

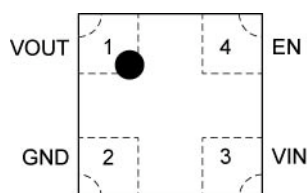
Ordering Information

Part Number	Part Marking ⁽¹⁾	Fast Turn On	Soft-Start	Load Discharge	Package ⁽²⁾
MIC94040YFL	— P4	•			4-Pin (1.2mm x 1.2mm) MLF [®]
MIC94041YFL	— P1	•		•	4-Pin (1.2mm x 1.2mm) MLF [®]
MIC94042YFL	— P2		•		4-Pin (1.2mm x 1.2mm) MLF [®]
MIC94043YFL	— P3		•	•	4-Pin (1.2mm x 1.2mm) MLF [®]

Notes:

1. MLF[®] Pin 1 Identifier symbol is “•”.
2. MLF[®] is a GREEN RoHS-compliant package. Lead finish is NiPdAu. Mold compound is Halogen Free.

Pin Configuration



Top View

4-Pin (1.2mm x 1.2mm) MLF[®]

Pin Description

Pin Number	Pin Name	Pin Function
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. Internal ~2MΩ Pull down resistor. Output will be off if this pin is left 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	
MLF [®] (θ_{JC})	90°C/W

Electrical Characteristics

$T_A = 25^\circ\text{C}$, bold values indicate $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$, 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} MIC94040, MIC94041		0.1	1	μA
		$V_{IN} = V_{EN} = 5.5\text{V}$, $I_D = \text{OPEN}$ Measured on V_{IN} MIC94042, MIC94043		7	10	
I_{EN}	Enable Input Current	$V_{IN} = V_{EN} = 5.5\text{V}$, $I_D = \text{OPEN}$		2.5	4	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 (MIC94041, MIC94043)	$V_{IN} = +3.6\text{V}$, $I_{TEST} = 1\text{mA}$, $V_{EN} = 0\text{V}$		250	400	Ω

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 thermal 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 MIC94040YFL and MIC94042YFL.

Electrical Characteristics (Dynamic)

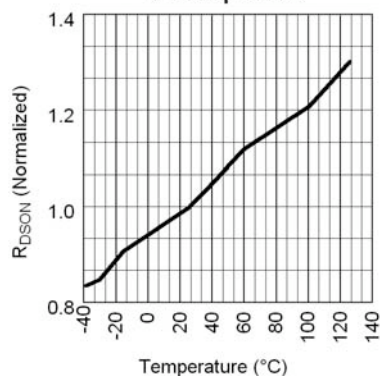
$T_A = 25^\circ\text{C}$, bold values indicate $-40^\circ\text{C} \leq T_A \leq +85^\circ\text{C}$, unless noted.

Symbol	Parameter	Condition	Min	Typ	Max	Units
$t_{\text{ON_DLY}}$	Turn-On Delay Time	$V_{\text{IN}} = +3.6\text{V}$, $I_{\text{D}} = -100\text{mA}$, $V_{\text{EN}} = 1.5\text{V}$ MIC94040, MIC94041		0.97	1.5	μs
		$V_{\text{IN}} = +3.6\text{V}$, $I_{\text{D}} = -100\text{mA}$, $V_{\text{EN}} = 1.5\text{V}$ MIC94042, MIC94043	50	106	185	μs
$t_{\text{ON_RISE}}$	Turn-On Rise Time	$V_{\text{IN}} = +3.6\text{V}$, $I_{\text{D}} = -100\text{mA}$, $V_{\text{EN}} = 1.5\text{V}$ MIC94040, MIC94041	0.5	0.9	5	μs
		$V_{\text{IN}} = +3.6\text{V}$, $I_{\text{D}} = -100\text{mA}$, $V_{\text{EN}} = 1.5\text{V}$ MIC94042, MIC94043	50	116	200	μs
$t_{\text{OFF_DLY}}$	Turn-Off Delay Time	$V_{\text{IN}} = +3.6\text{V}$, $I_{\text{D}} = -100\text{mA}$, $V_{\text{EN}} = 0\text{V}$		100	200	ns
$t_{\text{OFF_FALL}}$	Turn-Off Fall Time	$V_{\text{IN}} = +3.6\text{V}$, $I_{\text{D}} = -100\text{mA}$, $V_{\text{EN}} = 0\text{V}$		20	100	ns

Typical Characteristics

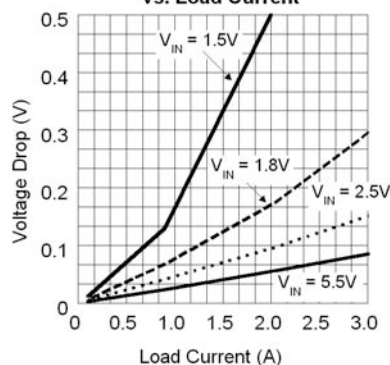
MIC94040/1/2/3

$R_{DS(on)}$ Variance
vs. Temperature



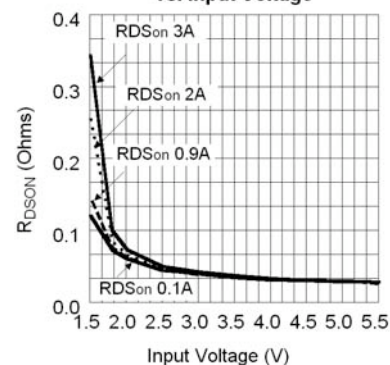
MIC94040/1/2/3

Voltage Drop
vs. Load Current



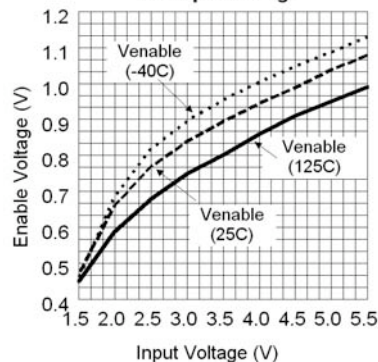
MIC94040/1/2/3

On Resistance
vs. Input Voltage



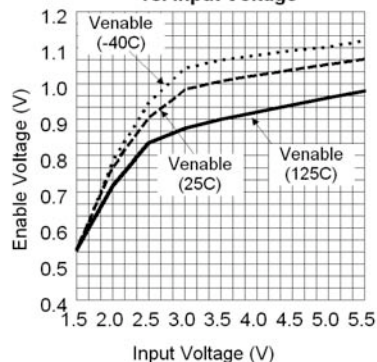
MIC94040/1

Enable Threshold
vs. Input Voltage



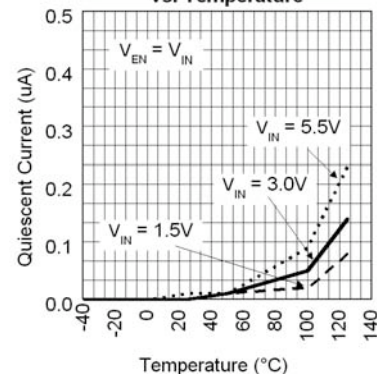
MIC94042/3

Enable Threshold
vs. Input Voltage



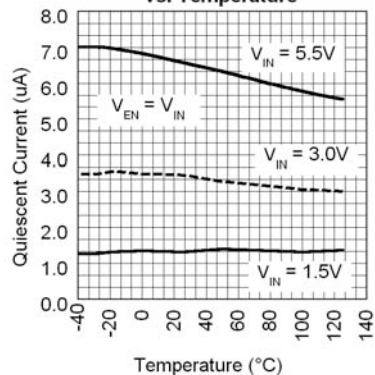
MIC94040/41

Quiescent Current
vs. Temperature



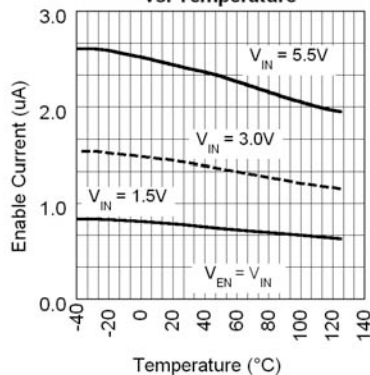
MIC94042/3

Quiescent Current
vs. Temperature



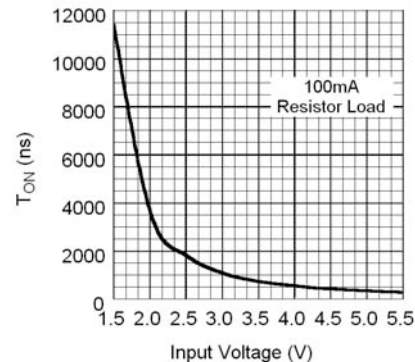
MIC94042/3

Enable Current
vs. Temperature



MIC94040/1

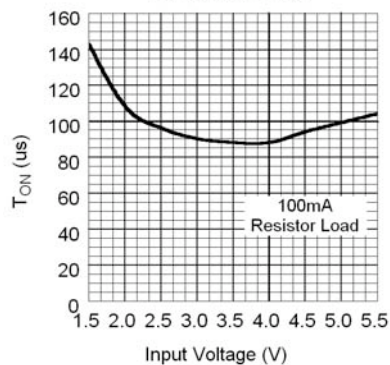
T_{ON} Delay
vs. Input Voltage



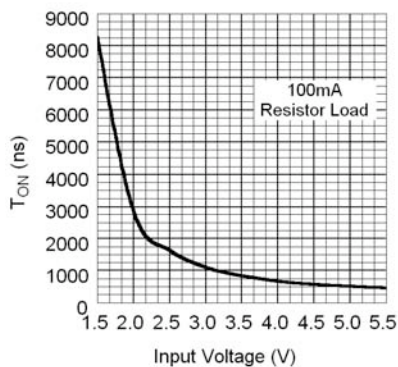
Typical Characteristics

MIC94042/3

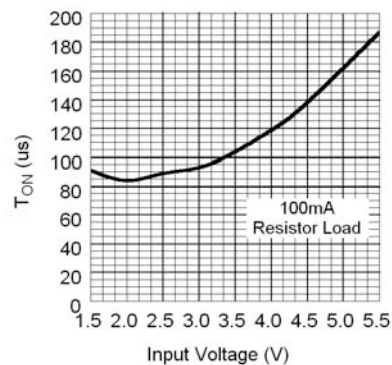
T_{ON} Delay
vs. Input Voltage


MIC94040/1

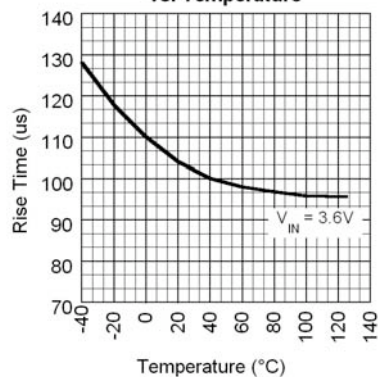
Rise Time
vs. Input Voltage


MIC94042/3

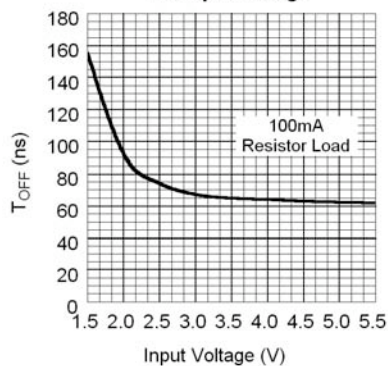
Rise Time
vs. Input Voltage


MIC94040/1

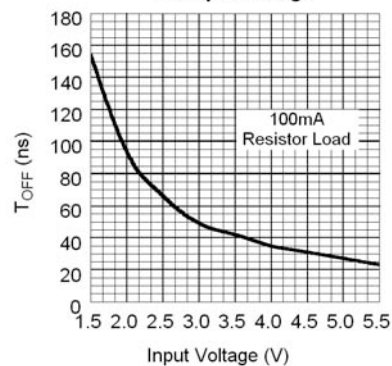
Turn on Rise Time
vs. Temperature


MIC94042/3

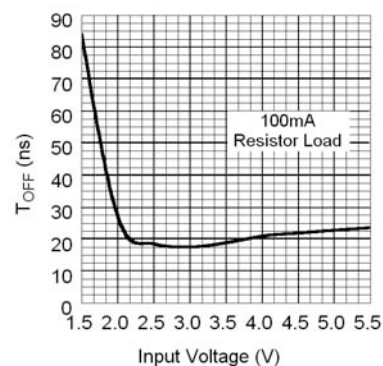
T_{OFF} Delay
vs. Input Voltage


MIC94040/1/2/3

T_{OFF} Delay
vs. Input Voltage

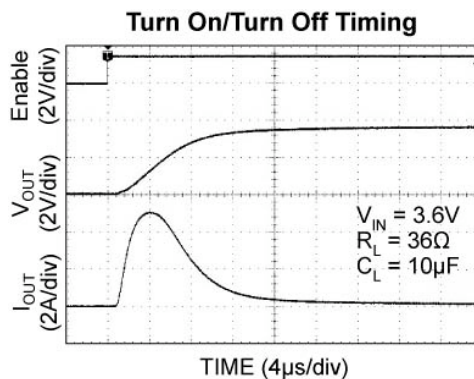
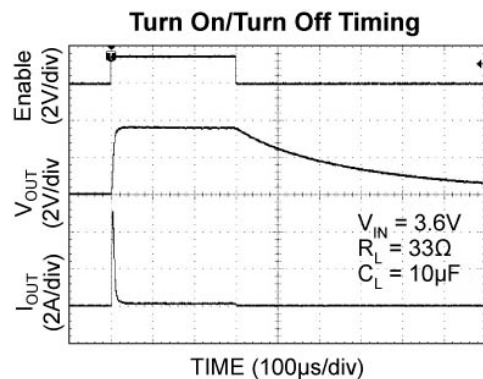
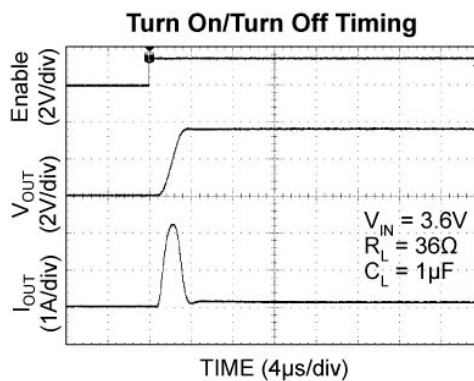
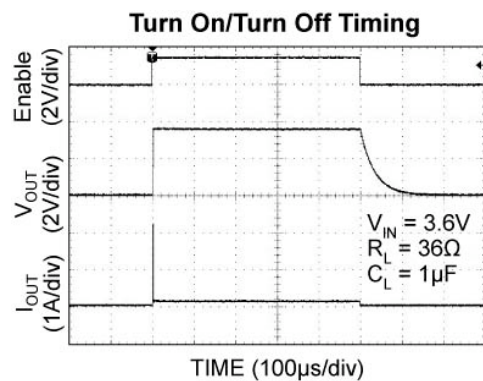
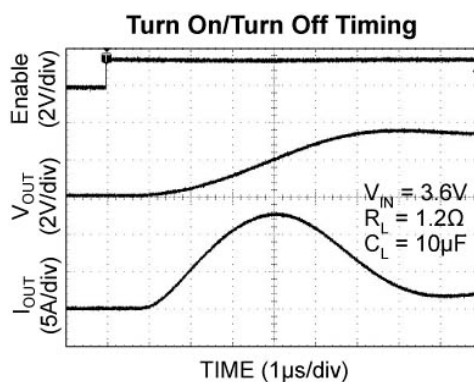
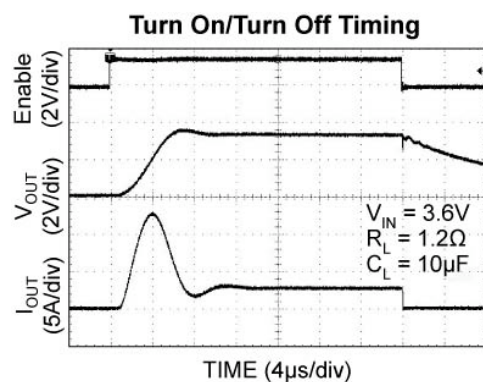
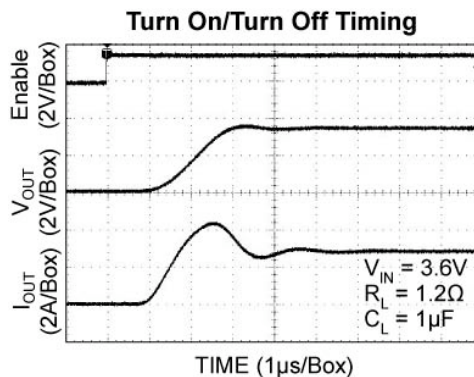
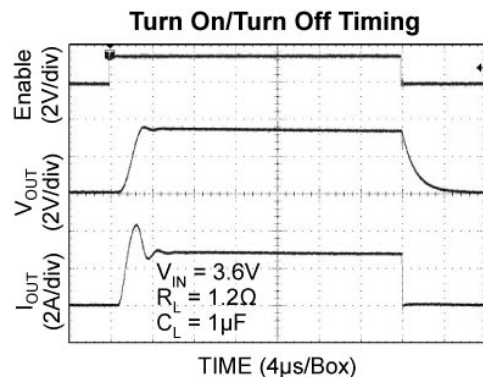

MIC94042/3

Fall Time
vs. Input Voltage

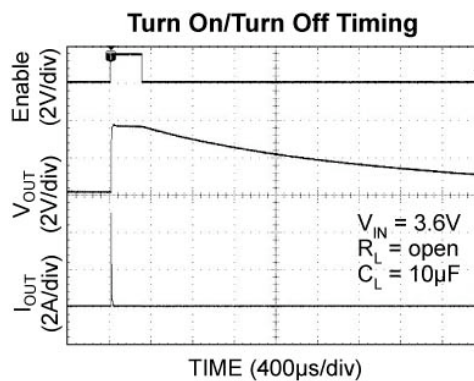
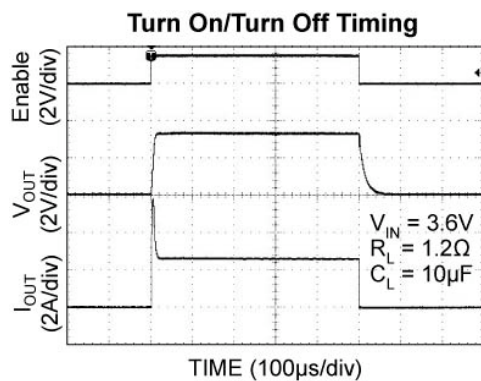
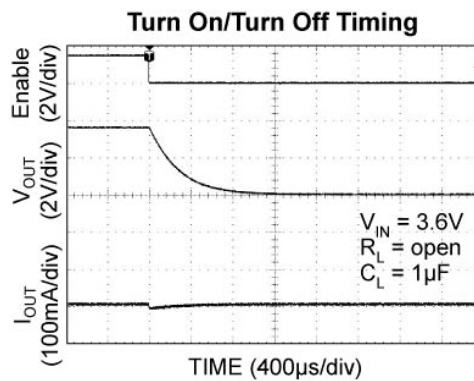
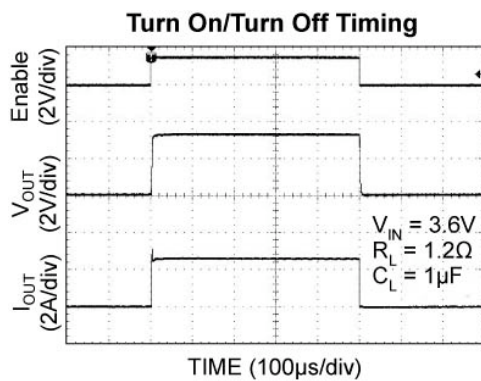
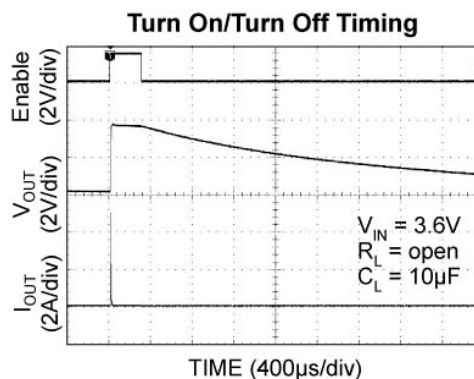
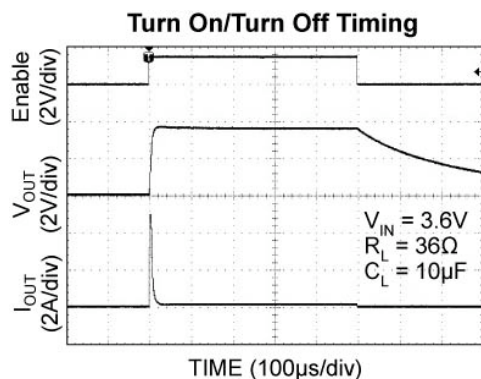
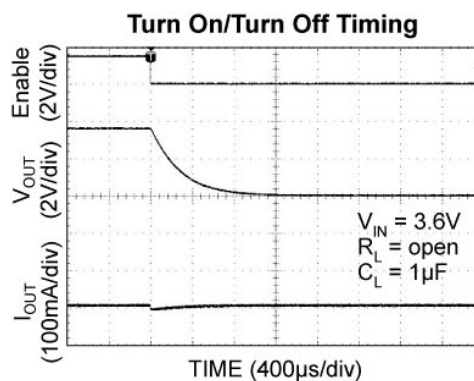
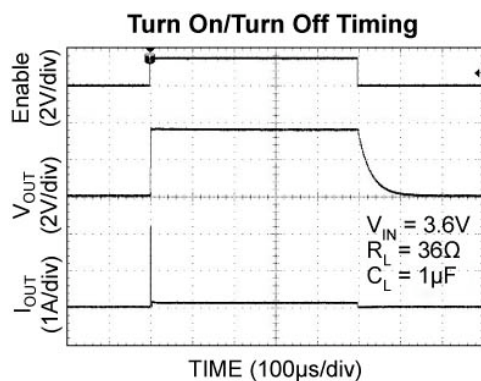


Functional Characteristics

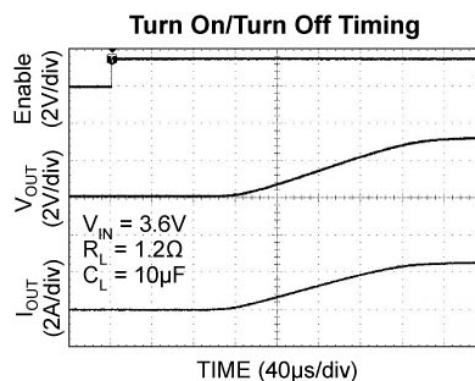
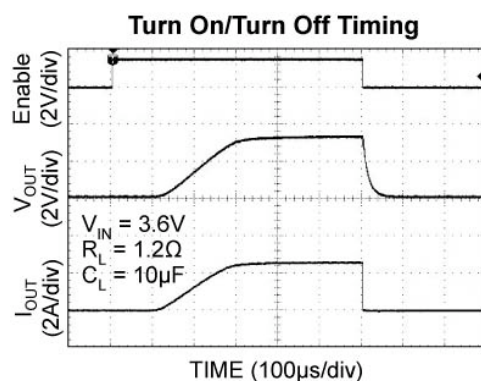
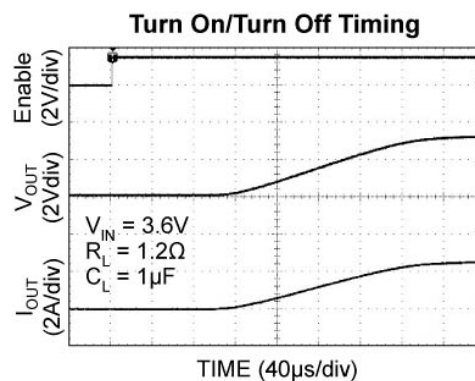
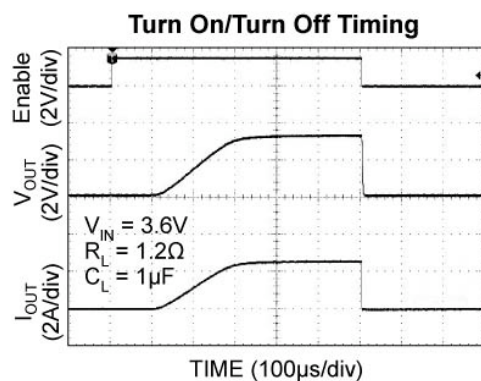
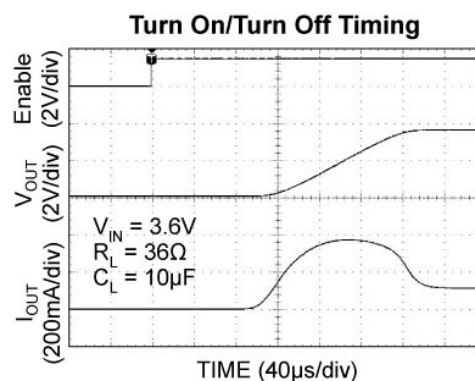
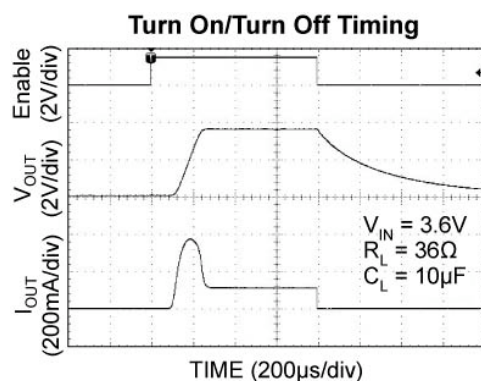
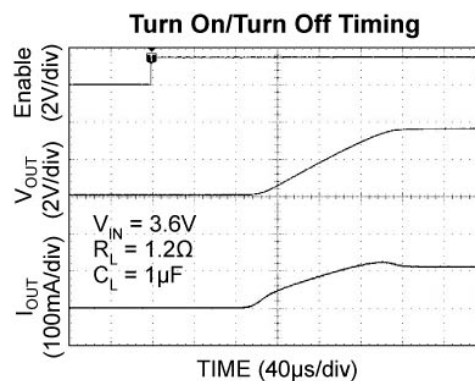
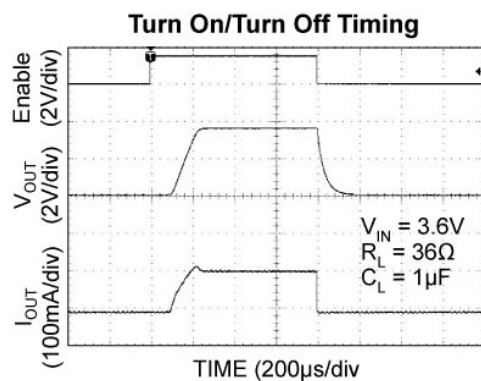
MIC94040



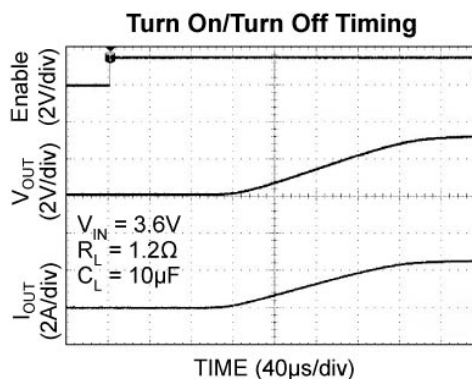
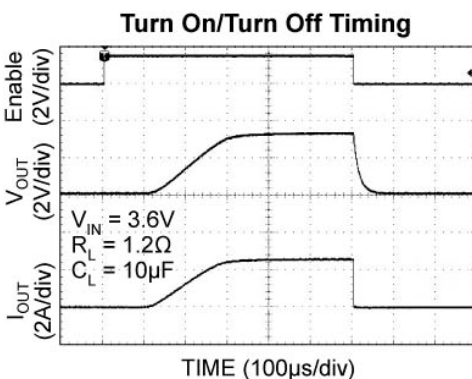
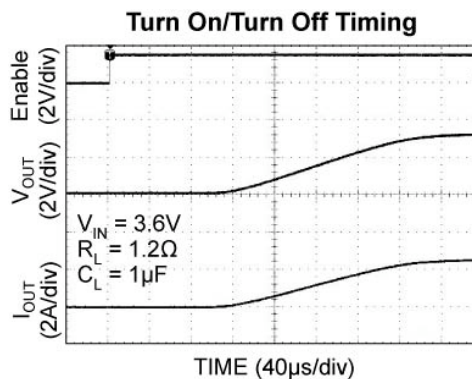
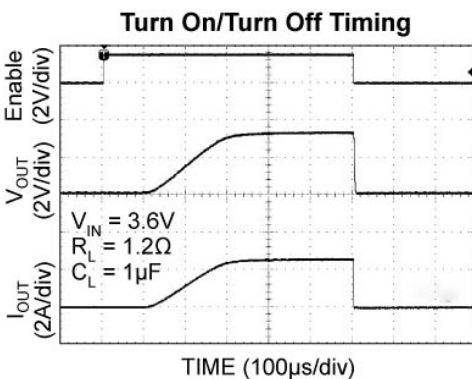
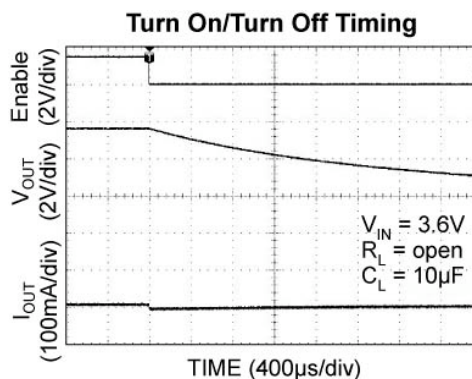
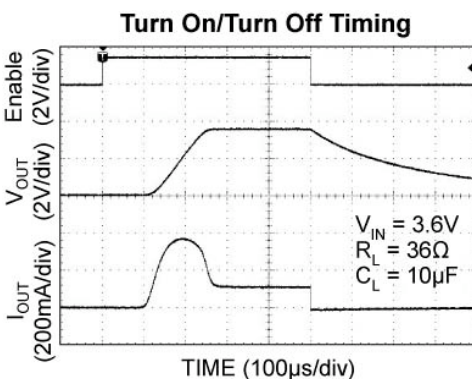
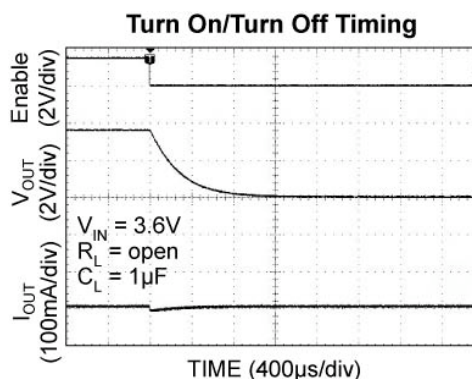
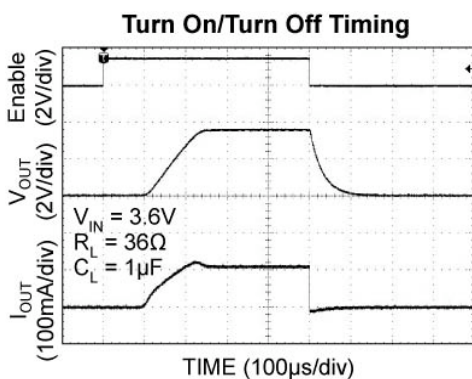
MIC94041



MIC94042



MIC94043



Application Information

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:

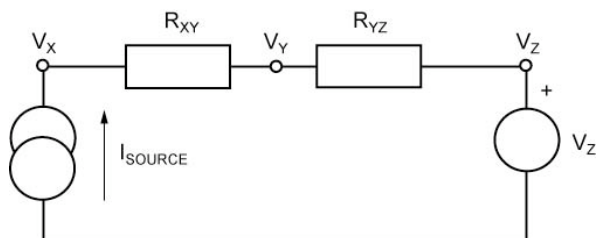


Figure 1. Simple Electrical Circuit

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:

$$V_x = I_{source} \cdot (R_{xy} + R_{yz}) + V_z$$

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 $^{\circ}\text{C}$).

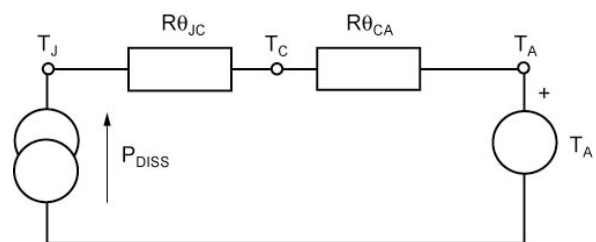


Figure 2. Simple Thermal Circuit

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 by 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 $^{\circ}\text{C}$.

Summary of variables:

$$I_{SW} = 2\text{A}$$

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

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

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

$$R_{\theta_{CA}} = 53^{\circ}\text{C/W Read from Graph in Figure 3}$$

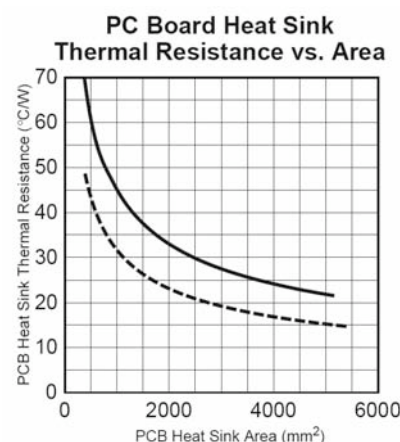


Figure 3. Excerpt from the LDO Book

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

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.

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

If this were a figure for worst case R_{SWmax} for 25 $^{\circ}\text{C}$, an additional consideration is to allow for the maximum junction temperature of 125 $^{\circ}\text{C}$, the actual worst case resistance in this case can be 30% higher (See $R_{DS(on)}$ variance vs. temperature graph). However, 90m Ω is the maximum over temperature.

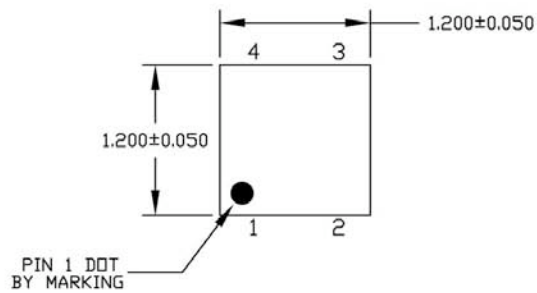
Therefore:

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

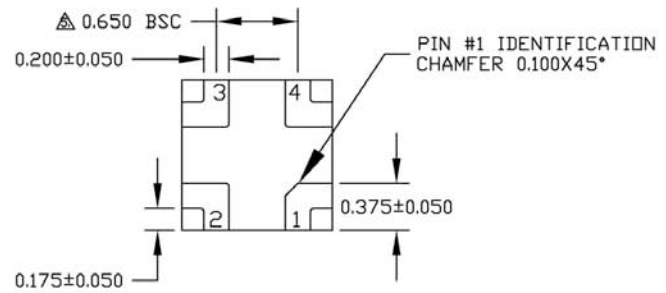
$$T_j = 101^{\circ}\text{C}$$

This is below the maximum 125 $^{\circ}\text{C}$.

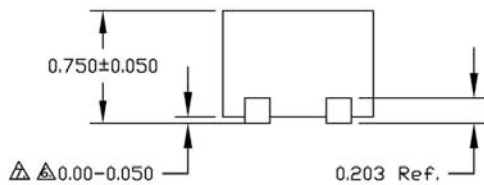
Package Information



TOP VIEW



BOTTOM VIEW

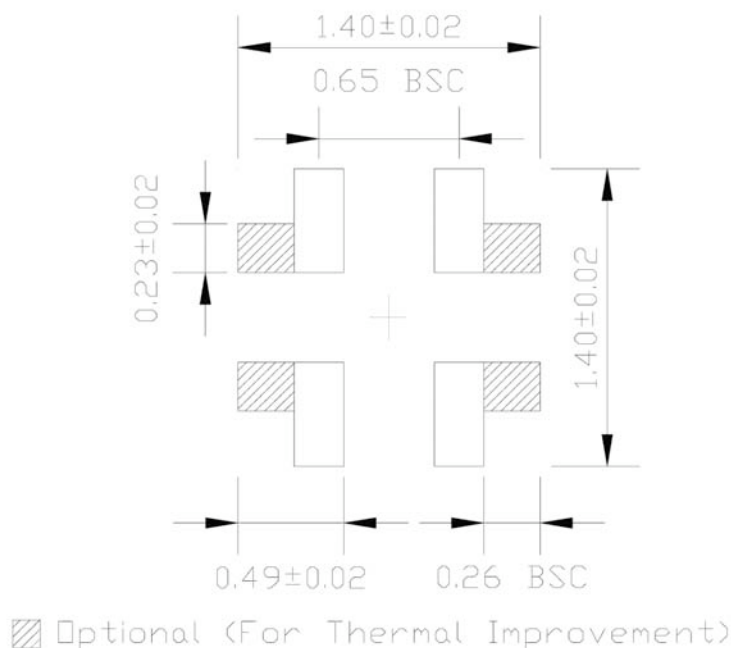


SIDE VIEW

- NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
 2. MAX. PACKAGE WARPAGE IS 0.05 mm.
 3. MAXIMUM ALLOWABLE BURRS IS 0.076 mm IN ALL DIRECTIONS.
 4. PIN #1 ID ON TOP WILL BE LASER/INK 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[®]

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."

Suggested Landing Pattern for 4 Pin (1.2mm x 1.2mm) MLF[®]

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