MIC94044/5

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

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 28mΩ 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 1.2mm x 1.2mm 4 pin MLF® package.

The MIC94044/5 provides a slew rate controlled soft-start turn-on of 1ms (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.

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

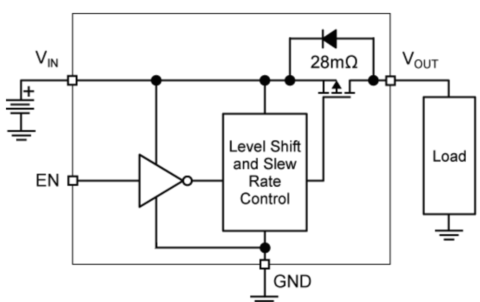
Features

- 28mΩ R_{DSON}
- 3A continuous operating current
- 1.2mm x 1.2mm space saving 4-pin MLF® 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: 1ms
- Load discharge circuit: MIC94045
- Ultra fast turn off time
- Junction operating temperature from -40ºC to +125ºC

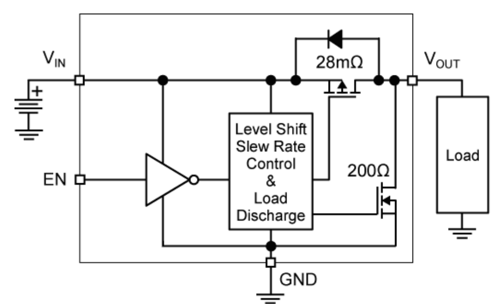
Applications

- 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

Typical Application



MIC94044 (1ms soft-start)



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

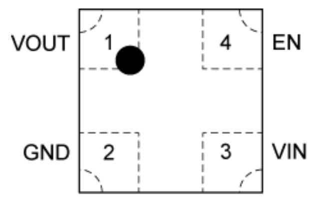
Ordering Information

Part Number	Marking	Soft-Start	Load Discharge	Package
MIC94044YFL	$\overline{\text{P5}}$	1ms		4-Pin 1.2mm x 1.2mm MLF®
MIC94045YFL	$\overline{\text{P6}}$	1ms	—	4-Pin 1.2mm x 1.2mm MLF®

Notes:

1. MLF® Pin 1 Identifier symbol is "●".
2. Over bar symbol (‾) may not be to scale.
3. MLF® is a GREEN RoHS-compliant package. Lead finish is NiPdAu. Mold compound is Halogen Free.

Pin Configuration



4-Pin 1.2mm x 1.2mm MLF®
(Top View)

Pin Description

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

Absolute Maximum Ratings [1]

Input Voltage (V_{IN})..+6V
Enable Voltage (V_{EN}) ....+6V
Continuous Drain Current (I_D) [3]
T_A = 25°C ....±3A
T_A = 85°C ....±2A
Pulsed Drain Current (I_{DP})[4] ....±6.0A
Continuous Diode Current (I_S)[5] ....–50mA
Storage Temperature (T_s) .... –55°C to +150°C
ESD Rating – HBM[6] 3kV

Operating Ratings [2]

Input Voltage (V_{IN})...................................... +1.7 to +5.5V
Junction Temperature (T_J) ....–40°C to +125°C
Package Thermal Resistance
1.2mm x 1.2mm MLF® -4L(θ_{JC}) ....90°C/W

Electrical Characteristics [7]

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

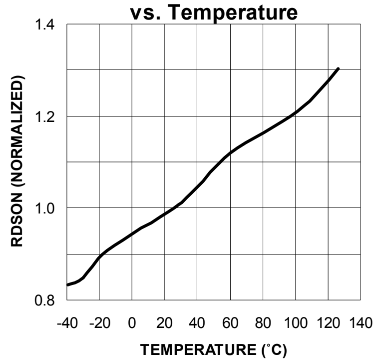
Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{EN_TH}	Enable Threshold Voltage	V_{IN} = 1.7V to 4.5V, I_D = –250µA	**0.4**		**1.2**	V
I_Q	Quiescent Current	V_{IN} = V_{EN} = 5.5V, I_D = OPEN Measured on V_{IN}		2.25	10	µA
I_{EN}	Enable Input Current	V_{IN} = V_{EN} = 5.5V, I_D = OPEN		0.1	1	µA
I_{SHUT-Q}	Quiescent Current (shutdown)	V_{IN} = +5.5V, V_{EN} = 0V, I_D = OPEN Measured on V_{IN}		0.1	1	µA
$I_{SHUT-SWITCH}$	OFF State Leakage Current	V_{IN} = +5.5V, V_{EN} = 0V, I_D = SHORT Measured on V_{OUT}, [7]		0.1	1	µA
$R_{DS(ON)}$	P-Channel Drain to Source ON Resistance	V_{IN} = +5.0V, I_D = –100mA, V_{EN} = 1.5V		28	**55**	mΩ
		V_{IN} = +4.5V, I_D = –100mA, V_{EN} = 1.5V		30	**60**	mΩ
		V_{IN} = +3.6V, I_D = –100mA, V_{EN} = 1.5V		33	**65**	mΩ
		V_{IN} = +2.5V, I_D = –100mA, V_{EN} = 1.5V		45	**90**	mΩ
		V_{IN} = +1.8V, I_D = –100mA, V_{EN} = 1.5V		72	**145**	mΩ
		V_{IN} = +1.7V, I_D = –100mA, V_{EN} = 1.5V		82	**160**	mΩ
$R_{SHUTDOWN}$	Turn-Off Resistance	V_{IN} = +3.6V, I_{TEST} = 1mA, V_{EN} = 0V MIC94045		200	**400**	Ω
Dynamic						
t_{ON_DLY}	Turn-On Delay Time	V_{IN} = +3.6V, I_D = –100mA, V_{EN} = 1.5V	0.2	0.85	1.5	ms
t_{ON_RISE}	Turn-On Rise Time	V_{IN} = +3.6V, I_D = –100mA, V_{EN} = 1.5V	0.4	1	1.5	ms
t_{OFF_DLY}	Turn-Off Delay Time	V_{IN} = +3.6V, I_D = –100mA, V_{EN} = 0V		100	200	ns
t_{OFF_FALL}	Turn-Off Fall Time	V_{IN} = +3.6V, I_D = –100mA, V_{EN} = 0V (No Output Capacitor)		20	100	ns

Notes:

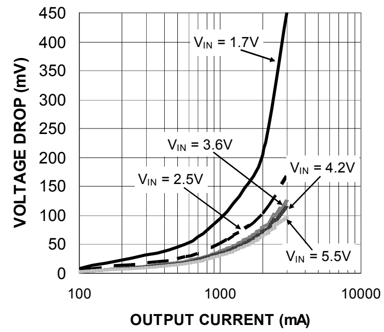
1. Exceeding the absolute maximum rating may damage the device.
2. The device is not guaranteed to function outside its operating rating.
3. With thermal contact to PCB. See power dissipation considerations section.
4. Pulse width <300µs with < 2% duty cycle.
5. Continuous body diode current conduction (reverse conduction, i.e. V_{OUT} to V_{IN}) is not recommended.
6. Devices are ESD sensitive. Handling precautions recommended. HBM (Human body model), 1.5kΩ in series with 100pF.
7. Measured on the MIC94044YFL.

Typical Characteristics

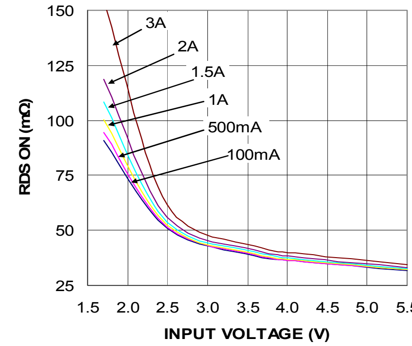
RDS_{ON} Variance vs. Temperature



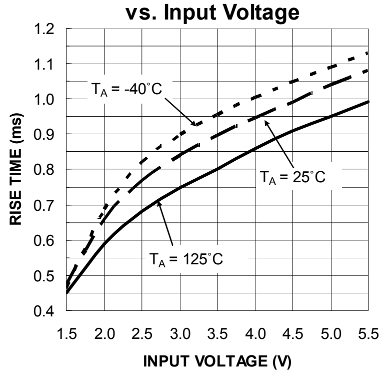
Voltage Drop vs. Output Current



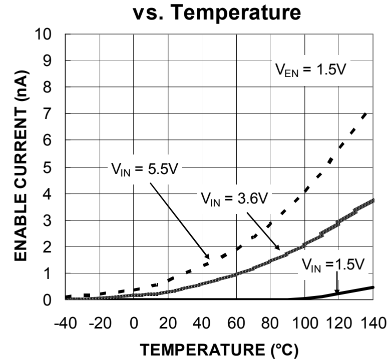
RDS_{ON} vs. V_{IN}



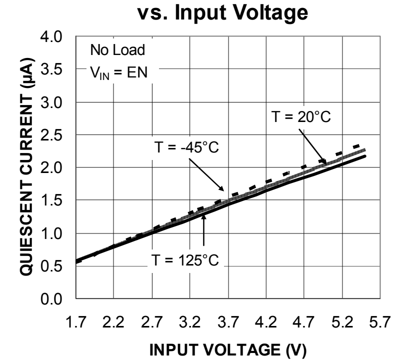
Rise Time vs. Input Voltage



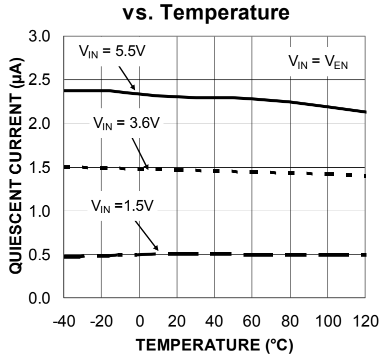
Enable Current vs. Temperature



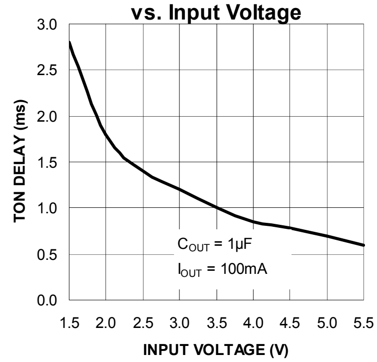
Quiescent Current vs. Input Voltage



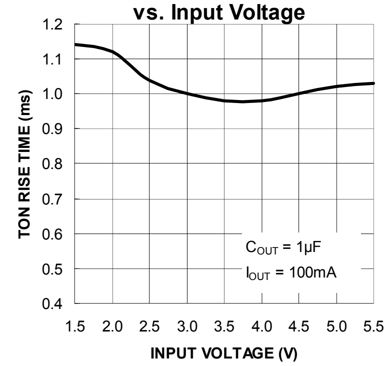
Quiescent Current vs. Temperature



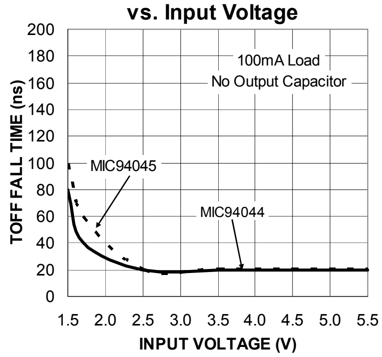
T_{ON} Delay vs. Input Voltage



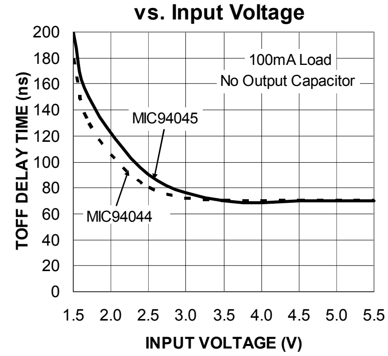
T_{ON} Rise Time vs. Input Voltage



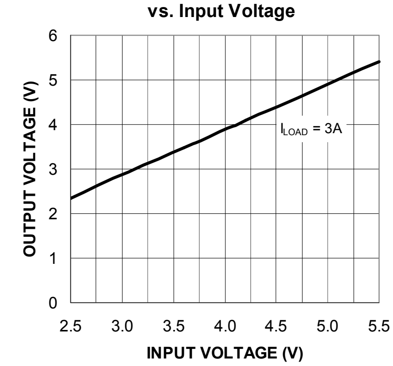
T_{OFF} Fall Time vs. Input Voltage



T_{OFF} Delay Time vs. Input Voltage

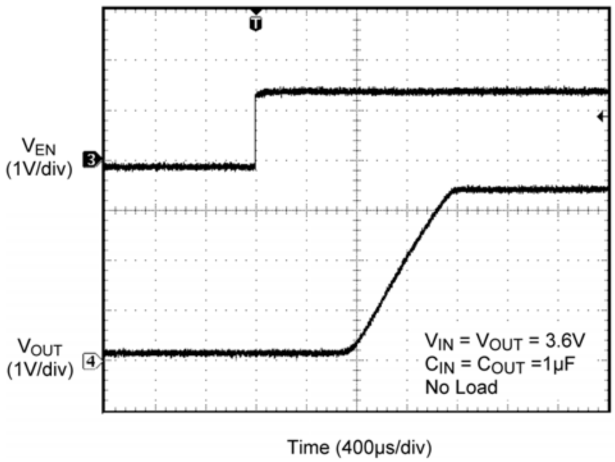


Output Voltage vs. Input Voltage

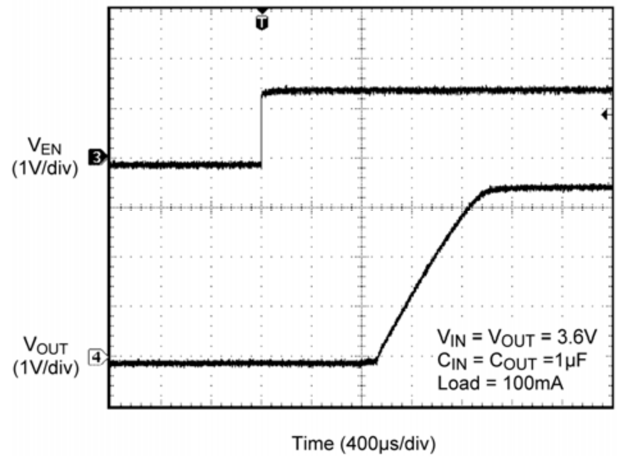


Functional Characteristics

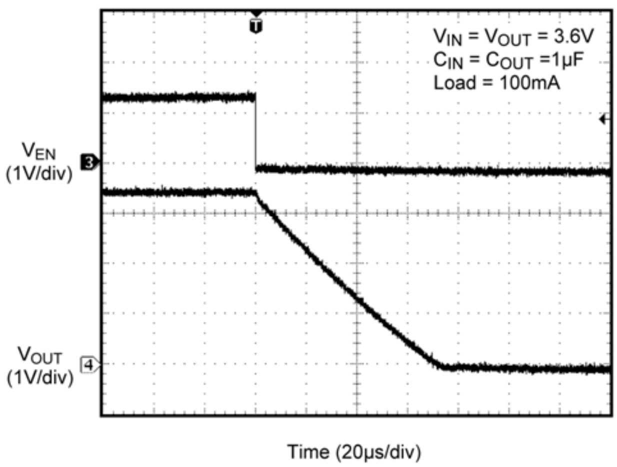
MIC94044/5 Turn On



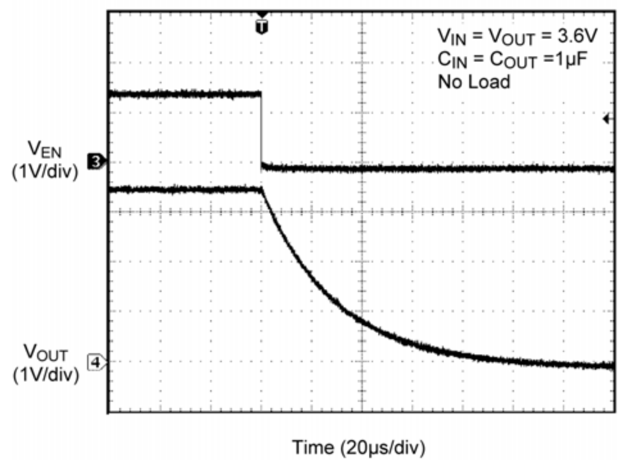
MIC94044/5 Turn On



MIC94044 Turn Off



MIC94045 Turn Off



Application Information

Power Switch SOA

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

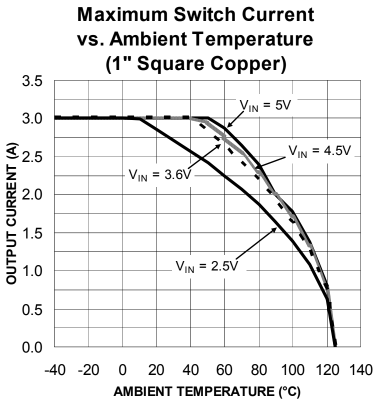


Figure 1: SOA Graph

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

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:

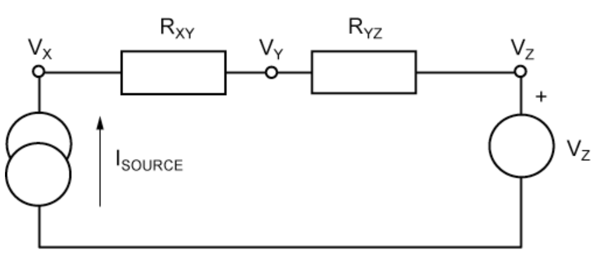


Figure 2: Simple Electrical Circuit

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 the equation:

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

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 ^{o}C/W) and voltage sources with temperature (in ^{o}C).

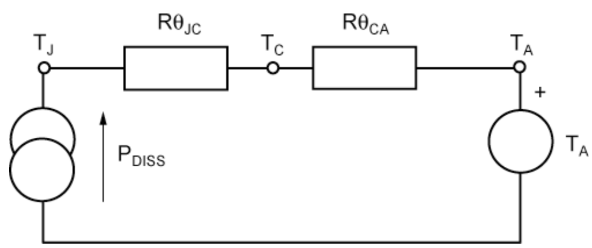


Figure 3: Simple Thermal Circuit

Now replacing the variables in the equation 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 ($R\theta_{JC}$).

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

P_{DISS} is calculated as $I_{SWITCH}^2 \times R_{SWmax}$. $R\theta_{JC}$ is found in the operating ratings section of the datasheet 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*" available from the Micrel website (LDO Application Hints).

Example:

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 25mm x 25mm ($625mm^2$). 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.

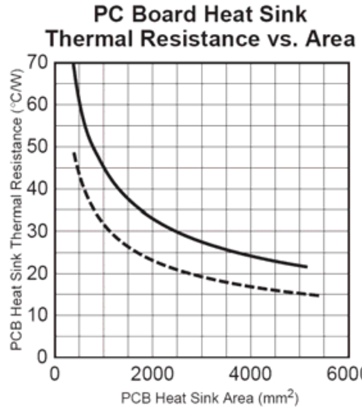


Figure 4: Excerpt from the LDO Book

Summary of variables:

I_{SW} = 2A

V_{IN} = 3V to 4.2V

T_A = 50°C

$R\theta_{JC}$ = 90°C/W from Datasheet

$R\theta_{CA}$ = 53°C/W Read from Graph in Figure 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 datasheet, so the next lower value of V_{IN} is used.

R_{SWmax} @ 2.5V = 90mΩ

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, 90mΩ is the maximum over temperature.

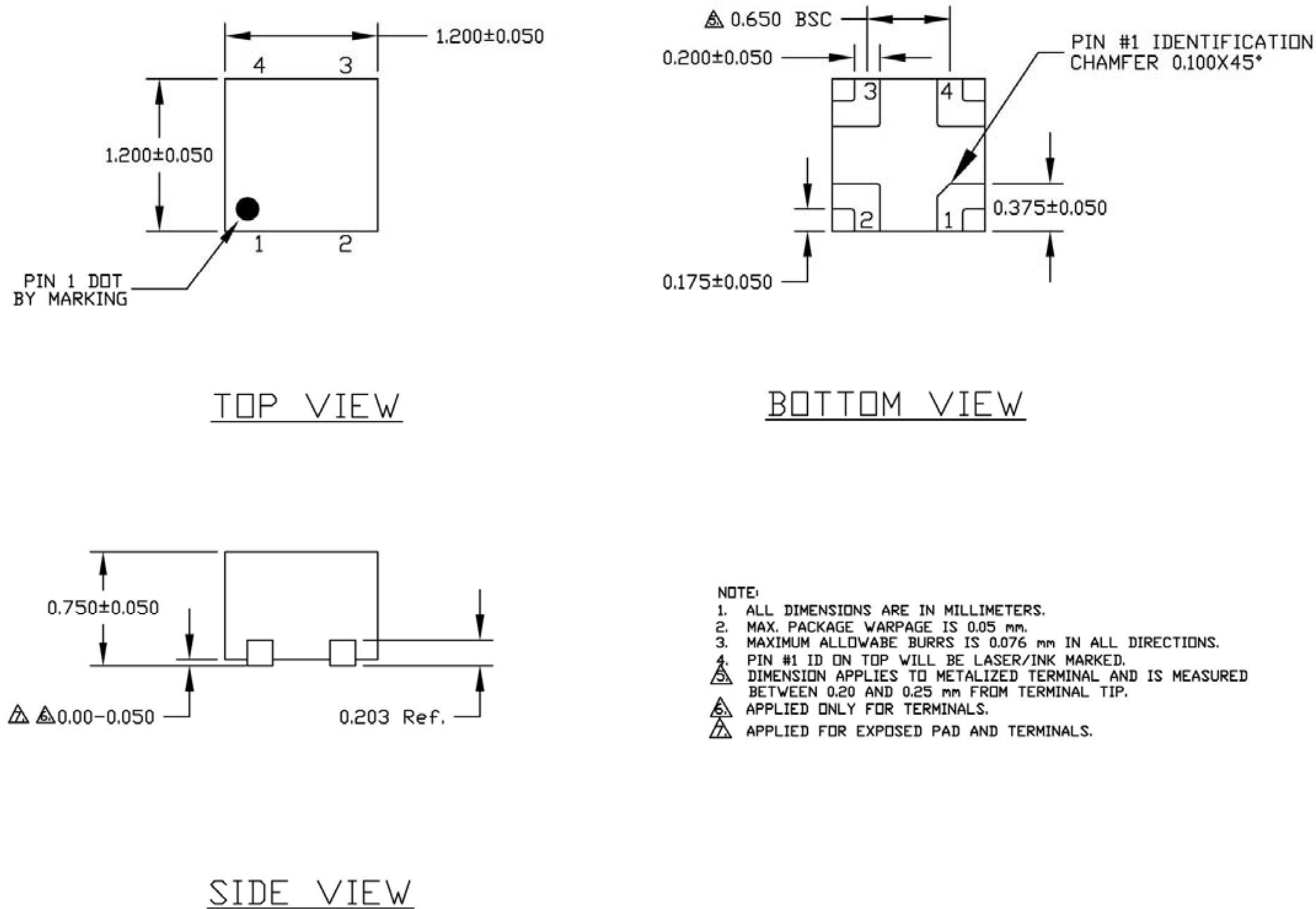
Therefore:

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

T_J = 101°C

This is below the maximum 125°C.

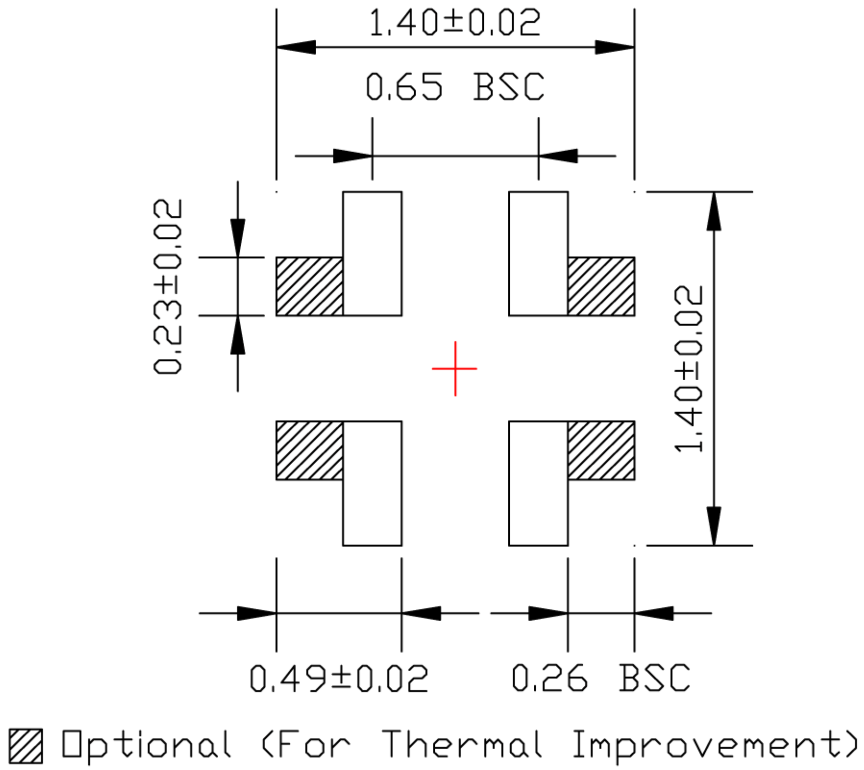
Package Information



4-Pin 1.2mm x 1.2mm MLF®

Recommended Land Pattern

LP # MLF1212D-4LD-LP-9
All units are in mm
Tolerance ± 0.05 if not noted



Disclaimer: This is only a recommendation based on information available to Micrel from its suppliers. Actual land pattern may have to be significantly different due to various materials and processes used in PCB assembly. Micrel makes no representation or warranty of performance based on the recommended land pattern."

4-Pin 1.2mm x 1.2mm MLF® Land Pattern

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