

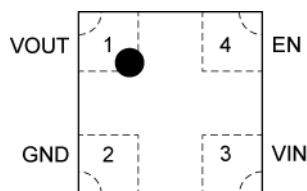
Ordering Information

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 ($\overline{}$) 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⁾	
$T_A = 25^\circ\text{C}$	$\pm 3\text{A}$
$T_A = 85^\circ\text{C}$	$\pm 2\text{A}$
Pulsed Drain Current (I_{DP}) ⁽⁴⁾	$\pm 6.0\text{A}$
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⁾

$T_A = 25^\circ\text{C}$, bold values indicate $-40^\circ\text{C} < T_J < +85^\circ\text{C}$, unless noted.

Symbol	Parameter	Condition	Min	Typ	Max	Units
V_{EN_TH}	Enable Threshold Voltage	$V_{IN} = 1.7\text{V to } 4.5\text{V}$, $I_D = -250\mu\text{A}$	0.4		1.2	V
I_Q	Quiescent Current	$V_{IN} = V_{EN} = 5.5\text{V}$, $I_D = \text{OPEN}$ Measured on V_{IN}		2.25	10	μA
I_{EN}	Enable Input Current	$V_{IN} = V_{EN} = 5.5\text{V}$, $I_D = \text{OPEN}$		0.1	1	μA
I_{SHUT-Q}	Quiescent Current (shutdown)	$V_{IN} = +5.5\text{V}$, $V_{EN} = 0\text{V}$, $I_D = \text{OPEN}$ Measured on V_{IN}		0.1	1	μA
$I_{SHUT-SWITCH}$	OFF State Leakage Current	$V_{IN} = +5.5\text{V}$, $V_{EN} = 0\text{V}$, $I_D = \text{SHORT}$ Measured on V_{OUT} , ⁽⁷⁾		0.1	1	μA
$R_{DS(ON)}$	P-Channel Drain to Source ON Resistance	$V_{IN} = +5.0\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 1.5\text{V}$		28	55	m Ω
		$V_{IN} = +4.5\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 1.5\text{V}$		30	60	m Ω
		$V_{IN} = +3.6\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 1.5\text{V}$		33	65	m Ω
		$V_{IN} = +2.5\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 1.5\text{V}$		45	90	m Ω
		$V_{IN} = +1.8\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 1.5\text{V}$		72	145	m Ω
		$V_{IN} = +1.7\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 1.5\text{V}$		82	160	m Ω
$R_{SHUTDOWN}$	Turn-Off Resistance	$V_{IN} = +3.6\text{V}$, $I_{TEST} = 1\text{mA}$, $V_{EN} = 0\text{V}$ MIC94045		200	400	Ω

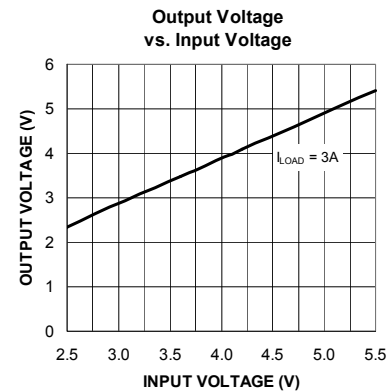
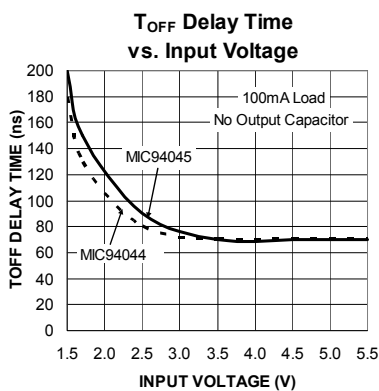
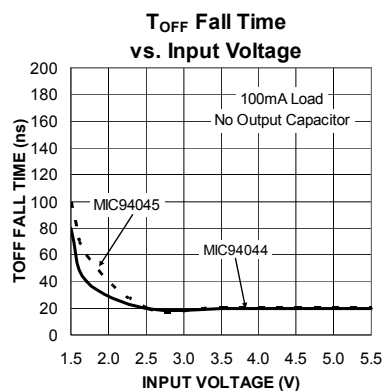
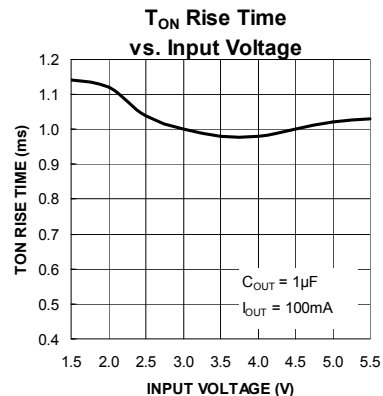
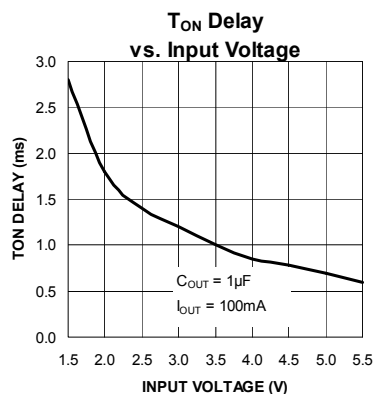
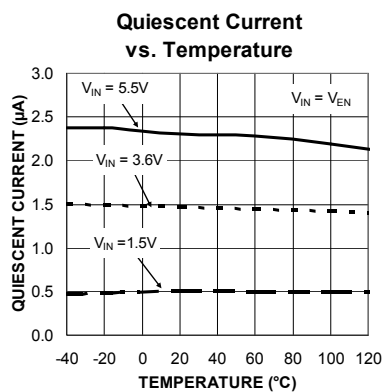
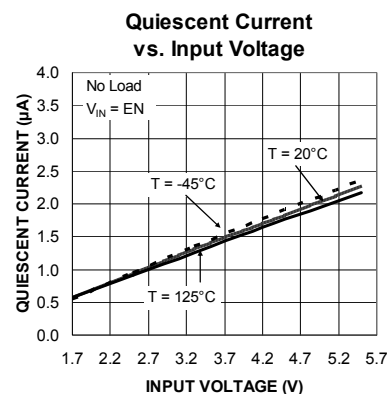
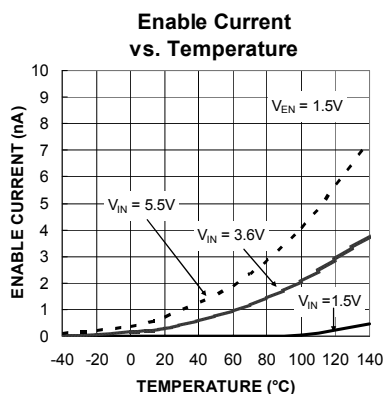
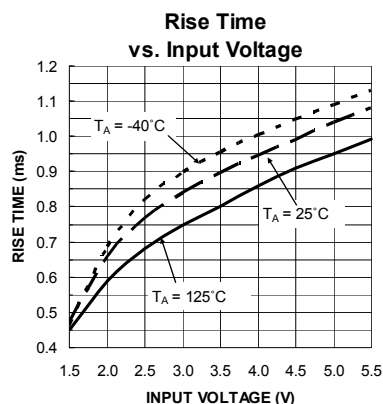
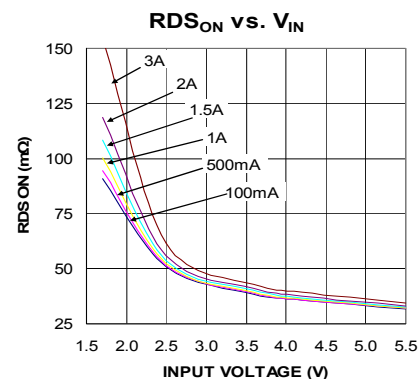
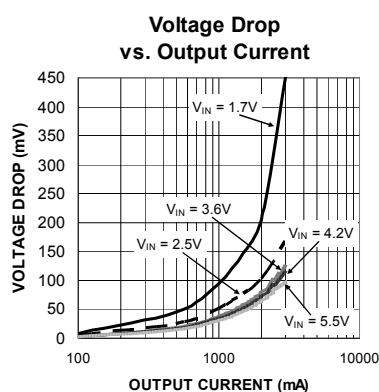
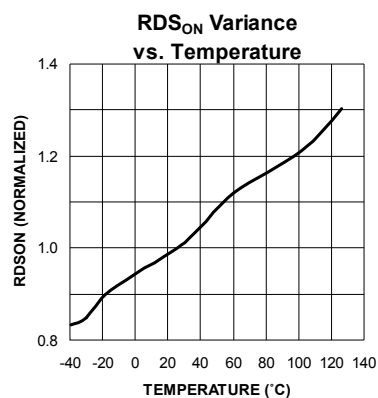
Dynamic

t_{ON_DLY}	Turn-On Delay Time	$V_{IN} = +3.6\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 1.5\text{V}$	0.2	0.85	1.5	ms
t_{ON_RISE}	Turn-On Rise Time	$V_{IN} = +3.6\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 1.5\text{V}$	0.4	1	1.5	ms
t_{OFF_DLY}	Turn-Off Delay Time	$V_{IN} = +3.6\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 0\text{V}$		100	200	ns
t_{OFF_FALL}	Turn-Off Fall Time	$V_{IN} = +3.6\text{V}$, $I_D = -100\text{mA}$, $V_{EN} = 0\text{V}$ (No Output Capacitor)		20	100	ns

Notes:

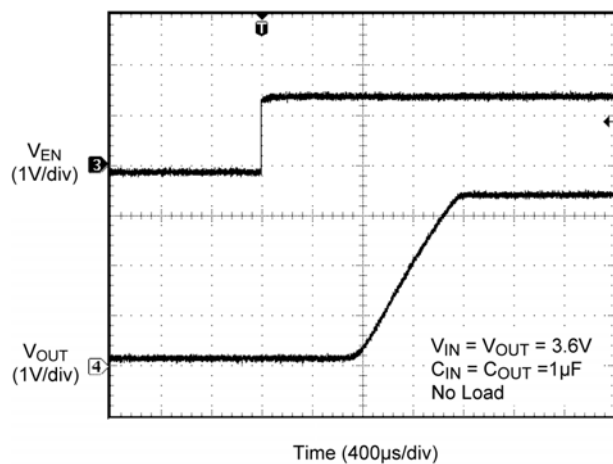
- Exceeding the absolute maximum rating may damage the device.
- The device is not guaranteed to function outside its operating rating.
- With thermal contact to PCB. See power dissipation considerations section.
- Pulse width <300 μs with < 2% duty cycle.
- Continuous body diode current conduction (reverse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

Typical Characteristics

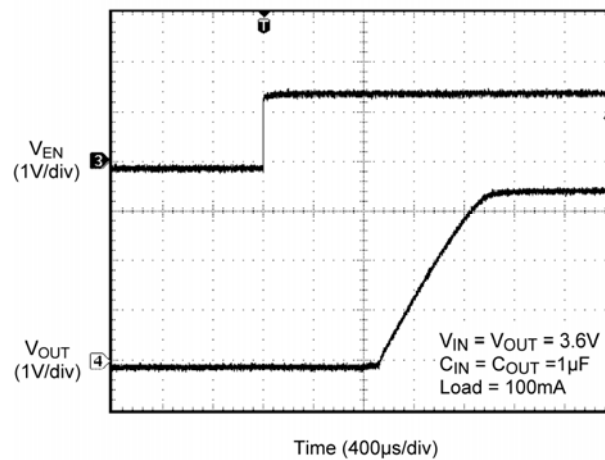


Functional Characteristics

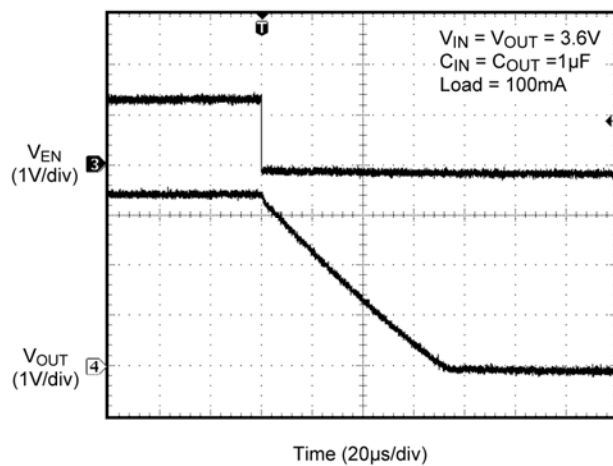
MIC94044/5 Turn On



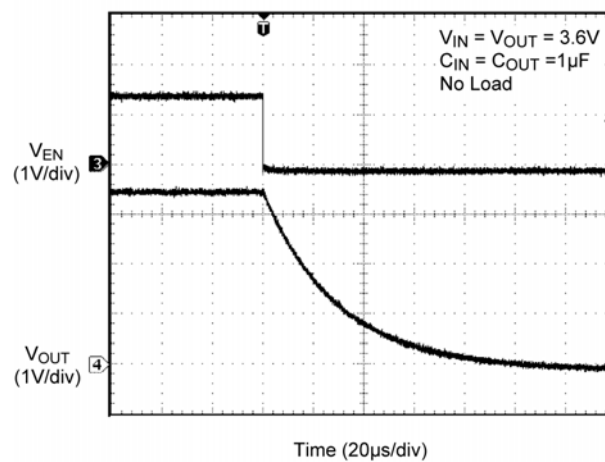
MIC94044/5 Turn On



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.

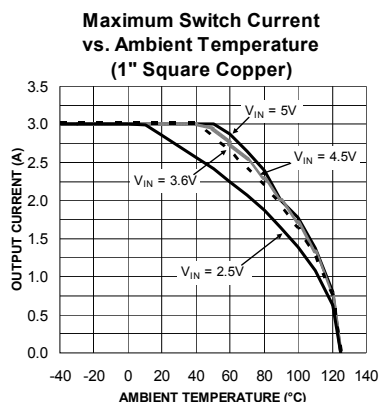


Figure 1: SOA Graph

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:

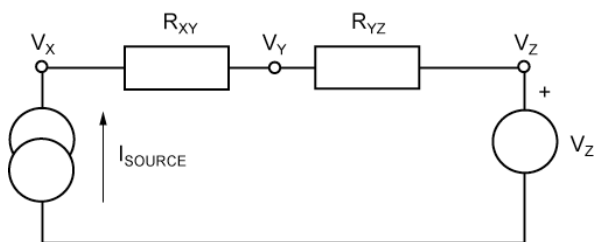


Figure 2: Simple Electrical Circuit

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:

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

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 $^{\circ}\text{C}/\text{W}$) and voltage sources with temperature (in $^{\circ}\text{C}$).

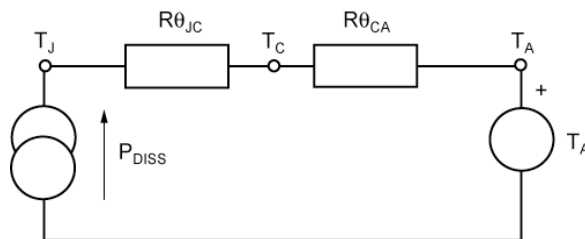


Figure 3: Simple Thermal Circuit

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 (625mm²). 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.

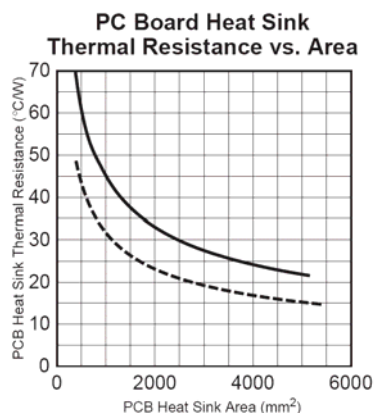


Figure 4: Excerpt from the LDO Book

Summary of variables:

$$I_{SW} = 2A$$

$$V_{IN} = 3V \text{ to } 4.2V$$

$$T_A = 50^{\circ}C$$

$$R_{\theta JC} = 90^{\circ}C/W \text{ from Datasheet}$$

$$R_{\theta CA} = 53^{\circ}C/W \text{ Read from Graph in Figure 4}$$

$$P_{DISS} = I_{SW}^2 \times R_{SWmax}$$

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.

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

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 $R_{DS(on)}$ variance vs. temperature graph). However, 90mΩ is the maximum over temperature.

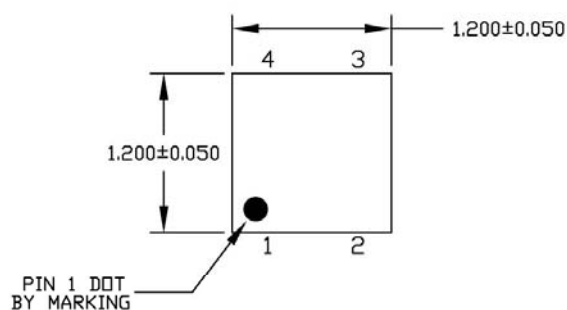
Therefore:

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

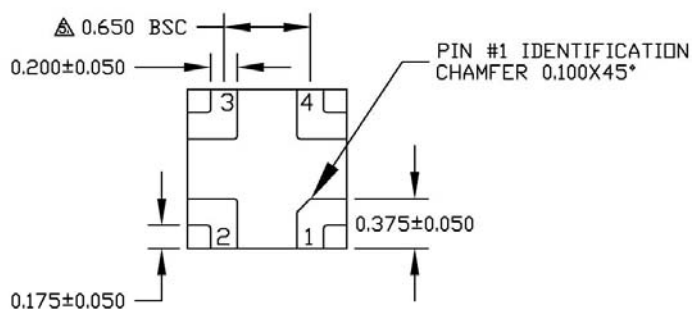
$$T_J = 101^{\circ}C$$

This is below the maximum 125°C.

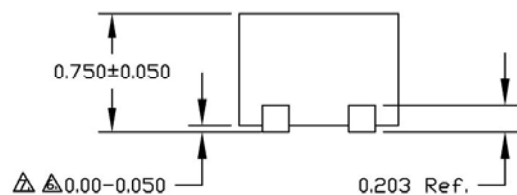
Package Information



TOP VIEW






BOTTOM VIEW



SIDE VIEW

NOTE:

- NOTE 1:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. MAX. PACKAGE VARPAGE IS 0.05 mm
 3. MAXIMUM ALLOWABLE BURRS IS 0.076 mm IN ALL DIRECTIONS.
- PIN #1 ID ON TOP WILL BE LASER/MARK MARKED.
-  DIMENSION APPLIES TO METALIZED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25 mm FROM TERMINAL TIP.
-  APPLIED ONLY FOR TERMINALS.
-  APPLIED FOR EXPOSED PAD AND TERMINALS.

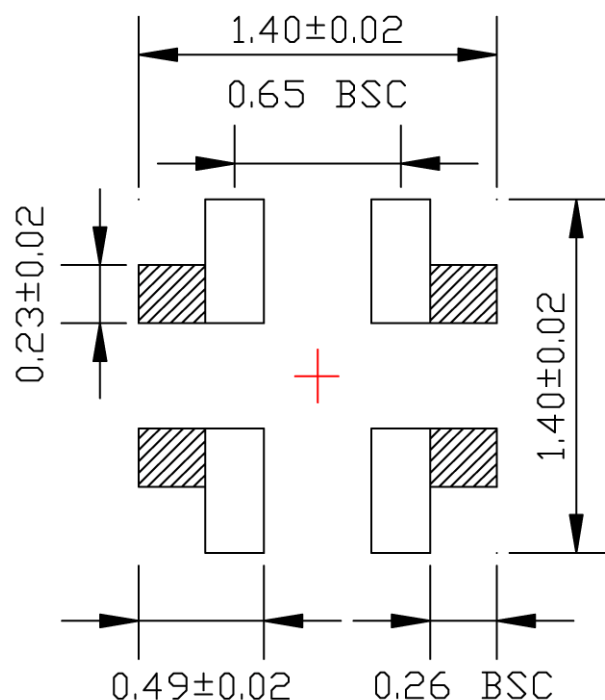
4-Pin 1.2mm x 1.2mm MLF®

Recommended Land Pattern

LP # MLF1212D-4LD-LP-9

All units are in mm

Tolerance ± 0.05 if not noted



Optional (For Thermal Improvement)

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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