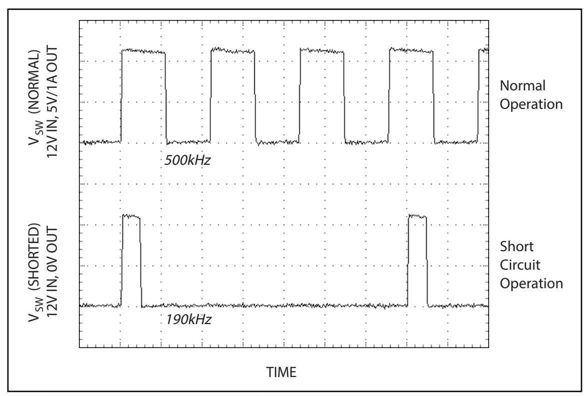


FIGURE 2-12: *Switching Frequency Foldback.*

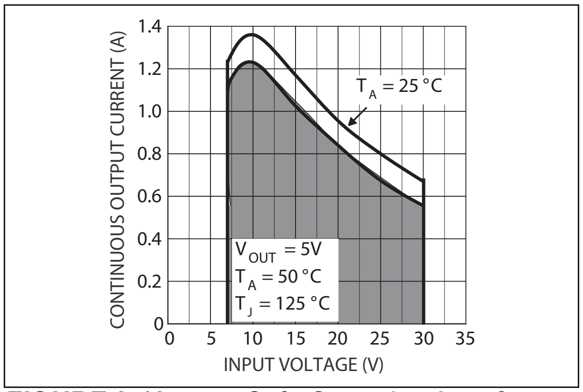


FIGURE 2-13: *Safe Operating Area for MIC4690.*

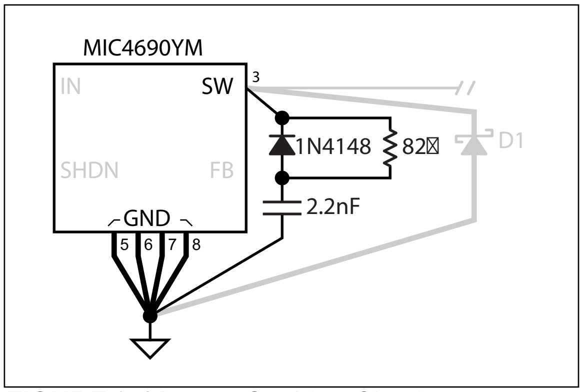


FIGURE 2-14: *Snubber Circuit.*

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	SHDN	Shutdown (Input): Logic low enables the regulator. Logic high (>1.5V) shuts down the regulator.
2	VIN	Supply Voltage (Input): Unregulated +4V to +30V continuous supply voltage with a maximum +34V transient voltage.
3	SW	Switch (Output): Emitter of NPN output switch. Connect to external storage inductor and Schottky diode.
4	FB	Feedback (Input): Connect to output on fixed output voltage versions or to 1.23V-tap of voltage-divider network for adjustable voltage version.
5, 6, 7, 8	GND	Ground.

4.0 FUNCTIONAL DESCRIPTION

The MIC4690 is a variable duty cycle switch-mode regulator with an internal power switch. Refer to the Functional Block Diagram.

4.1 Supply Voltage

The MIC4690 operates from a +4V to +30V (transients to +34V) unregulated input. Highest efficiency operation is from a supply voltage around +12V. See Figure 2-4.

4.2 Enable/Shutdown

The Shutdown (SHDN) input is TTL-compatible. A logic-low enables the regulator. A logic-high shuts down the internal regulator, which reduces the current to typically 1.5 µA when $V_{SHDN} = V_{IN}$ = 12V and 30 µA when V_{SHDN} = 5V. See Figure 4-1.

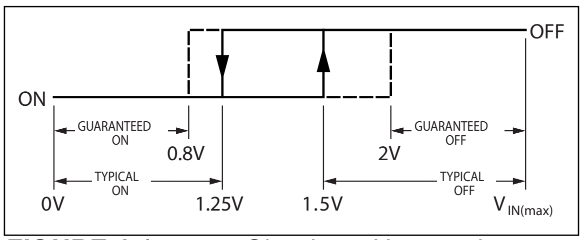


FIGURE 4-1: *Shutdown Hysteresis.*

4.3 Feedback

Fixed-voltage versions of the MIC4690 have an internal resistive divider from the Feedback (FB) pin. Connect FB directly to the output voltage.

Adjustable versions require an external resistive voltage divider from the output voltage to ground, center tapped to the FB pin. See Table 5-1 for recommended resistor values.

4.4 Duty Cycle Control

A fixed-gain error amplifier compares the feedback signal with a 1.23V bandgap voltage reference. The resulting error amplifier output voltage is compared to a 500 kHz sawtooth waveform to produce a voltage-controlled variable duty cycle output.

A higher feedback voltage increases the error amplifier output voltage. A higher error amplifier voltage (comparator inverting input) causes the comparator to detect only the peaks of the sawtooth, reducing the duty cycle of the comparator output. A lower feedback voltage increases the duty cycle. The MIC4690 uses a voltage-mode control architecture.

4.5 Output Switching

When the internal switch is ON, an increasing current flows from the supply V_{IN}, through external storage inductor L1, to output capacitor C_{OUT} and the load. Energy is stored in the inductor as current increases with time.

When the internal switch is turned OFF, the collapse of the magnetic field in L1 forces current to flow through fast recovery diode D1, charging C_{OUT}.

4.6 Output Capacitor

External output capacitor C_{OUT} provides stabilization and reduces ripple.

4.7 Return Paths

During the switch-on time, the output capacitor and load currents return to the supply ground. During the switching cycle's off period, current is being supplied to the output capacitor and load by storage inductor L1, which means that D1 is part of the high-current return path.

5.0 APPLICATIONS INFORMATION

5.1 Adjustable Regulators

Adjustable regulators require a 1.23V feedback signal. Recommended voltage divider resistor values for common output voltages are included in Table 5-1.

For other voltages, the resistor values can be determined using the following formulas.

EQUATION 5-1:

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

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

$$V_{REF} = 1.23V$$

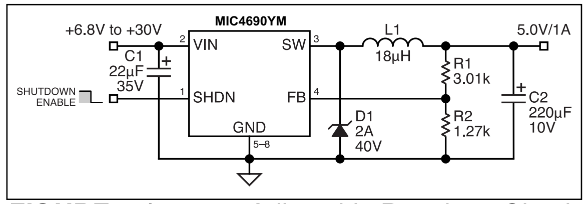


FIGURE 5-1: *Adjustable Regulator Circuit.*

TABLE 5-1: RECOMMENDED COMPONENTS FOR COMMON OUTPUT VOLTAGES

V_{OUT}	R1 (Note 1)	R2 (Note 1)	V_{IN}	C_{IN}	D1	L1	C_{OUT}	I_{OUT}
5.0V	3.01 kΩ	976Ω	6.8V - 30V	22 µF, 35V Vishay-Dale 595D226X0035D2T Micro Commercial	2A, 40V Schottky SS24	18 µH Sumida CDRH6D38NP-180 NC	220 µF, 10V Vishay-Dale 594D227X0010D2T	See SOA
5.0V	3.01 kΩ	976Ω	6.8V - 14V	47 µF, 20V Vishay-Dale 595D476X0020C2T Micro Commercial	2A, 20V Schottky SS22	18 µH Sumida CDRH6D38NP-180 NC	100 µF, 6.3V Vishay-Dale 595D107X06R3C2T	1.0A
3.3V	3.01 kΩ	1.78 kΩ	4.9V - 14V	47 µF, 20V Vishay-Dale 595D476X0020C2T Micro Commercial	2A, 20V Schottky SS22	15 µH Sumida CDRH6D38-150NC	120 µF, 4.0V Vishay-Dale 595D127X0004C2T	1.0A
2.5V	3.01 kΩ	2.94 kΩ	4.25V - 14V	47 µF, 20V Vishay-Dale 595D476X0020C2T Micro Commercial	2A, 20V Schottky SS22	10 µH Sumida CDRH6D38-100NC	120 µF, 4.0V Vishay-Dale 595D127X0004C2T	1.0A
1.8V	3.01 kΩ	6.49 kΩ	4.0V - 14V	47 µF, 20V Vishay-Dale 595D476X0020C2T Micro Commercial	2A, 20V Schottky SS22	10 µH Sumida CDRH6D38-100NC	120 µF, 4.0V Vishay-Dale 595D127X0004C2T	1.0A

Note 1: All resistors 1%.

5.2 Thermal Considerations

The MIC4690 SuperSwitcher™ features a standard 8-lead small-outline package profile, but with much higher power dissipation than a standard SOP-8. Microchip's MIC4690 SuperSwitcher is the first DC/DC converter to take full advantage of this package.

The reason that this package has higher power dissipation (lower thermal resistance) is that Pins 5 through 8 and the die-attach paddle are a single piece of metal. The die is attached to the paddle with thermally conductive adhesive. This provides a low thermal resistance path from the junction of the die to the ground pins. This design significantly improves package power dissipation by allowing excellent heat transfer through the ground leads to the printed circuit board.

One limitation of the maximum output current on any MIC4690 design is the junction-to-ambient thermal resistance (θ_{JA}) of the design (package and ground plane).

Examining θ_{JA} in more detail:

EQUATION 5-2:

$$\theta_{JA} = \theta_{JC} + \theta_{CA}$$

Where:
θ_{JC} = Junction-to-case thermal resistance
θ_{CA} = Case-to-ambient thermal resistance

θ_{JC} is a relatively constant 20°C/W for a power SOIC-8.

θ_{CA} is dependent on layout and is primarily governed by the connection of Pins 5 though 8 to the ground plane. The purpose of the ground plane is to function as a heat sink.

θ_{JA} is ideally 63°C/W, but will vary depending on the size of the ground plane to which the device is attached.

5.2.1 DETERMINING GROUND PLANE HEATSINK AREA

There are two methods of determining the minimum ground plane area required by the MIC4690.

Quick Method:

Make sure that MIC4690 Pins 5 though 8 are connected to a ground plane with a minimum area of 6 cm^2. This ground plane should be as close to the MIC4690 as possible. The area may be distributed in any shape around the package or on any PCB layer *as long as there is good thermal contact to Pins 5 though 8*. This ground plane area is more than sufficient for most designs.

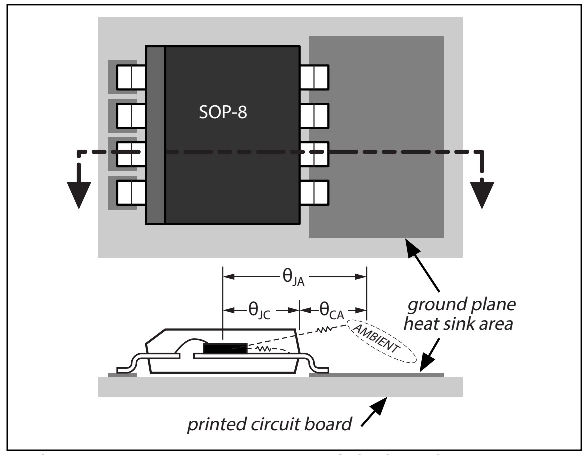


FIGURE 5-2: *Power SOIC-8 Cross Section.*

When designing with the MIC4690, it is a good practice to connect Pins 5 through 8 to the largest ground plane that is practical for the specific design.

Checking the Maximum Junction Temperature:

For this example, with an output power (P_{OUT}) of 5W, (5V output at 1A maximum with V_{IN} = 12V) and 50°C maximum ambient temperature, what is the maximum junction temperature?

Referring to the Figure 2-3, read the efficiency (η) for 1A output current at V_{IN} = 12V or perform your own measurement.

The efficiency (η = 75%) is used to determine how much of the output power (P_{OUT}) is dissipated in the regulator circuit (P_D).

EQUATION 5-3:

$$P_D = \frac{P_{OUT}}{\eta} - P_{OUT}$$

$$P_D = \frac{5W}{0.75} - 5W$$

$$P_D = 1.67W$$

A worst-case rule of thumb is to assume that 80% of the total output power dissipation is in the MIC4690 ($P_{D(IC)}$) and 20% is in the diode-inductor-capacitor circuit.

EQUATION 5-4:

$$P_{D(IC)} = 0.8 \times P_D$$

$$P_{D(IC)} = 0.8 \times 1.67W$$

$$P_{D(IC)} = 1.336W$$

Calculate the worst-case junction temperature:

EQUATION 5-5:

$$T_J = P_{D(IC)} \times \theta_{JC} + (T_C - T_A) + T_{A(MAX)}$$

Where:
T_J = Junction temperature
$P_{D(IC)}$ = MIC4690 power dissipation
θ_{JC} = Junction-to-case thermal resistance (approximately 20°C/W)
T_C = Pin temperature measurement taken at the entry point of Pin 6 or Pin 7
T_A = Ambient temperature
$T_{A(MAX)}$ = Maximum ambient operating temperature for the specific design

Calculating the maximum junction temperature given a maximum ambient temperature of 50°C:

EQUATION 5-6:

$$T_J = 1.336\text{W} \times 20°\text{C/W} + (63°\text{C} - 25°\text{C}) + 50°\text{C}$$

$$T_J = 114.72°\text{C}$$

This value is within the allowable maximum operating junction temperature of 125°C as listed in the Operating Ratings ‡. Typical thermal shutdown is 160°C and is listed in the Electrical Characteristics table.

5.3 Layout Considerations

Layout is very important when designing any switching regulator. Rapidly changing currents through the printed circuit board traces and stray inductance can generate voltage transients that can cause problems.

To minimize stray inductance and ground loops, keep trace lengths, indicated by the heavy lines in Figure 5-3, as short as possible. For example, keep D1 close to Pin 3 and Pins 5 through 8, keep L1 away from sensitive node FB, and keep C_{IN} close to Pin 2 and Pins 5 though 8. See the Thermal Considerations section for ground plane layout.

The feedback pin should be kept as far way from the switching elements (usually L1 and D1) as possible.

A circuit with sample layouts are provided. See Figure 5-4 and Figure 6-1 through Figure 6-4. Gerber files are available upon request.

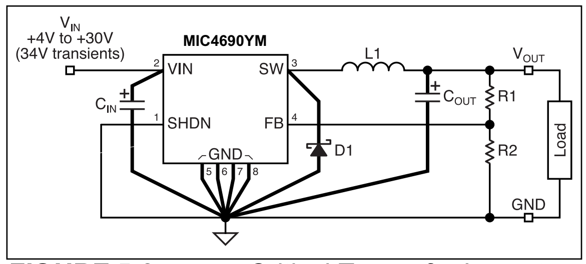


FIGURE 5-3: Critical Traces for Layout.

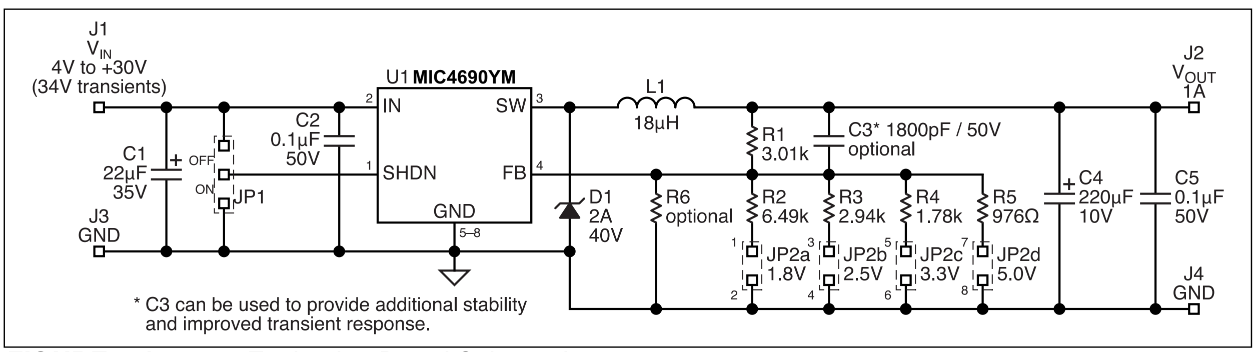


FIGURE 5-4: Evaluation Board Schematic.

6.0 PCB LAYOUTS

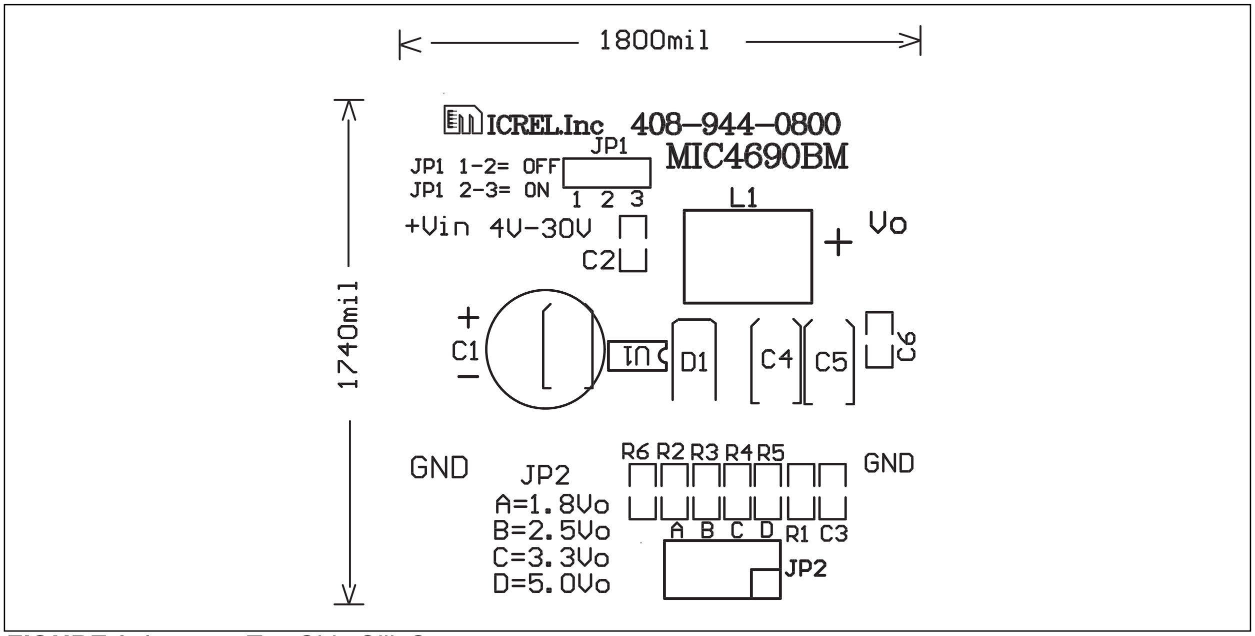


FIGURE 6-1: Top-Side Silk Screen.

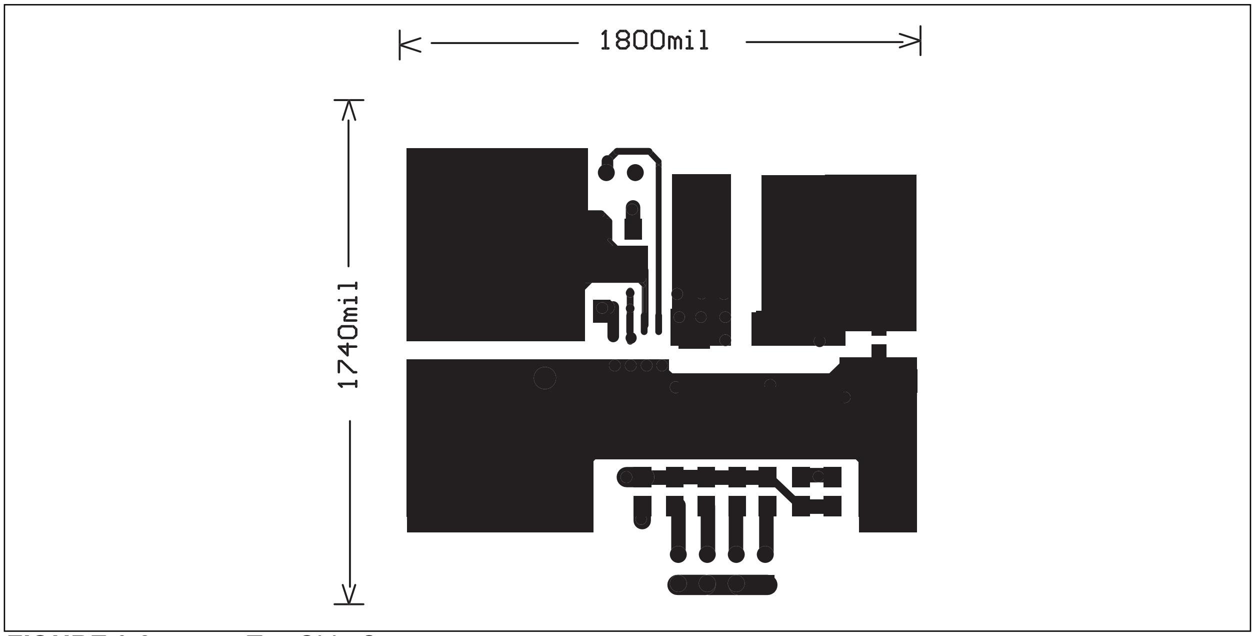


FIGURE 6-2: Top-Side Copper.

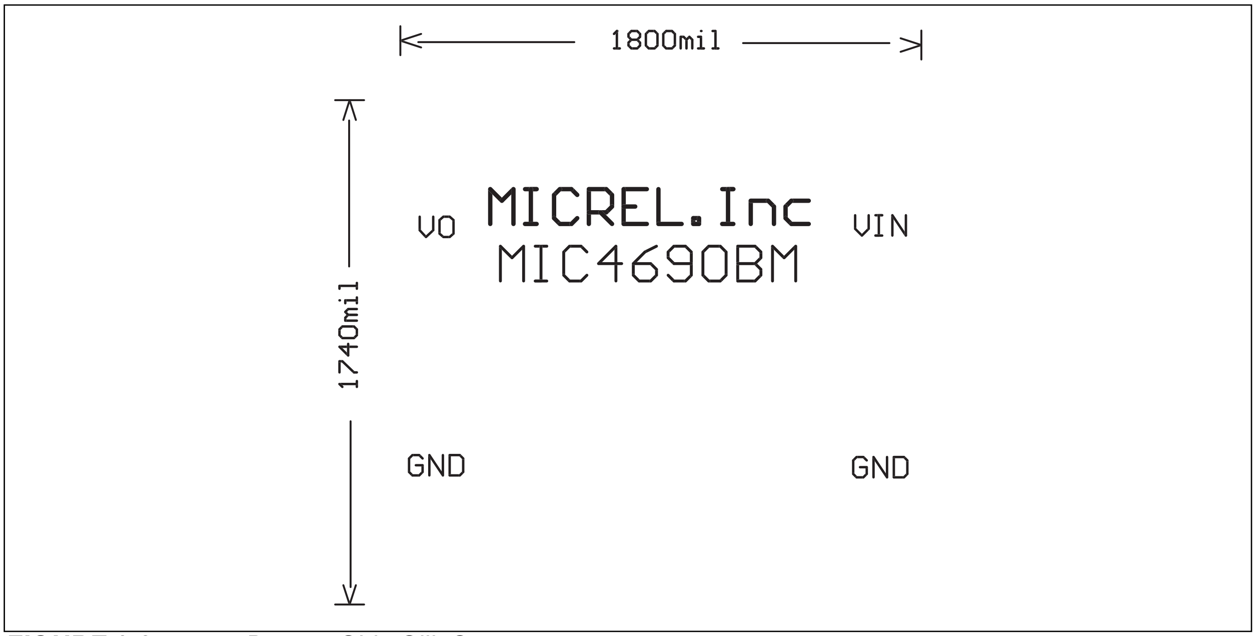


FIGURE 6-3: Bottom-Side Silk Screen.

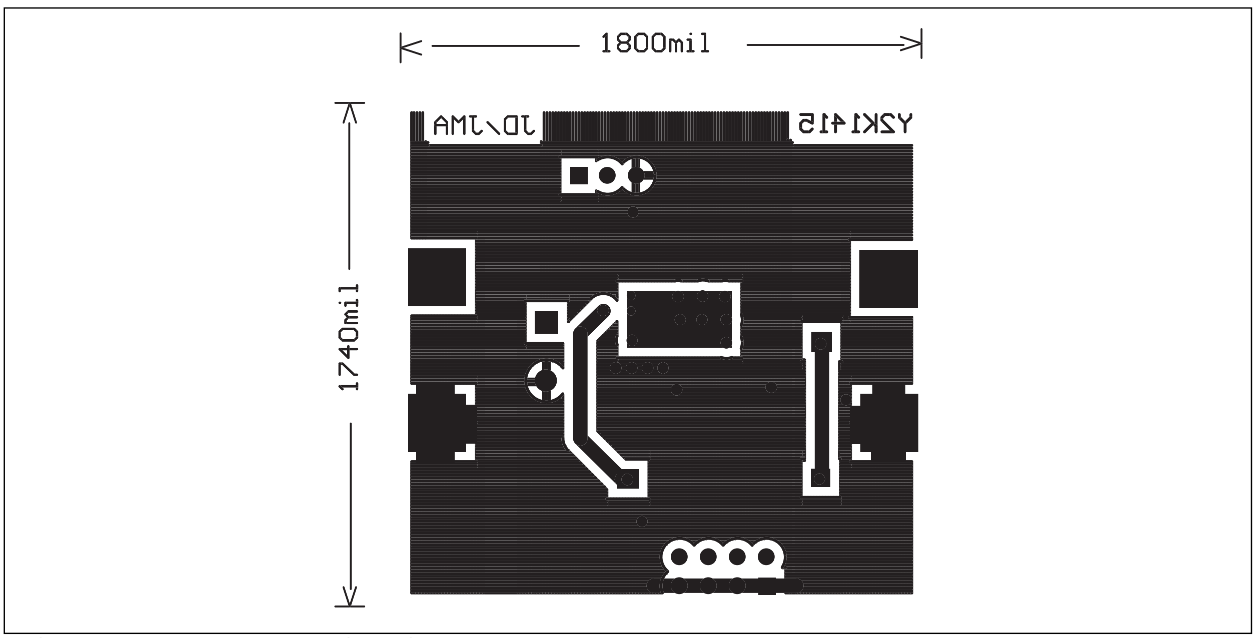
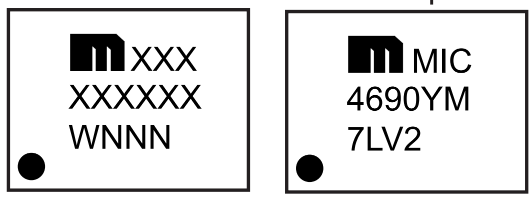


FIGURE 6-4: Bottom-Side Copper.

7.0 PACKAGING INFORMATION

7.1 Package Marking Information

8-Lead SOIC*   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).

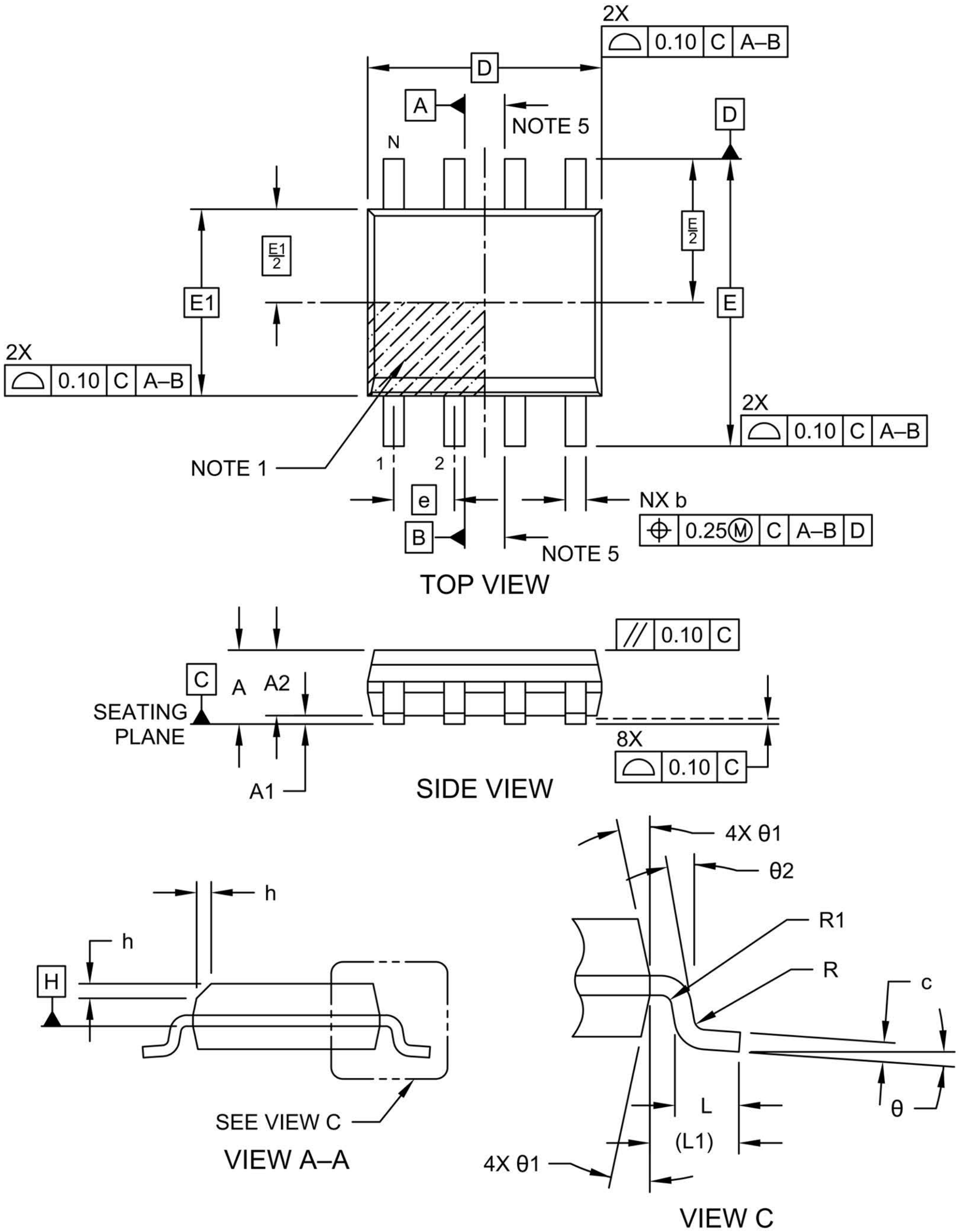
Note: In the event the full Microchip part number cannot be marked on one line, it will be carried over to the next line, thus limiting the number of available characters for customer-specific information. Package may or may not include the corporate logo.

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

8-Lead Plastic Small Outline (EMA) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

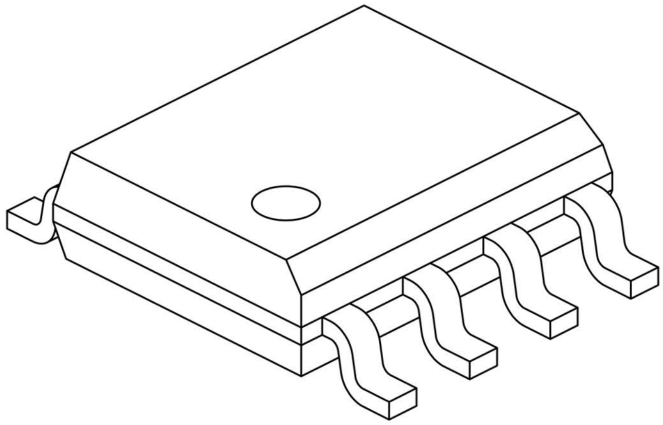
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing No. C04-00057-EMA Rev L Sheet 1 of 2

8-Lead Plastic Small Outline (EMA) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

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



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Pins	N	8		
Pitch	e	1.27 BSC		
Overall Height	A	–	–	1.75
Molded Package Thickness	A2	1.25	–	-
Standoff §	A1	0.10	–	0.25
Overall Width	E	6.00 BSC		
Molded Package Width	E1	3.90 BSC		
Overall Length	D	4.90 BSC		
Chamfer (Optional)	h	0.25	–	0.50
Foot Length	L	0.40	–	1.27
Footprint	L1	1.04 REF		
Lead Thickness	c	0.17	–	0.25
Lead Width	b	0.31	–	0.51
Lead Bend Radius	R	0.07	–	–
Lead Bend Radius	R1	0.07	–	–
Foot Angle	θ	0°	–	8°
Mold Draft Angle	θ1	5°	–	15°
Lead Angle	θ2	0°	–	–

Notes:

1. The Pin 1 visual index feature may vary, but it must be located within the hatched area.
2. § Significant Characteristic
3. Dimensions D and E1 do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.15mm per side.
4. Dimensioning and tolerancing per ASME Y14.5M

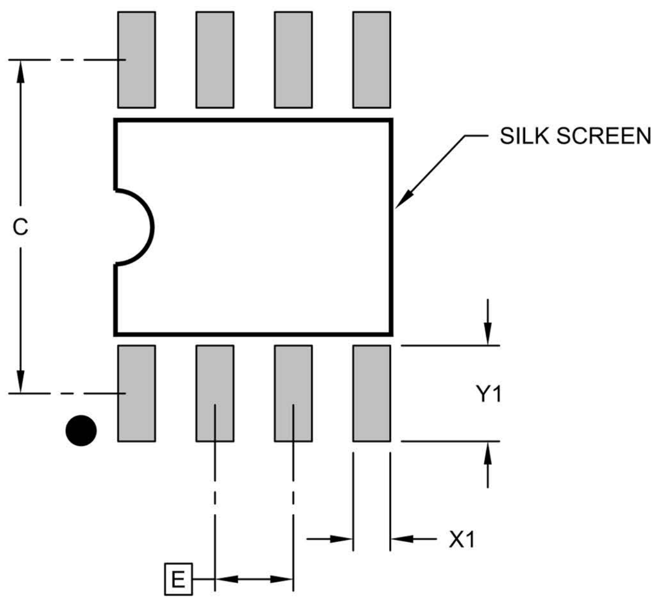
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

   REF: Reference Dimension, usually without tolerance, for information purposes only.
5. Datums A & B to be determined at Datum H.

Microchip Technology Drawing No. C04-00057-EMA Rev L Sheet 2 of 2

8-Lead Plastic Small Outline (EMA) - Narrow, 3.90 mm (.150 In.) Body [SOIC]

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	
Contact Pad Spacing	C		5.40	
Contact Pad Width (X8)	X1			0.60
Contact Pad Length (X8)	Y1			1.55

Notes:

1. Dimensioning and tolerancing per ASME Y14.5M
   BSC: Basic Dimension. Theoretically exact value shown without tolerances.

Microchip Technology Drawing C04-02057-EMA Rev L

APPENDIX A: REVISION HISTORY

Revision A (August 2025)

- Converted Micrel document MIC4690 to Microchip data sheet DS20007033A.
- 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 Number	X	X	-XX
Device	Temp. Range	Package	Media Type

Device:	MIC4690:		500 kHz, 1A SuperSwitcher™ Buck Regulator
Temperature Range:	Y	=	–40°C to +125°C
Package:	M	=	8-Lead SOIC
Media Type:	<blank> TR	= =	95/Tube 2,500/Reel

Examples:

a) MIC4690YM:
MIC4690, –40°C to +125°C Temp. Range, 8-Lead SOIC, 95/Tube

b) MIC4690YM-TR:
MIC4690, –40°C to +125°C Temp. Range, 8-Lead SOIC, 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.

NOTES:

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