MIC94044/5

28 mΩ R_{DSON} 3A High Side Load Switch in 1.2 mm x 1.2 mm UDFN Package

Features

- 28 mΩ R_{DSON}
- 3A Continuous Operating Current
- 1.2 mm x 1.2 mm Space Saving 4-Lead UDFN Package
- 1.7V to 5.5V Input Voltage Range
- Internal Level Shift for CMOS/TTL Control Logic
- Ultra Low Quiescent Current
- Micro-Power Shutdown Current
- Soft-Start: 1 ms
- Load Discharge Circuit: MIC94045
- Ultra Fast Turn Off Time
- Junction Operating Temperature from -40ºC to +125ºC

Applications

- Solid State Drives (SSD)
- Cellular Phones
- Portable Navigation Devices (PND)
- Personal Media Players (PMP)
- Ultra Mobile PCs
- Portable Instrumentation
- Other Portable Applications
- PDAs
- Industrial and DataComm Equipment

General Description

The MIC94044 and MIC94045 are high-side load switches designed to operate from 1.7V to 5.5V input voltage. The load switch pass element is an internal 28 mΩ R_{DSON} P-channel MOSFET which enables the device to support up to 3A of continuous current. Additionally, the load switch supports 1.5V logic level control and shutdown features in a tiny 1.2 mm × 1.2 mm 4-lead UDFN package.

The MIC94044/5 provides a slew rate controlled soft-start turn-on of 1 ms (typical) to prevent an in-rush current event from pulling down the input supply voltage.

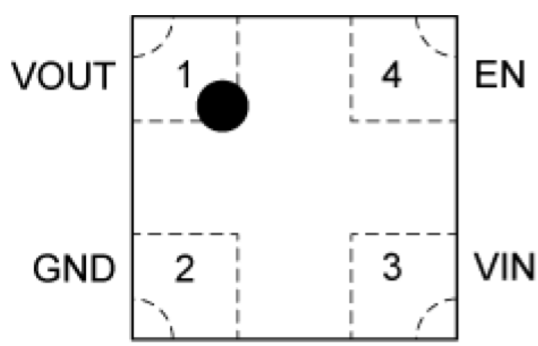
The MIC94045 features an active load discharge circuit which switches in a 200Ω load when the switch is disabled to automatically discharge a capacitive load.

Internal level shift circuitry allows low voltage logic signals to switch higher supply voltages. The enable voltage can be as high as 5.5V and is not limited by the input voltage.

The MIC94044/5 operating voltage range makes them ideal for Lithium ion and NiMH/NiCad/Alkaline battery powered systems, as well as non-battery powered applications. The devices provide low quiescent current and low shutdown current to maximize battery life.

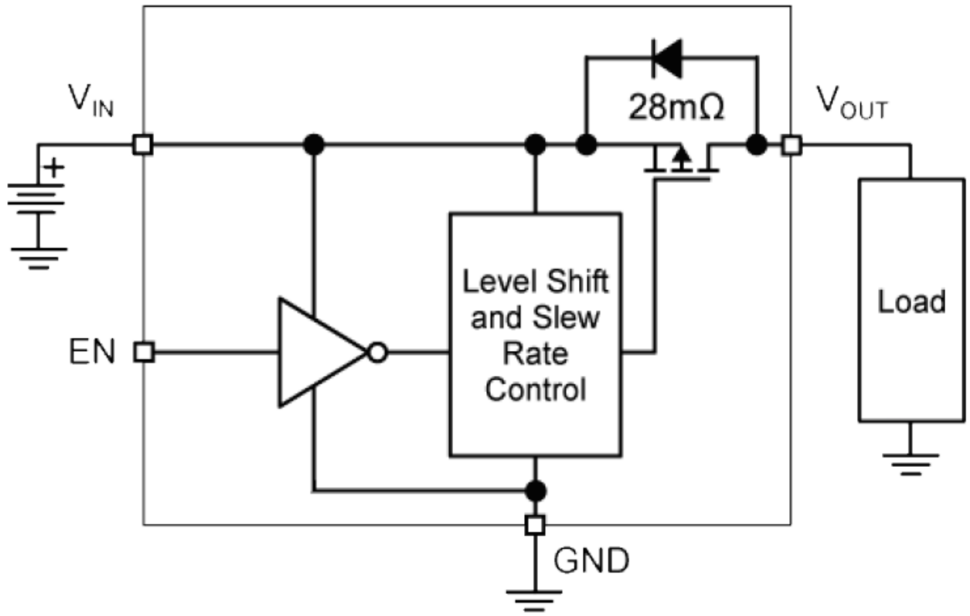
Package Types

MIC94044/5
4-Lead 1.2 mm x 1.2 mm UDFN

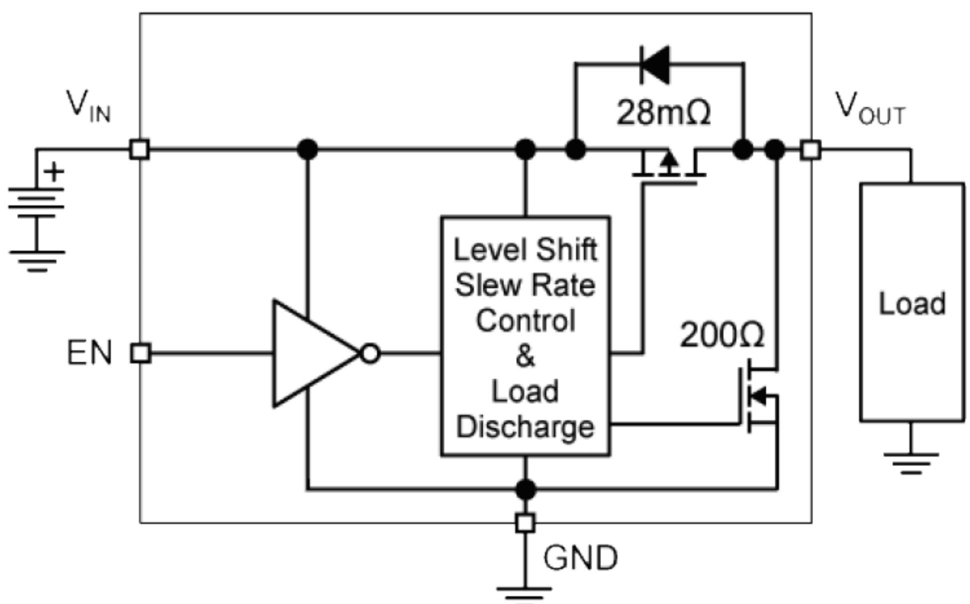


Typical Application Circuits

MIC94044
(1 ms soft-start)



MIC94045
(1 ms soft-start with auto-discharge)



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Input Voltage (V_{IN}) ....+6.0V
Enable Voltage (V_{EN}) ....+6.0V
Continuous Drain Current (I_D) (Note 1), T_A = 25°C....................±3A
Continuous Drain Current (I_D) (Note 1), T_A = 85°C....................±2A
Pulsed Drain Current (I_{DP}) (Note 2) ....±6.0A
Continuous Diode Current (I_S) (Note 3) ....–50mA
ESD Rating—HBM (Note 4)....................3 kV

Operating Ratings ‡

Input Voltage (V_{IN}) ....+1.7V to +5.5V

† Notice: Exceeding the absolute maximum rating may damage the device.

‡ Notice: The device is not guaranteed to function outside its operating rating.

Note 1: With thermal contact to PCB. See power dissipation considerations section.

2: Pulse width < 300 µs with < 2% duty cycle.

3: Continuous body diode current conduction (reverse conduction, i.e. V_{OUT} to V_{IN}) is not recommended.

4: Devices are ESD sensitive. Handling precautions recommended. HBM (human body model), 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

T_A = 25°C, bold values indicate –40°C < T_J < +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Enable Threshold Voltage	V_{EN_TH}	**0.4**	—	**1.2**	V	V_{IN} = 1.7V to 4.5V, I_D = –250 µA
Quiescent Current	I_Q	—	2.25	10	µA	V_{IN} = V_{EN} = 5.5V, I_D = OPEN, Measured on V_{IN}
Enable Input Current	I_{EN}	—	0.1	1	µA	V_{IN} = V_{EN} = 5.5V, I_D = OPEN
Quiescent Current (Shutdown)	I_{SHUT-Q}	—	0.1	1	µA	V_{IN} = +5.5V, V_{EN} = 0V, I_D = OPEN, Measured on V_{IN}
OFF State Leakage Current	$I_{SHUT-SWITCH}$	—	0.1	1	µA	V_{IN} = +5.5V, V_{EN} = 0V, I_D = SHORT, Measured on V_{OUT} (Note 2)
P-Channel Drain to Source ON Resistance	$R_{DS(ON)}$	—	28	**55**	mΩ	V_{IN} = +5.0V, I_D = –100 mA, V_{EN} = 1.5V
		—	30	**60**	mΩ	V_{IN} = +4.5V, I_D = –100 mA, V_{EN} = 1.5V
		—	33	**65**	mΩ	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V
		—	45	**90**	mΩ	V_{IN} = +2.5V, I_D = –100 mA, V_{EN} = 1.5V
		—	72	**145**	mΩ	V_{IN} = +1.8V, I_D = –100 mA, V_{EN} = 1.5V
		—	82	**160**	mΩ	V_{IN} = +1.7V, I_D = –100 mA, V_{EN} = 1.5V
Turn-off Resistance	$R_{SHUTDOWN}$	—	200	**400**	Ω	V_{IN} = +3.6V, I_{TEST} = 1 mA, V_{EN} = 0V, MIC94045

Note 1: Devices are ESD sensitive. Handling precautions recommended. HBM (human body model), 1.5 kΩ in series with 100 pF.

2: Measured on the MIC94044YFL.

ELECTRICAL CHARACTERISTICS (CONTINUED)

T_A = 25°C, bold values indicate –40°C < T_J < +85°C, unless noted.

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Dynamic						
Turn-on Delay Time	t_{ON_DLY}	0.2	0.85	1.5	ms	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V
Turn-on Rise Time	t_{ON_RISE}	0.4	1	1.5	ms	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V
Turn-off Delay Time	t_{OFF_DLY}	—	100	200	ns	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 0V
Turn-off Fall Time	t_{OFF_FALL}	—	20	100	ns	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 0V (No Output Capacitor)

Note 1: Devices are ESD sensitive. Handling precautions recommended. HBM (human body model), 1.5 kΩ in series with 100 pF.

2: Measured on the MIC94044YFL.

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Operating Junction Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature Range	T_s	–55	—	+150	°C	—
Package Thermal Resistance						
1.2 mm × 1.2 mm UDFN	θ_{JC}	—	90	—	°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.

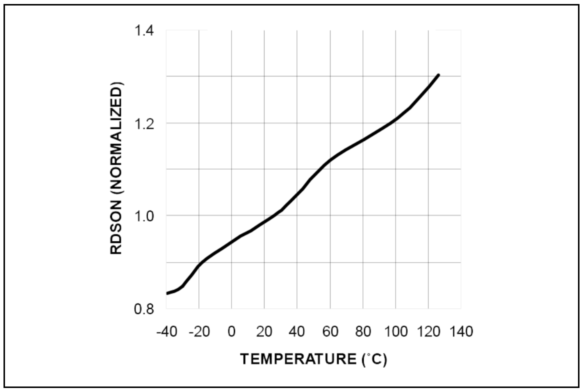


FIGURE 2-1: *RDS_{ON} Variance vs. Temperature.*

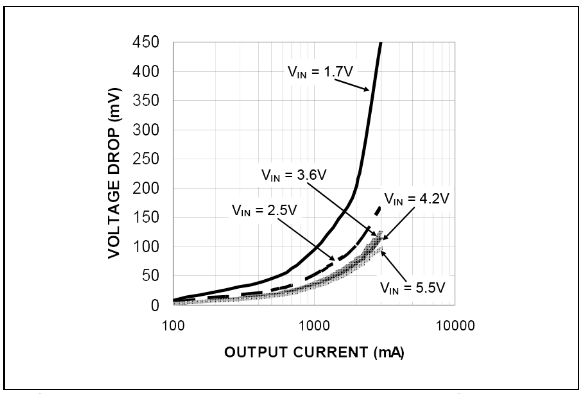


FIGURE 2-2: *Voltage Drop vs. Output Current.*

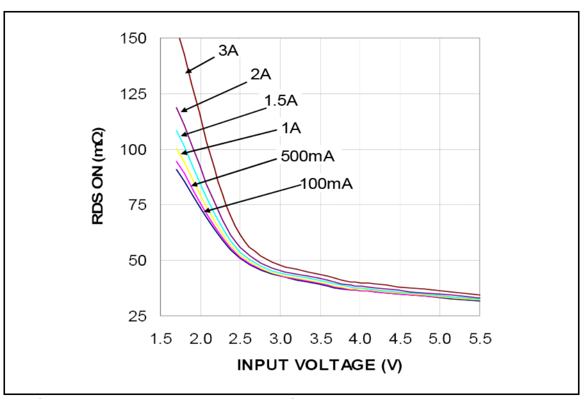


FIGURE 2-3: *RDS_{ON} vs. V_{IN}.*

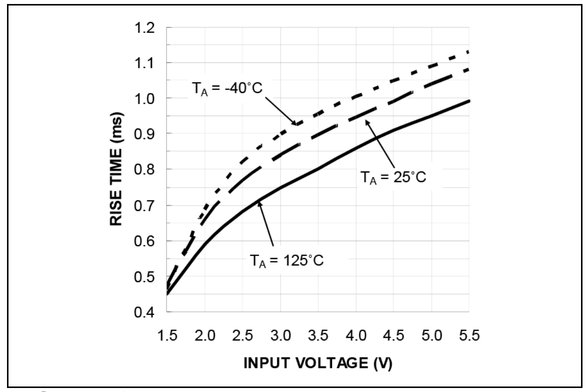


FIGURE 2-4: *Rise Time vs. Input Voltage.*

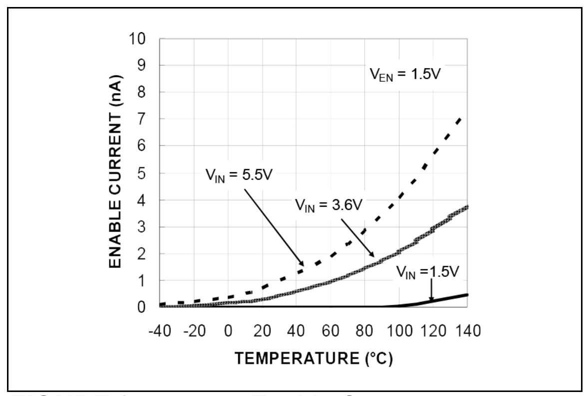


FIGURE 2-5: *Enable Current vs. Temperature.*

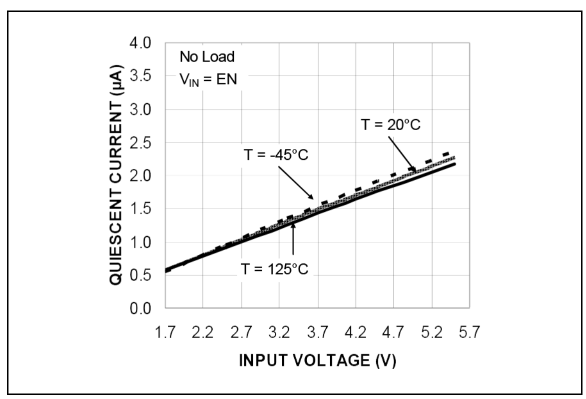


FIGURE 2-6: *Quiescent Current vs. Input Voltage.*

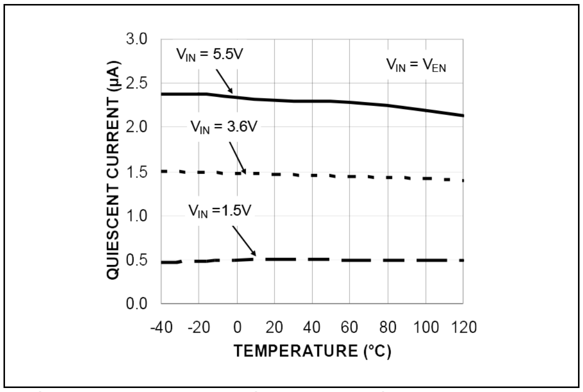


FIGURE 2-7: *Quiescent Current vs. Temperature.*

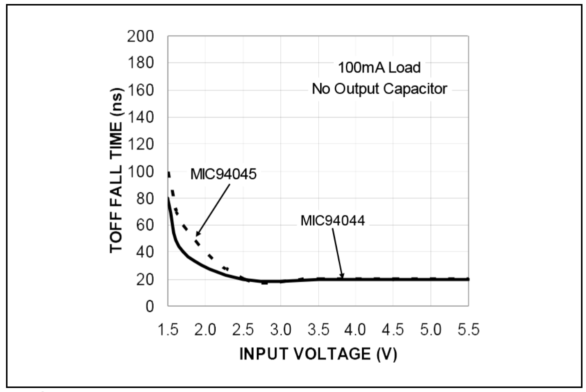


FIGURE 2-10: *T_{OFF} Fall Time vs. Input Voltage.*

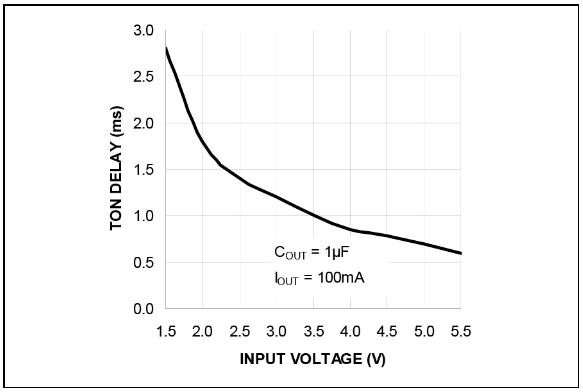


FIGURE 2-8: *T_{ON} Delay vs. Input Voltage.*

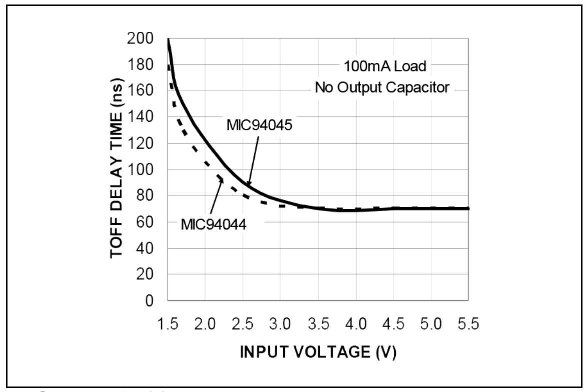


FIGURE 2-11: *T_{OFF} Delay Time vs. Input Voltage.*

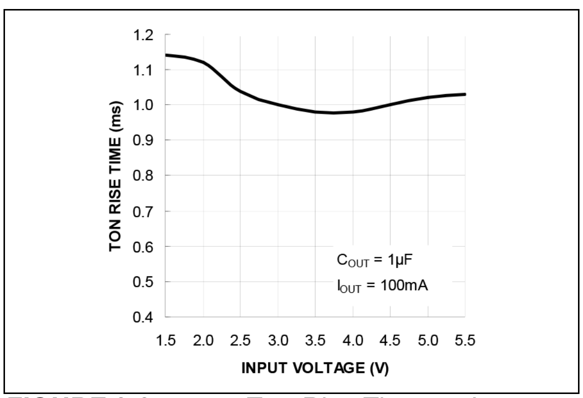


FIGURE 2-9: *T_{ON} Rise Time vs. Input Voltage.*

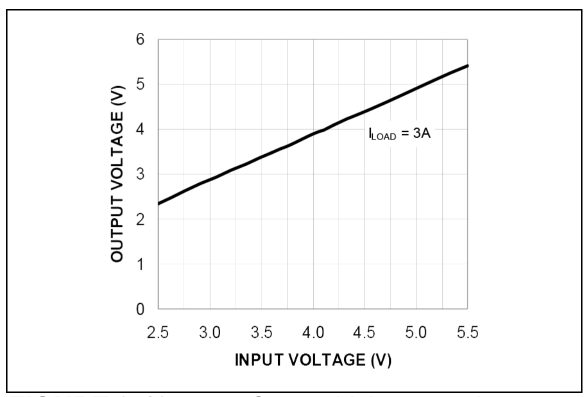


FIGURE 2-12: *Output Voltage vs. Input Voltage.*

3.0 TYPICAL WAVEFORMS

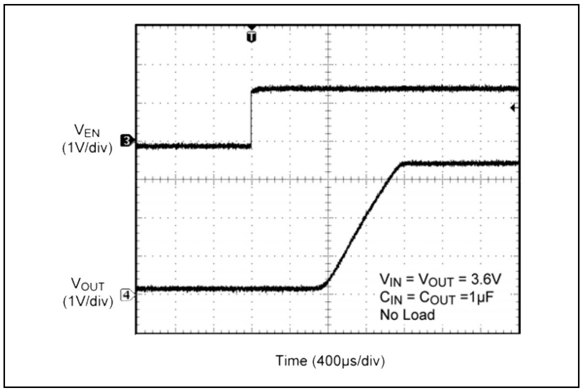


FIGURE 3-1: *MIC94044/5 Turn On.*

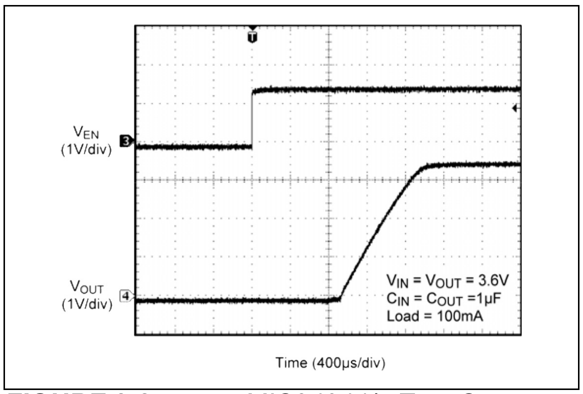


FIGURE 3-2: *MIC94044/5 Turn On.*

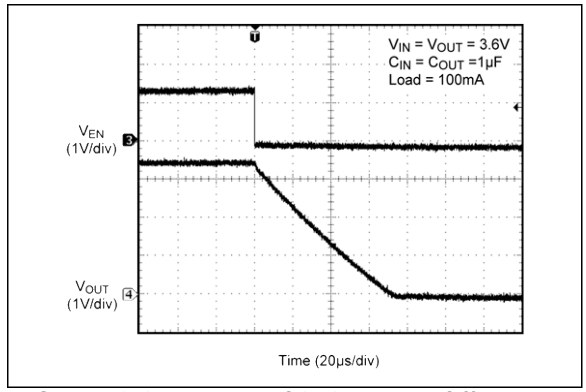


FIGURE 3-3: *MIC94044 Turn Off.*

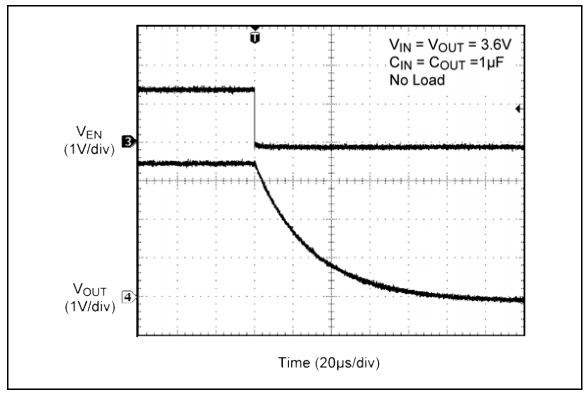


FIGURE 3-4: *MIC94045 Turn Off.*

4.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 4-1.

TABLE 4-1: PIN FUNCTION TABLE

Pin Number	Pin Name	Description
1	VOUT	Drain of P-channel MOSFET.
2	GND	Ground should be connected to electrical ground.
3	VIN	Source of P-channel MOSFET.
4	EN	Enable (Input): Active-high CMOS/TTL control input for switch. Do not leave floating.

5.0 APPLICATION INFORMATION

5.1 Power Switch SOA

The safe operating area (SOA) curve represents the boundary of maximum safe operating current and maximum safe operating ambient temperature.

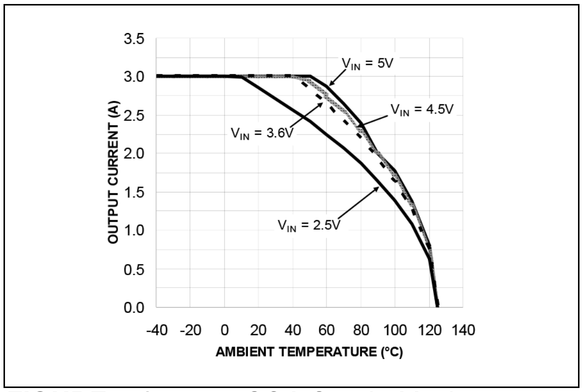


FIGURE 5-1: *SOA Graph: Maximum Switch Current vs. Ambient Temperature (1” Square Copper).*

The curves above show the SOA for various values of VIN, mounted on a typical 1 layer, 1 square inch copper board.

5.2 Power Dissipation Considerations

As with all power switches, the current rating of the switch is limited mostly by the thermal properties of the package and the PCB it is mounted on. There is a simple ohms law type relationship between thermal resistance, power dissipation and temperature, which are analogous to an electrical circuit:

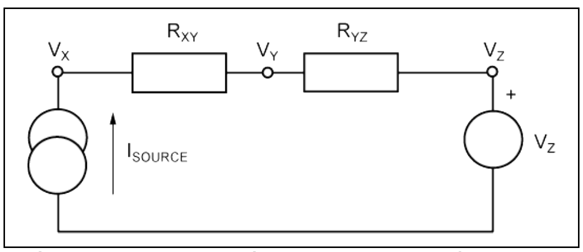


FIGURE 5-2: *Simple Electrical Circuit.*

From this simple circuit we can calculate V_X if we know I_{SOURCE}, V_Z and the resistor values, R_{XY} and R_{YZ} using Equation 5-1:

EQUATION 5-1:

$$V_X = I_{SOURCE} \times (R_{XY} + R_{YZ}) + V_Z$$

Thermal circuits can be considered using these same rules and can be drawn similarly by replacing current sources with power dissipation (in Watts), resistance with thermal resistance (in ˚C/W) and voltage sources with temperature (in ˚C).

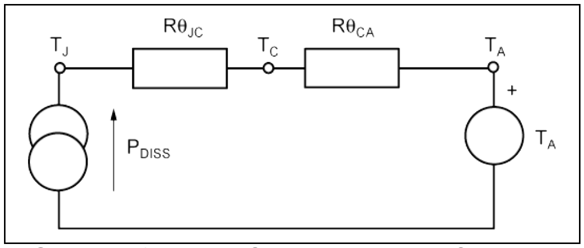


FIGURE 5-3: *Simple Electrical Circuit.*

Now replacing the variables in Equation 5-1 for V_X, we can find the junction temperature (T_J) from power dissipation, ambient temperature and the known thermal resistance of the PCB ($R\theta_{CA}$) and the package (RθJC), using Equation 5-2:

EQUATION 5-2:

$$T_J = P_{DISS} \times (R\theta_{JC} + R\theta_{CA}) + T_A$$

P_{DISS} is calculated as $I_{SWITCH}^2 \times R_{SWmax}$. $R\theta_{JC}$ is found in the operating ratings section of the data sheet and $R\theta_{CA}$ (the PCB thermal resistance) values for various PCB copper areas is discussed in the document “Designing with Low Dropout Voltage Regulators.”

EXAMPLE 5-1:

A switch is intended to drive a 2A load and is placed on a printed circuit board which has a ground plane area of at least 25 mm × 25 mm (625 mm^2). The Voltage source is a Li-ion battery with a lower operating threshold of 3V and the ambient temperature of the assembly can be up to 50˚C.

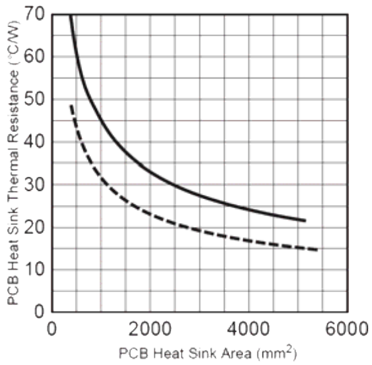


FIGURE 5-4: *Excerpt from the LDO Book.*

Summary of variables:

- I_{SW} = 2A
- V_{IN} = 3V to 4.2V
- T_A = 50˚C
- $R\theta_{JC}$ = 90˚C/W from data sheet
- $R\theta_{CA}$ = 53˚C/W (read from Figure 5-4)
- $P_{DISS} = I_{SW}^2 \times R_{SWmax}$

The worst case switch resistance (R_{SWmax}) at the lowest V_{IN} of 3V is not available in the data sheet, so the next lower value of V_{IN} is used.

EQUATION 5-3:

$$R_{SWmax} @ 2.5V = 90m\Omega$$

If this were a figure for worst case R_{SWmax} for 25˚C, an additional consideration is to allow for the maximum junction temperature of 125˚C, the actual worst case resistance in this case can be 30% higher (see R_{DSON} variance vs. temperature graph). However, 90 mΩ is the maximum overtemperature. Therefore:

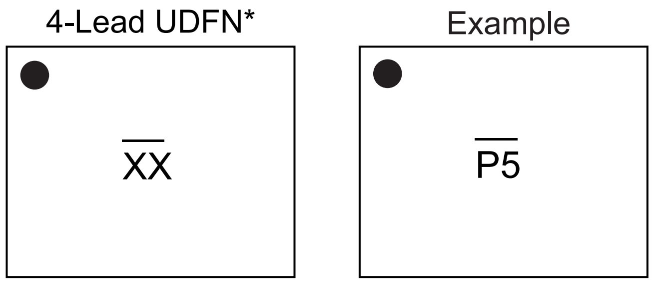
EQUATION 5-4:

$$T_J = 2^2 \times 0.090 \times (90 + 53) + 50$$
$$T_J = 101°C$$

This is below the maximum 125˚C.

6.0 PACKAGING INFORMATION

6.1 Package Marking Information



PACKAGE MARKING DRAWING SYMBOLS LEGEND

Symbol	Definition
XX . . . X	Product code or customer-specific information. (Note 1, Note 2)
YYWW	Date code, where YY is the last 2 digits of calendar year and WW is the work week (i.e., week of January 1 is week 01). (Note 3)
M	Month of assembly (if applicable). January is represented by “A” and each month thereafter follows the order of the alphabet through “L” for December.
NNN	Alphanumeric traceability code. (Note 3, Note 4)
(e3)	Pb-free JEDEC designator for Matte Tin (Sn).
*	Indicates this package is Pb-free. The Pb-free JEDEC designator (the symbol in the row above this one) 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 1: If the full Microchip part number cannot fit on one line, it will be carried over to the next line, limiting the number of available characters for customer-specific information. The package may or may not include the corporate logo.

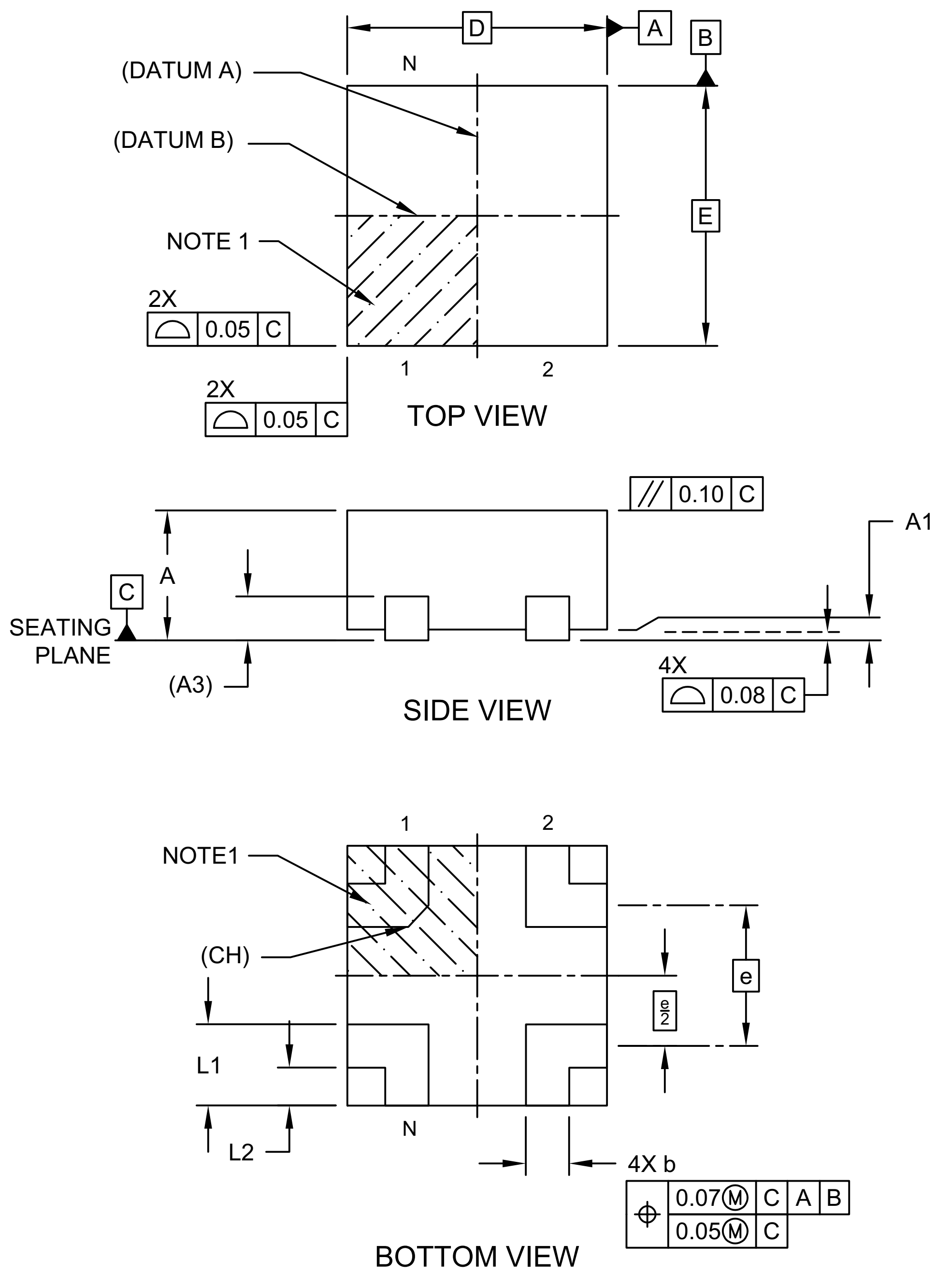
2: Any underbar (_) and/or overbar (‾) symbols shown in a package marking drawing may not be to scale.

3: If the full date code (YYWW) and the alphanumeric traceability code (NNN)—usually marked together on the last or only line of a package marking as the seven-character YYWWNNN—cannot fit on the package together, the codes will be truncated based on the number of available character spaces, as follows: 6 characters = YWWNNN; 5 characters = WWNNN; 4 characters = WNNN; 3 characters = NNN; 2 characters = NN; 1 character = N.

4: Some products might have a “Y” symbol at the end of the last or only line in a package marking, usually at the end of the alphanumeric traceability code (NNN or truncated versions), to indicate the product is Pb-free.

4-Lead 1.2 mm × 1.2 mm UDFN [HEA] Package Outline and Recommended Land Pattern

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



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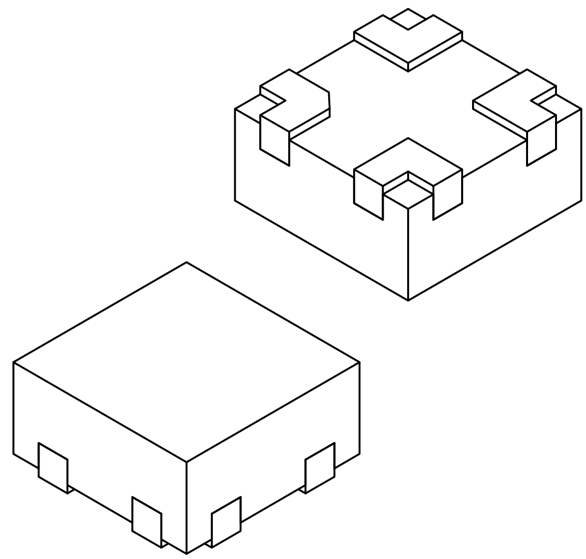
4-Lead 1.2 mm × 1.2 mm UDFN [HEA] Package Outline and Recommended Land Pattern

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 Terminals	N		4	
Pitch	e		0.65 BSC	
Overall Height	A	0.50	0.55	0.60
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.203 REF	
Overall Length	D		1.20 BSC	
Overall Width	E		1.20 BSC	
Terminal Width	b	0.15	0.20	0.25
Terminal Length	L1	0.325	0.375	0.425
Edge to Terminal	L2	0.125	0.175	2.25

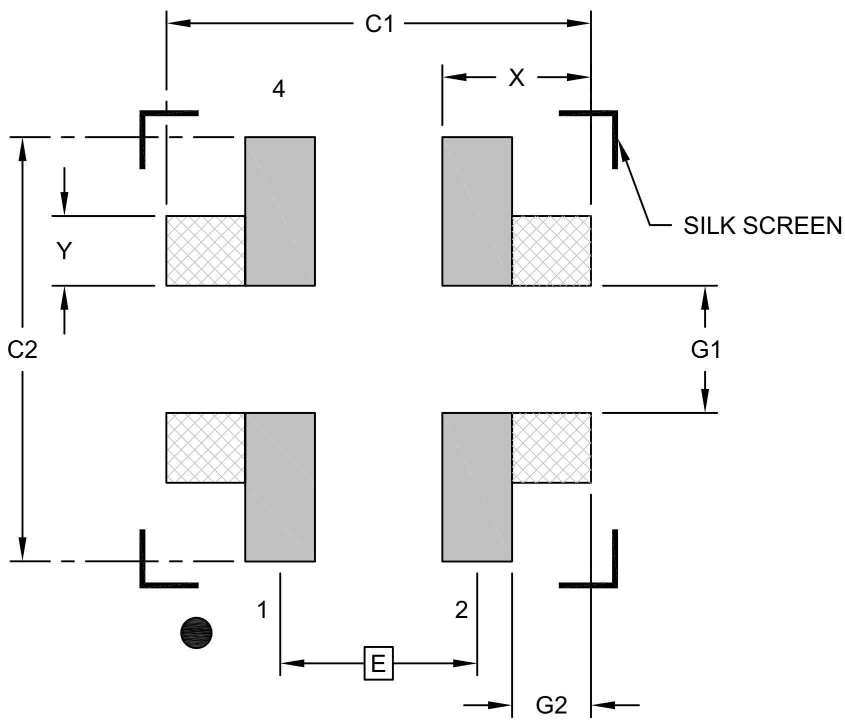
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. Package is saw singulated
3. 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 C04-1044 Rev A Sheet 2 of 2

4-Lead 1.2 mm × 1.2 mm UDFN [HEA] Package Outline and Recommended Land Pattern

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		0.65 BSC	
Contact Pad Spacing	C1		1.40	
Contact Pad Spacing	C2		1.40	
Contact Pad Width (X4)	X			0.51
Contact Pad Length (X4)	Y			0.25
Contact Pad to Contact Pad (X4)	G1	0.42		
Edge to Contact Pad (X4)	G2	0.24		

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 C04-3044 Rev A

APPENDIX A: REVISION HISTORY

Revision A (August 2024)

- Converted Micrel document MIC94044/5 to Microchip data sheet DS20006920A.
- 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	XX	-XX
Device	Junction Temp. Range	Package	Media Type

Device:	MIC94044/5:		1.2 MHz PWM White LED Driver with OVP
Junction Temperature Range:	Y	=	40°C to +125°C
Package:	FL	=	4-Lead 1.2 mm x 1.2 mm UDFN
Media Type:	-TR	=	5000/Reel

Examples:

a) MIC94044YFL-TR: MIC94044, –40°C to +125°C Junction Temp. Range, 4-Lead 1.2 mm x 1.2 mm UDFN, 5000/Reel

b) MIC94045YFL-TR: MIC94045, –40°C to +125°C Junction Temp. Range, 4-Lead 1.2 mm x 1.2 mm UDFN, 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 options.

NOTES:

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

- Microchip products meet the specifications contained in their particular Microchip Data Sheet.
- Microchip believes that its family of products is secure when used in the intended manner, within operating specifications, and under normal conditions.
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ISBN: 978-1-6683-0099-2

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