MIC94070/1/2/3

High-Side Power Switches

Features

- 1.7V to 5.5V Input Voltage Range
- 1.2A Continuous Operating Current
- 3A Pulse Current
- 120 mΩ $R_{DS(ON)}$ (Typical)
- Built-In Level Shift for Control Logic; Can be Operated by 1.5V Logic
- Low 2 µA Quiescent Current
- Soft-Start: MIC94072/73
- Micropower Shutdown <1 µA
- Load Discharge Circuit: MIC94071, MIC94073
- Space Saving 1.2 mm x 1.6 mm UDFN Package

Applications

- Load Switch in Portable Applications:
  - Cellular phones
  - PDAs
  - MP3 Players
  - Digital Cameras
  - Portable Instrumentation
- Battery Switch-Over Circuits
- Level Translator

General Description

The MIC94070, MIC94071, MIC94072, and MIC94073 are high-side load switches designed for operation between 1.7V to 5.5V. The devices contain a low on-resistance P-channel MOSFET that supports 1.2A of continuous current. The MIC94071 and MIC94073 feature an active load discharge circuit that ensures capacitive loads retain no charge when the main switch is in an OFF state.

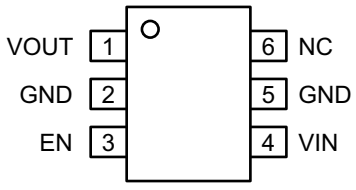
MIC94070 and MIC94071 feature rapid turn-on while MIC94072 and MIC94073 provide a slew rate controlled soft-start turn-on of 800 µs (typical) to prevent in-rush current from glitching supply rails.

An active pull-down on the enable input keeps MIC94070/73 in a default OFF state until the EN pin is pulled to a high level. Built-in level shift circuitry allows low voltage logic signals to switch higher supply voltages, or vice versa; high level logic signals can control low level voltages.

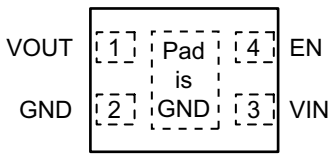
MIC94070/73's operating voltage range makes them suitable for 1-cell Lithium ion and 2- to 3-cell NiMH/NiCad/Alkaline powered systems, as well as all 5V applications. Their low operating current of 2 µA and low shutdown current of <1 µA maximize battery life.

Package Types

MIC94070/1/2/3
6-Lead SC-70 (C6)
(Top View)

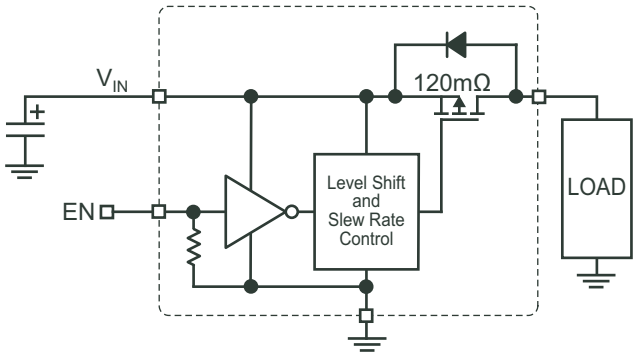


MIC94070/1/2/3
4-Lead UDFN (MT)
(Top View)

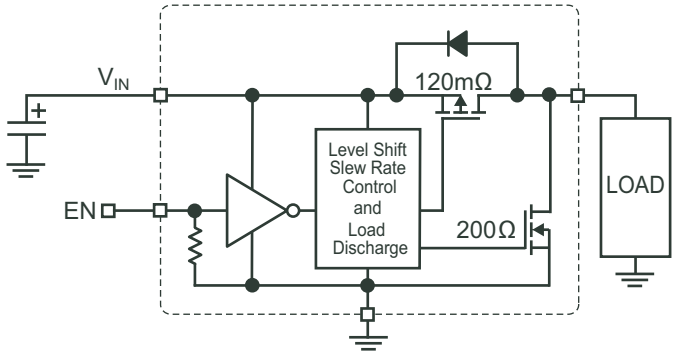


Typical Application Circuits

MIC94070, MIC94072
Load Switch Application



MIC94071, MIC94073
Load Switch with Capacitive Load Discharge



1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Input Voltage (V_{IN}) ..... +6V
Enable Voltage (V_{EN}) ..... +6V
Continuous Drain Current (I_D, Note 1)
UDFN (T_A = +25°C) ..... ±1.2A
SC-70 (T_A = +25°C) ..... ±1.2A
Pulsed Drain Current (I_{DP}, Note 2) ..... ±3.0A
Continuous Diode Current (I_S, Note 3) ..... –50 mA
ESD Rating (HBM, Note 4) ..... 4 kV

Operating Ratings ‡

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

† 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: With backside thermal contact to PCB.

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 valid for –40°C ≤ T_A ≤ +125°C, unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Enable Threshold Voltage	V_{EN_TH}	0.5	—	1.2	V	V_{IN} = 1.8V to 4.5V, I_D = –250 µA
		0.4	—	1.2	V	V_{IN} = 1.7V to 4.5V, I_D = –250 µA
Supply Current	I_Q	—	50 nA	5	µA	V_{IN} = V_{EN} = 5.5V, I_D = OPEN Measured on the VIN pin, Note 1
Enable Input Current	I_{EN}	—	2	4	µA	V_{IN} = V_{EN} = 5.5V, I_D = OPEN
Shutdown Current	I_{SHUT-Q}	—	25 nA	1	µA	V_{IN} = +5.5V, V_{EN} = 0V, I_D = OPEN Measured on the VIN pin, Note 1
OFF State Leakage Current	$I_{SHUT-SWITCH}$	—	50 nA	1	µA	V_{IN} = +5.5V, V_{EN} = 0V, I_D = SHORT, Measured on VOUT, Note 1
P-Channel Drain-to-Source ON Resistance SC-70 Package	$R_{DS(ON)}$	—	120	170	mΩ	V_{IN} = +5.0V, I_D = –100 mA, V_{EN} = 1.5V
		—	130	185	mΩ	V_{IN} = +4.5V, I_D = –100 mA, V_{EN} = 1.5V
		—	145	210	mΩ	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V
		—	165	225	mΩ	V_{IN} = +2.5V, I_D = –100 mA, V_{EN} = 1.5V
		—	200	260	mΩ	V_{IN} = +1.8V, I_D = –100 mA, V_{EN} = 1.5V
		—	210	285	mΩ	V_{IN} = +1.7V, I_D = –100 mA, V_{EN} = 1.5V

ELECTRICAL CHARACTERISTICS (CONTINUED)

T_A = +25°C, **bold** values valid for –40°C ≤ T_A ≤ +125°C, unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
P-Channel Drain-to-Source ON Resistance UDFN Package	$R_{DS(ON)}$	—	100	160	mΩ	V_{IN} = +5.0V, I_D = –100 mA, V_{EN} = 1.5V
		—	110	165	mΩ	V_{IN} = +4.5V, I_D = –100 mA, V_{EN} = 1.5V
		—	125	180	mΩ	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V
		—	145	200	mΩ	V_{IN} = +2.5V, I_D = –100 mA, V_{EN} = 1.5V
		—	180	240	mΩ	V_{IN} = +1.8V, I_D = –100 mA, V_{EN} = 1.5V
		—	190	265	mΩ	V_{IN} = +1.7V, I_D = –100 mA, V_{EN} = 1.5V
Load Discharge Resistance (MIC94071, MIC94073)	$R_{DISCHARGE}$	—	200	400	Ω	V_{IN} = +3.6V, I_{TEST} = 1 mA, V_{EN} = 0V

Note 1: Measured on the MIC94070YMT, for other part numbers, please contact Microchip.

ELECTRICAL CHARACTERISTICS (DYNAMIC)

V_{IN} = 5V, T_A = +25°C, **bold** values valid for –40°C ≤ T_A ≤ +125°C, unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Turn-On Delay Time	t_{ON_DLY}	—	0.85	1.5	µs	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94070, 71
		—	700	1200	µs	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94072, 73
Turn-On Rise Time	t_{ON_RISE}	0.5	1	5	µs	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94070, 71
		500	800	1500	µs	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94072, 73
Turn-Off Delay Time	t_{OFF_DLY}	—	100	200	ns	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94070, 71
		—	60	200	ns	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94072, 73
Turn-Off Fall Time	t_{OFF_FALL}	—	60	100	ns	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94070, 71
		—	60	100	ns	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94072, 73

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Storage Temperature Range	T_S	–55	—	+150	°C	—
Junction Temperature Range	T_J	–40	—	+125	°C	—
Package Thermal Resistances						
Thermal Resistance, SC-70 6-Ld	θ_{JA}	—	240	—	°C/W	—
Thermal Resistance, UDFN 8-Ld	θ_{JA}	—	172	—	°C/W	—
	θ_{JC}	—	134	—	°C/W	Note 1

Note 1: With backside thermal contact to PCB.

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.

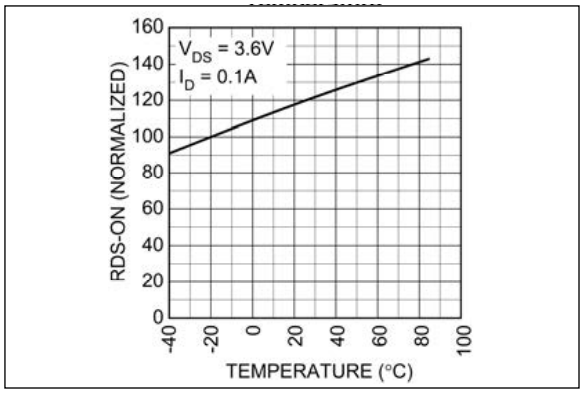


FIGURE 2-1: *RDS-ON Variance with Temperature.*

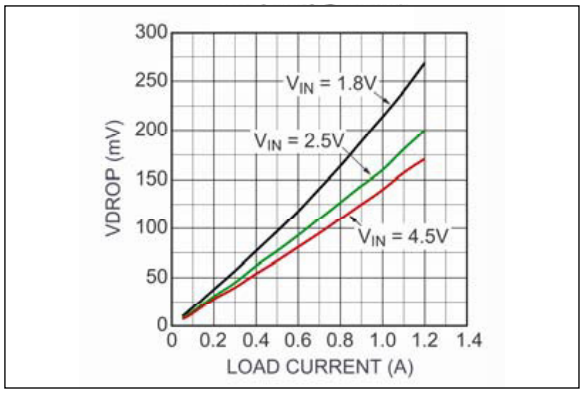


FIGURE 2-4: *Voltage Drop vs. Load Current.*

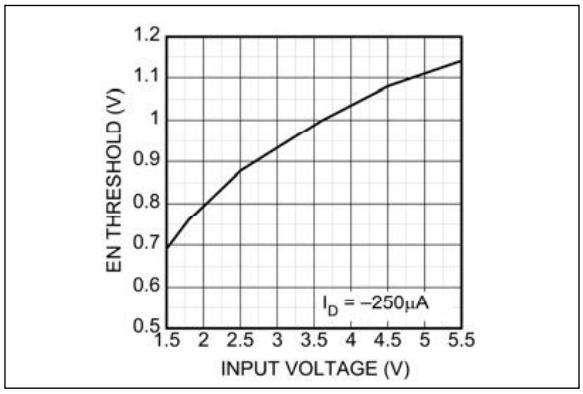


FIGURE 2-2: *EN Threshold Voltage vs. Input Voltage.*

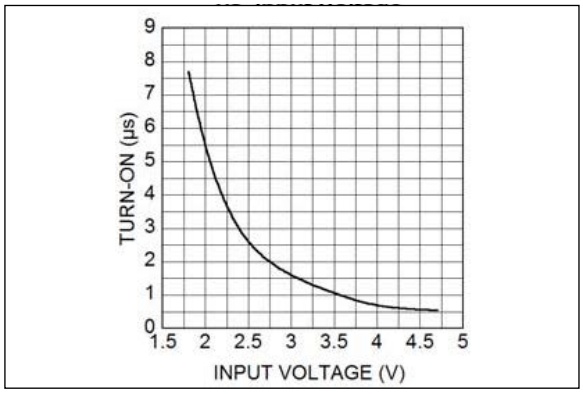


FIGURE 2-5: *MIC94070/71 Turn-On Delay vs. Input Voltage.*

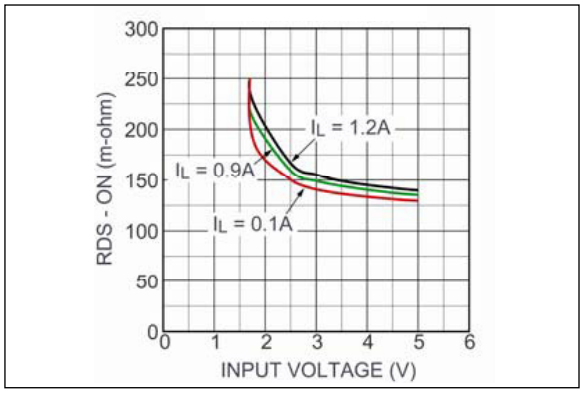


FIGURE 2-3: *On Resistance vs. Input Voltage.*

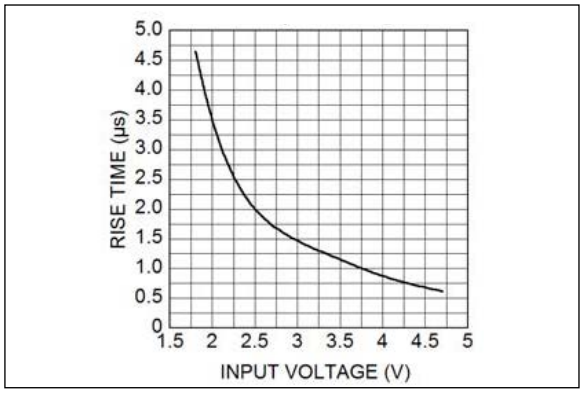


FIGURE 2-6: *MIC94070/71 Rise Time vs. Input Voltage.*

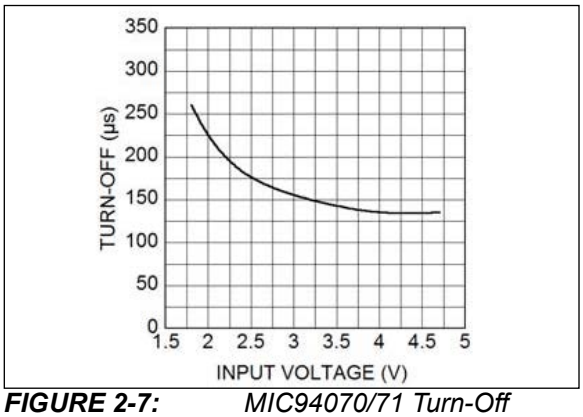


FIGURE 2-7: *MIC94070/71 Turn-Off Delay vs. Input Voltage.*

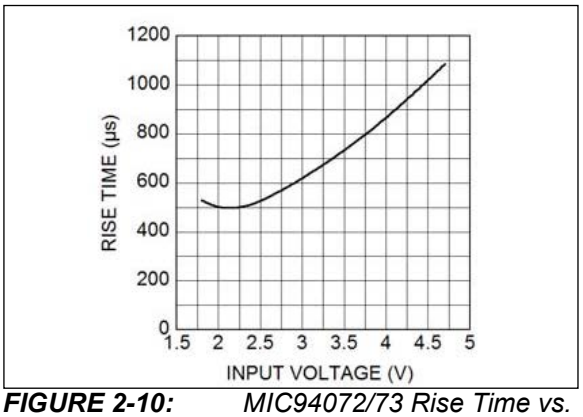


FIGURE 2-10: *MIC94072/73 Rise Time vs. Input Voltage.*

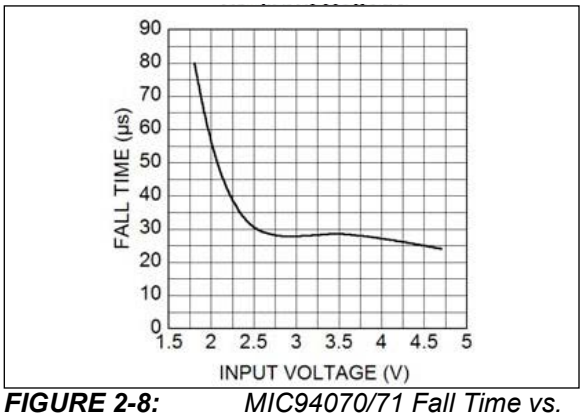


FIGURE 2-8: *MIC94070/71 Fall Time vs. Input Voltage.*

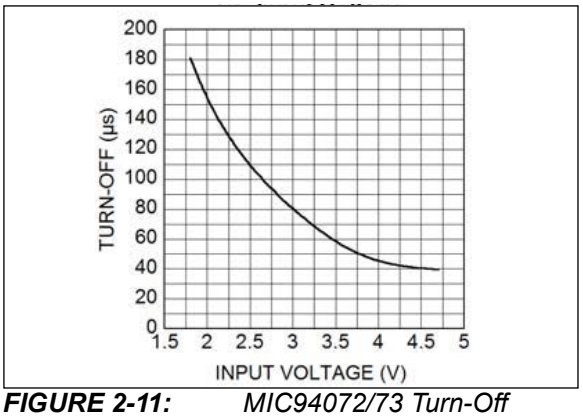


FIGURE 2-11: *MIC94072/73 Turn-Off Delay vs. Input Voltage.*

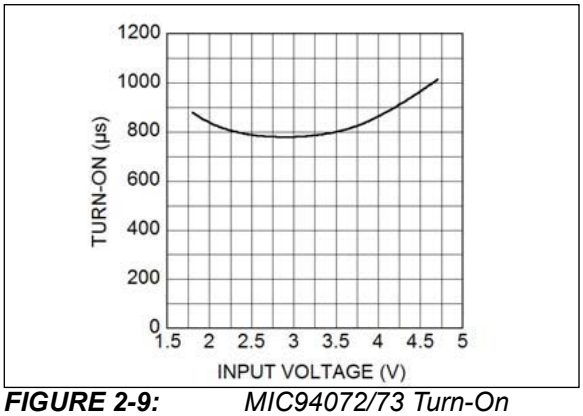


FIGURE 2-9: *MIC94072/73 Turn-On Delay vs. Input Voltage.*

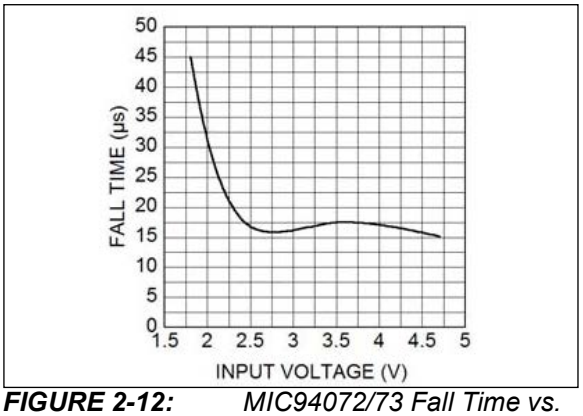


FIGURE 2-12: *MIC94072/73 Fall Time vs. Input Voltage.*

MIC94070

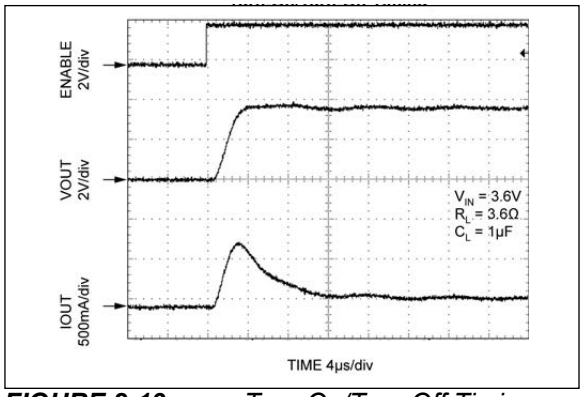


FIGURE 2-13: *Turn-On/Turn-Off Timing.*

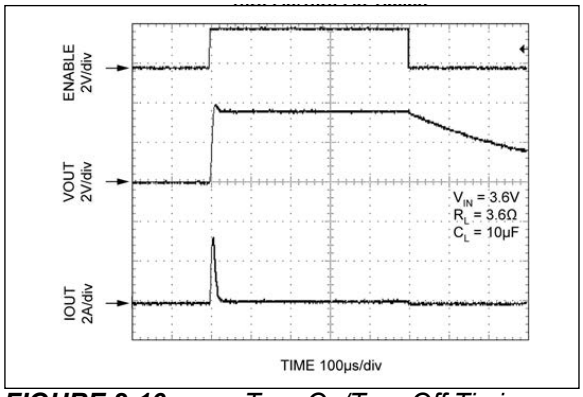


FIGURE 2-16: *Turn-On/Turn-Off Timing.*

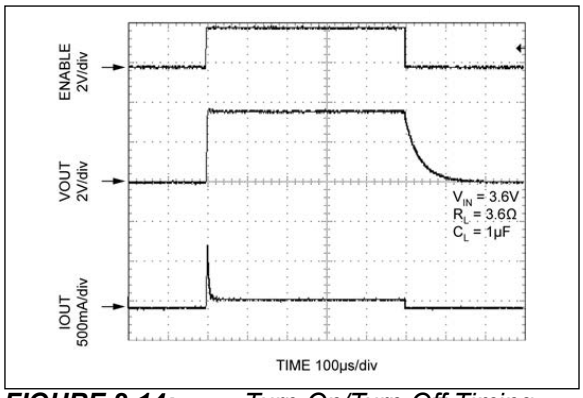


FIGURE 2-14: *Turn-On/Turn-Off Timing.*

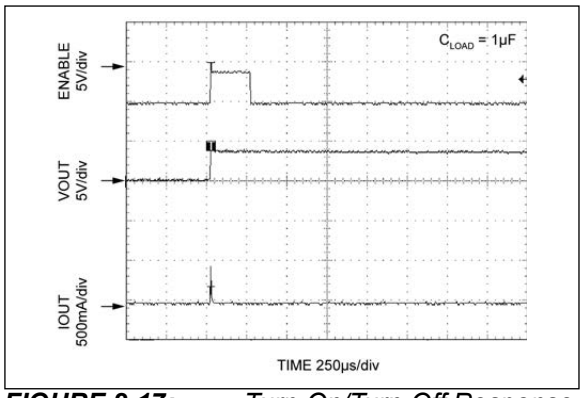


FIGURE 2-17: *Turn-On/Turn-Off Response.*

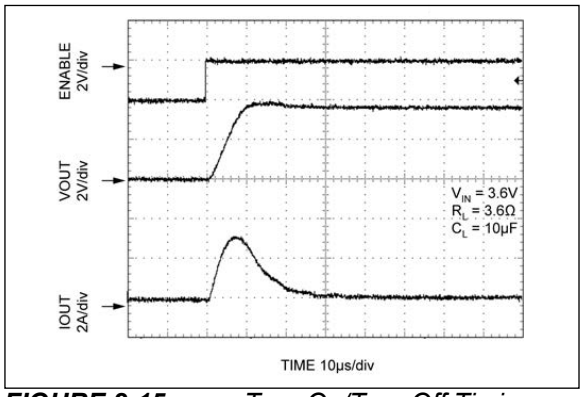


FIGURE 2-15: *Turn-On/Turn-Off Timing.*

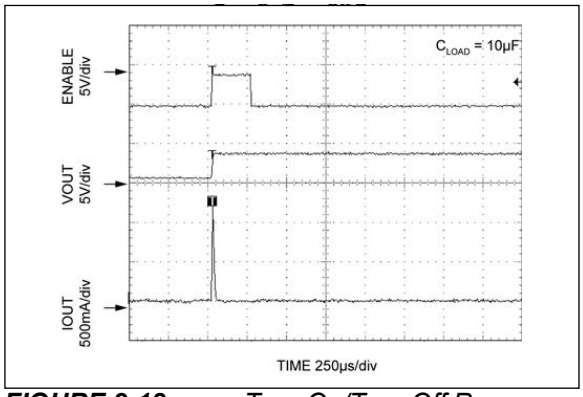


FIGURE 2-18: *Turn-On/Turn-Off Response.*

MIC94071

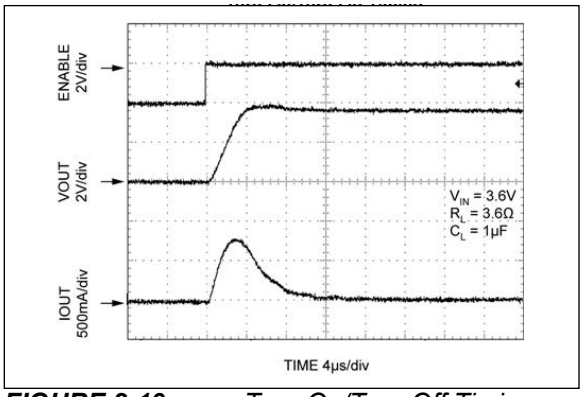


FIGURE 2-19: *Turn-On/Turn-Off Timing.*

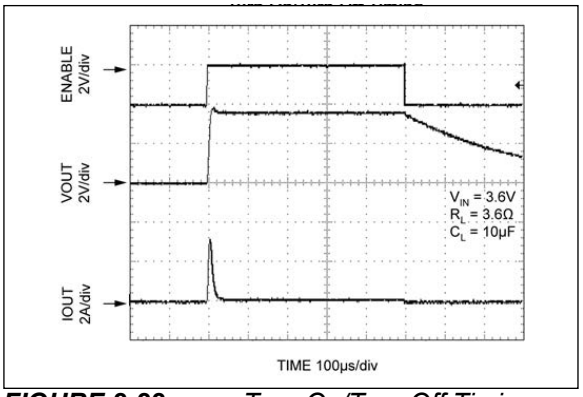


FIGURE 2-22: *Turn-On/Turn-Off Timing.*

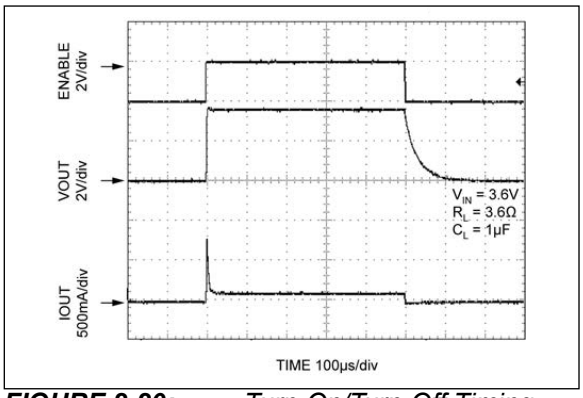


FIGURE 2-20: *Turn-On/Turn-Off Timing.*

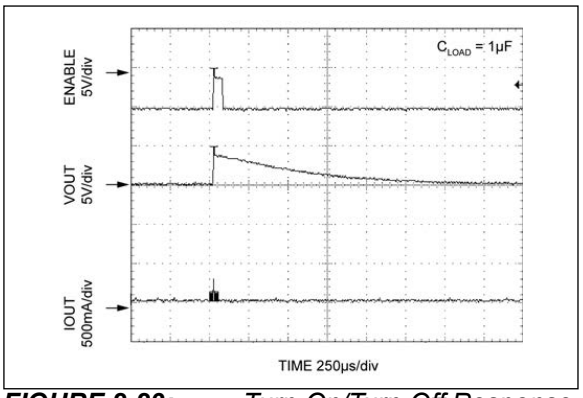


FIGURE 2-23: *Turn-On/Turn-Off Response.*

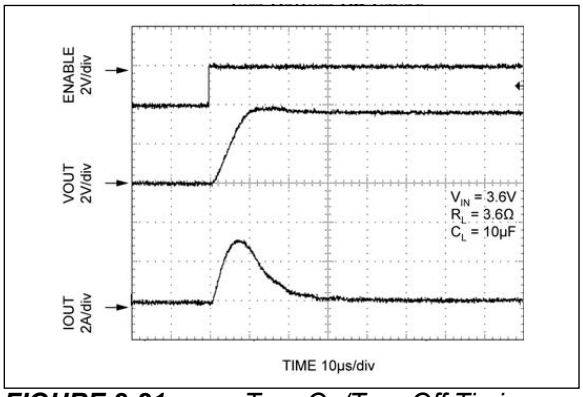


FIGURE 2-21: *Turn-On/Turn-Off Timing.*

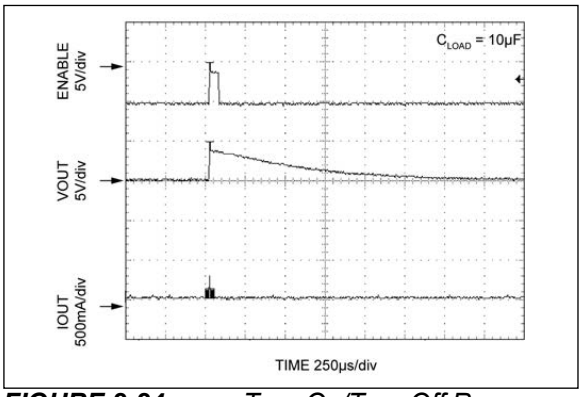


FIGURE 2-24: *Turn-On/Turn-Off Response.*

MIC94072

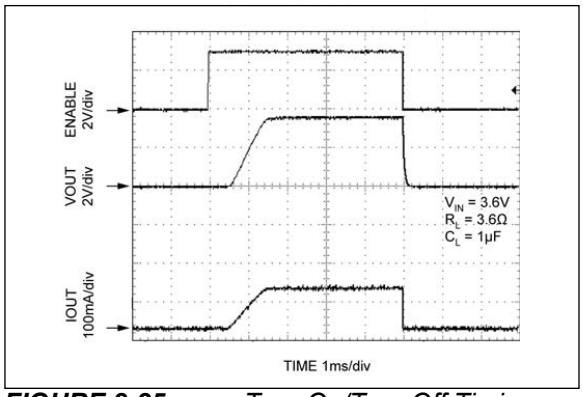


FIGURE 2-25: *Turn-On/Turn-Off Timing.*

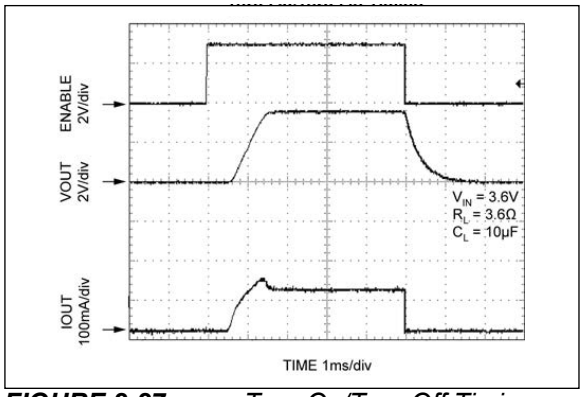


FIGURE 2-27: *Turn-On/Turn-Off Timing.*

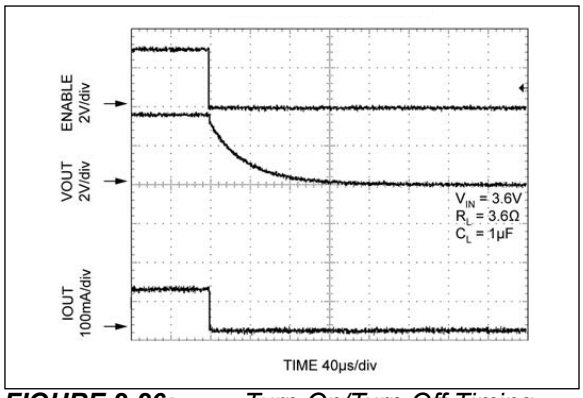


FIGURE 2-26: *Turn-On/Turn-Off Timing.*

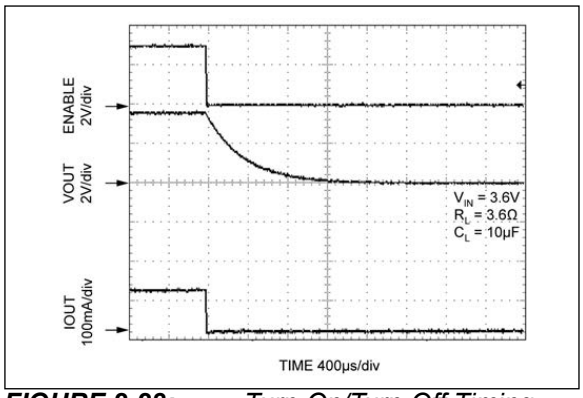


FIGURE 2-28: *Turn-On/Turn-Off Timing.*

MIC94073

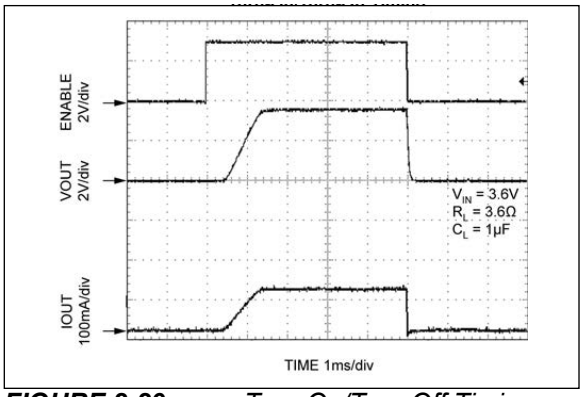


FIGURE 2-29: *Turn-On/Turn-Off Timing.*

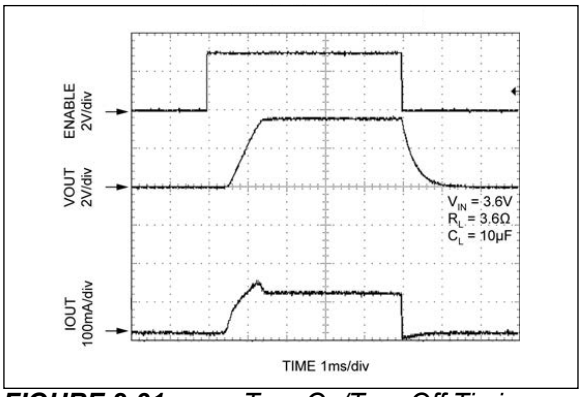


FIGURE 2-31: *Turn-On/Turn-Off Timing.*

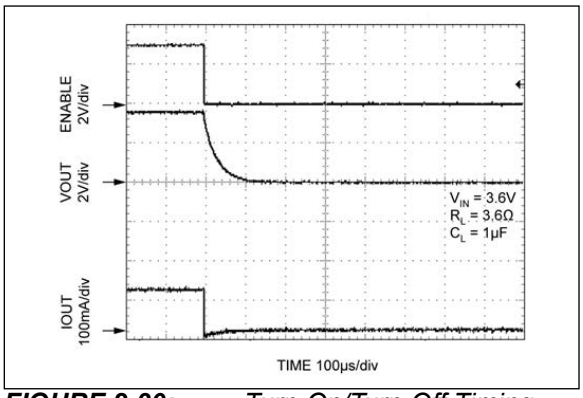


FIGURE 2-30: *Turn-On/Turn-Off Timing.*

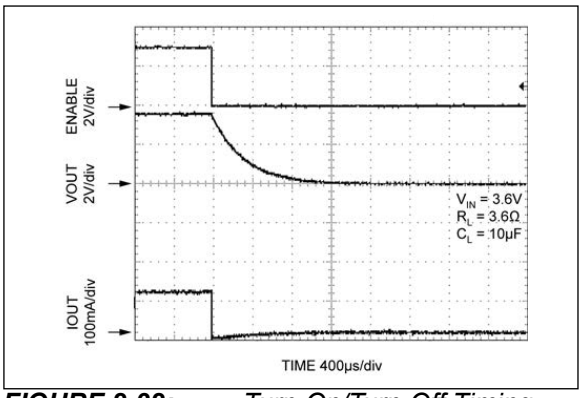


FIGURE 2-32: *Turn-On/Turn-Off Timing.*

3.0 PIN DESCRIPTIONS

The descriptions of the pins are listed in Table 3-1.

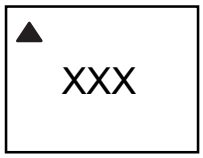
TABLE 3-1: PIN FUNCTION TABLE

Pin Number SC-70	Pin Number UDFN	Pin Name	Description
1	1	VOUT	Drain of P-channel MOSFET.
2, 5	2	GND	Ground and the backside pad (UDFN only) should both be connected to electrical ground.
4	3	VIN	Source of P-channel MOSFET.
3	4	EN	Enable (Input): Active-high CMOS compatible control input for switch A. Do not leave floating.
6	—	NC	No Internal Connection. A signal or voltage applied to this pin will have no effect on device operation.

4.0 PACKAGING INFORMATION

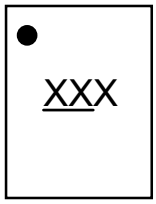
4.1 Package Marking Information

4-Lead UDFN*

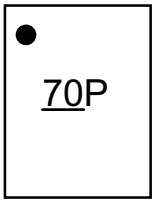


Example

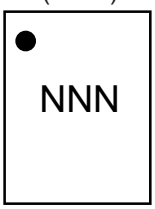
6-Lead SC70* (Front)



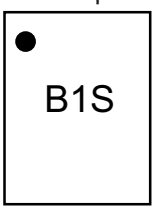
Example



6-Lead SC70* (Back)



Example

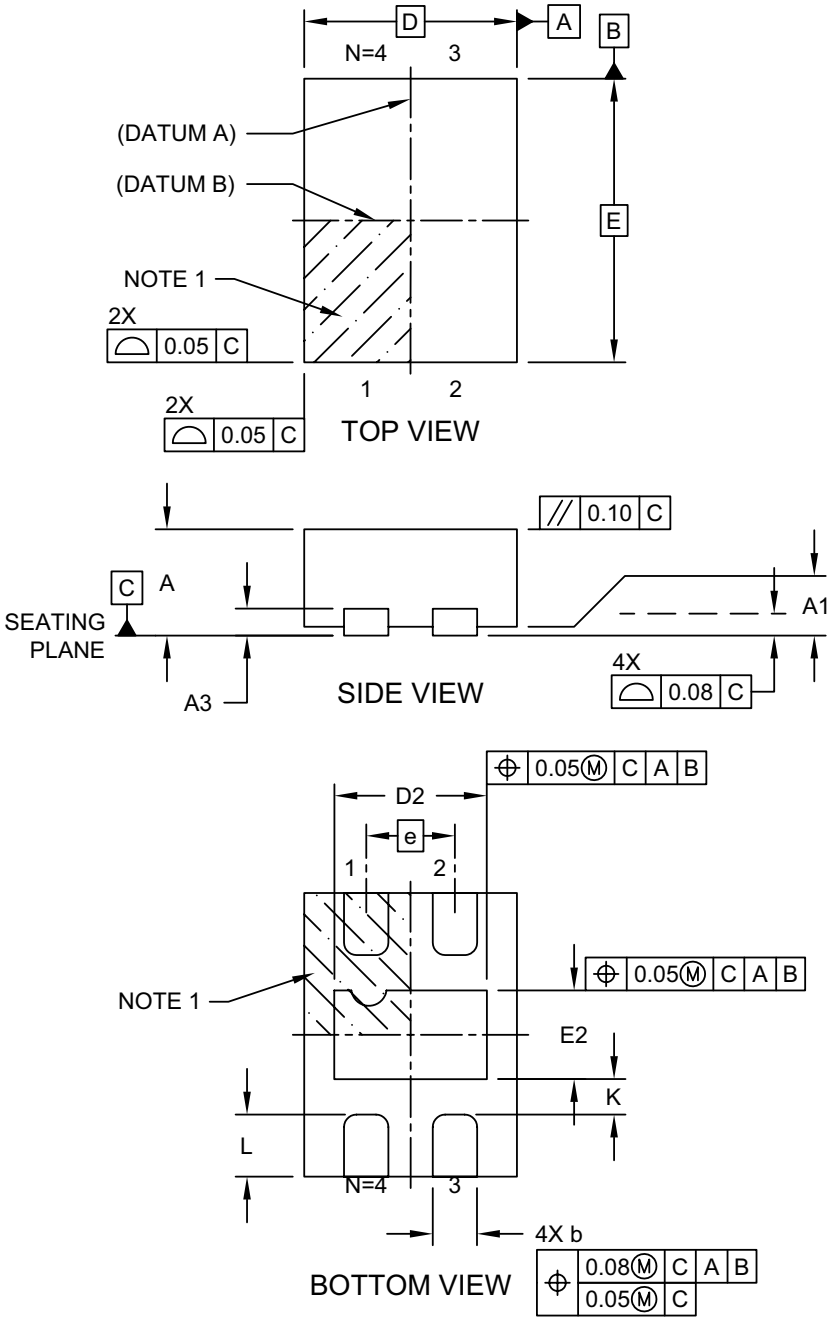


Legend:	XX...X	Product code or customer-specific information
	Y	Year code (last digit of calendar year)
	YY	Year code (last 2 digits of calendar year)
	WW	Week code (week of January 1 is week ‘01’)
	NNN	Alphanumeric traceability code
	(e3)	Pb-free JEDEC® designator for Matte Tin (Sn)
	*	This package 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

4-Lead Ultra Thin Dual Flat, No Lead Package (HGA) - 1.2x1.6x0.6 mm Body [UDFN]
Micrel Legacy Package TMLF1216D-04L

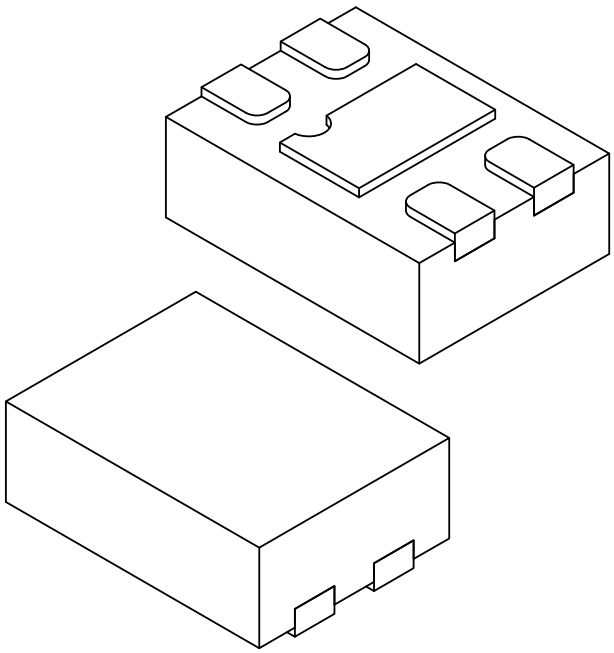
Note:	For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



Microchip Technology Drawing C04-1152 Rev A Sheet 1 of 2

4-Lead Ultra Thin Dual Flat, No Lead Package (HGA) - 1.2x1.6x0.6 mm Body [UDFN] Micrel Legacy Package TMLF1216D-04L

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		0.50 BSC	
Overall Height	A	0.50	0.55	0.60
Standoff	A1	0.00	0.02	0.05
Terminal Thickness	A3		0.152 REF	
Overall Length	D		1.20 BSC	
Exposed Pad Length	D2	0.81	0.86	0.91
Overall Width	E		1.60 BSC	
Exposed Pad Width	E2	0.45	0.50	0.55
Terminal Width	b	0.20	0.25	0.30
Terminal Length	L	0.30	0.35	0.40
Terminal-to-Exposed-Pad	K	0.20	–	–

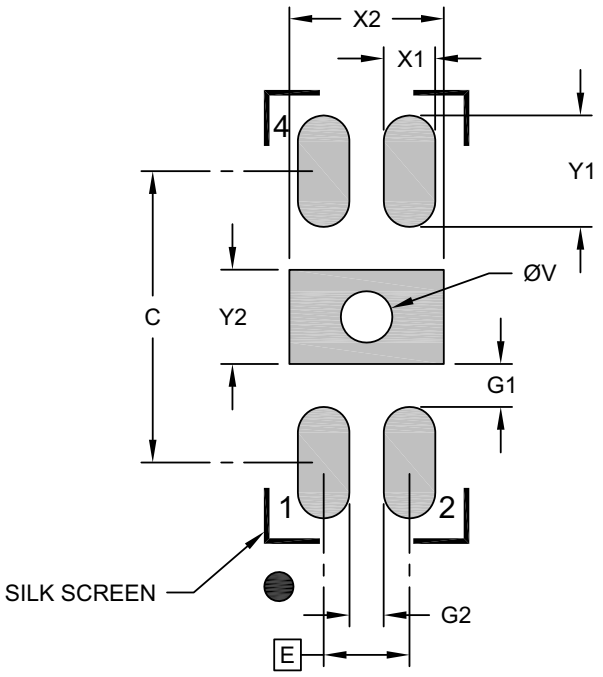
Notes:

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 C04-1152 Rev A Sheet 2 of 2

4-Lead Ultra Thin Dual Flat, No Lead Package (HGA) - 1.2x1.6x0.6 mm Body [UDFN] Micrel Legacy Package TMLF1216D-04L

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		0.50 BSC	
Optional Center Pad Width	X2			0.90
Optional Center Pad Length	Y2			0.55
Contact Pad Spacing	C		1.70	
Contact Pad Width (X4)	X1			0.30
Contact Pad Length (X4)	Y1			0.65
Contact Pad to Center Pad (X4)	G1	0.25		
Contact Pad to Contact Pad (X2)	G2	0.20		
Thermal Via Diameter	V		0.30	

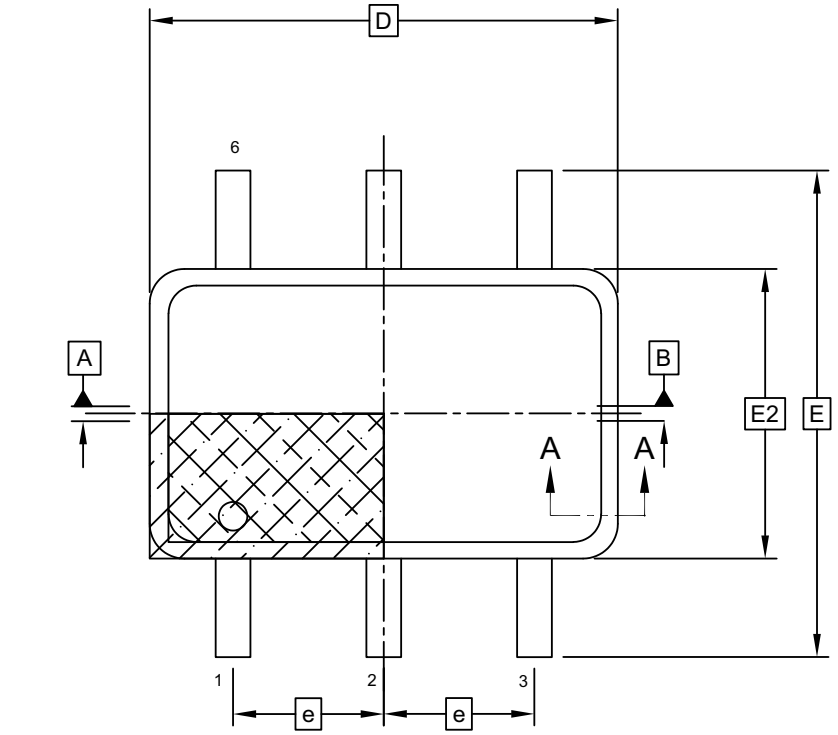
Notes:

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

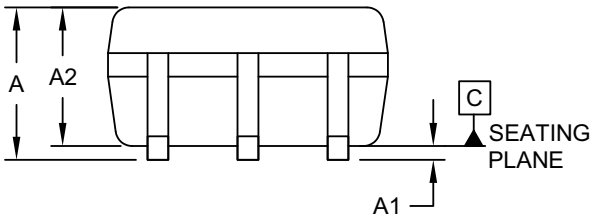
Microchip Technology Drawing C04-3152 Rev A

6-Lead Plastic package, EIAJ standard (D4A) - 2.0x1.25 mm Body [SC70]
Micrel Legacy Package

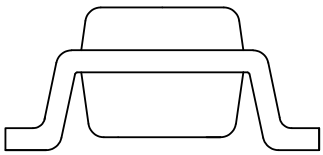
Note: For the most current package drawings, please see the Microchip Packaging Specification located at http://www.microchip.com/packaging



TOP VIEW



SIDE VIEW

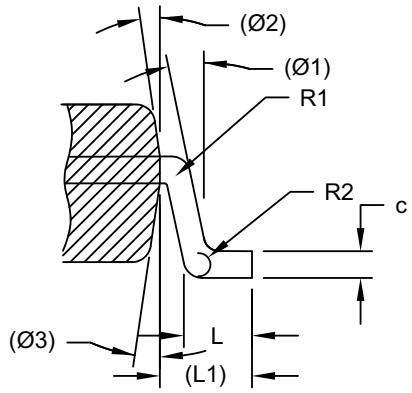


END VIEW

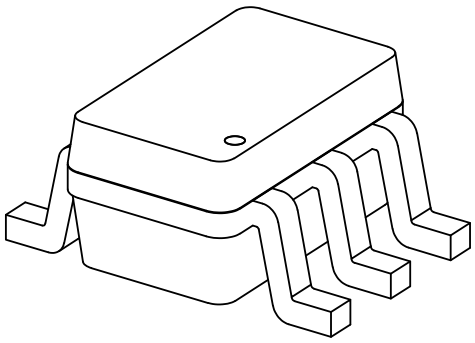
Microchip Technology Drawing C04-1133 Rev A Sheet 1 of 2

6-Lead Plastic package, EIAJ standard (D4A) - 2.0x1.25 mm Body [SC70]
Micrel Legacy Package

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



SECTION A–A



Units		MILLIMETERS		
Dimension Limits		MIN	NOM	MAX
Number of Terminals	N		6	
Pitch	e		0.65 BSC	
Overall Height	A	-	-	1.10
Standoff	A1	0.00	-	0.10
Molded Package Thickness	A2	0.80	–	1.00
Overall Length	D		2.00 BSC	
Overall Width	E		2.10 BSC	
Molded Package Width	E2		1.25 BSC	
Terminal Width	b	0.15	–	0.30
Terminal Thickness	c	0.08	-	0.25
Terminal Length	L	0.21	–	0.46
Footprint	L1		0.55 REF	
Lead Bend Radius	R1	0.02	-	0.08
Lead Bend Radius	R2	0.08	-	0.20
Lead Angle	θ1		12° REF	
Mold Draft Angle	θ2		8° REF	
Mold Draft Angle	θ3		8° REF	

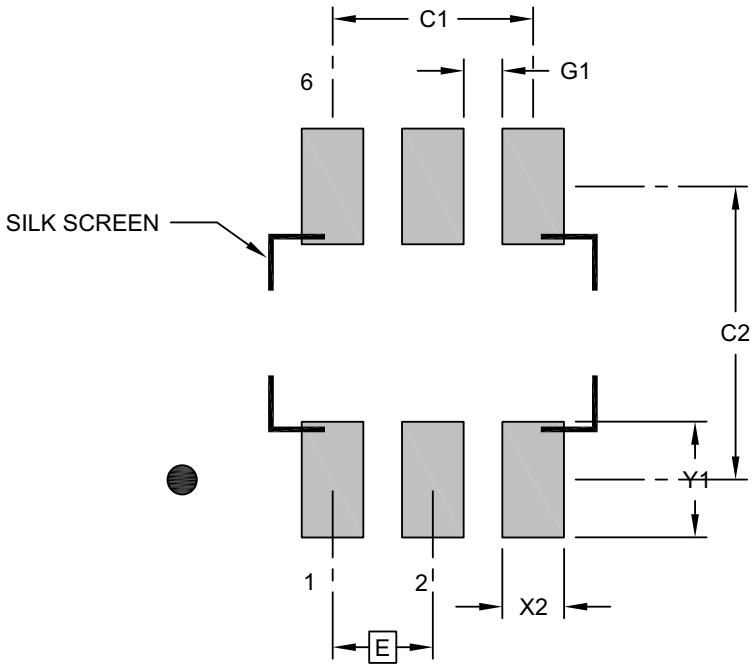
Notes:

1. Pin 1 visual index feature may vary, but must be located within the hatched area.
2. 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 C04-1133 Rev A Sheet 2 of 2

6-Lead Plastic package, EIAJ standard (D4A) - 2.0x1.25 mm Body [SC70]
Micrel Legacy Package

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		1.30	
Contact Pad Spacing	C2		1.90	
Contact Pad Width (X6)	X1			0.42
Contact Pad Length (X6)	Y1			0.77
Contact Pad to Contact Pad (X4)	G1	0.25		

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 C04-2133 Rev A

APPENDIX A: REVISION HISTORY

Revision A (May 2024)

- Converted Micrel document MIC94070/1/2/3 to Microchip data sheet DS20006896A.
- 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	Temperature Range	Package	Media Type

Device:	MIC94070:		High-Side Power Switch with Fast Turn-On
	MIC94071:		High-Side Power Switch with Fast Turn-On and Load Discharge
	MIC94072:		High-Side Power Switch with Soft-Start
	MIC94073:		High-Side Power Switch with Soft-Start and Load Discharge
Temperature Range:	Y	=	–40°C to +125°C
Package:	C6	=	6-Lead SC70
	MT	=	4-Lead UDFN
Media Type:	TR	=	5,000/Reel (SC70 option only)
	TR	=	3,000/Reel (UDFN option only)

Examples:

a) MIC94070YC6-TR: MIC94070, –40°C to +125°C Temp. Range, 6-Lead SC70, 5,000/Reel

b) MIC94070YMT-TR: MIC94070, –40°C to +125°C Temp. Range, 4-Lead UDFN, 3,000/Reel

c) MIC94071YC6-TR: MIC94071, –40°C to +125°C Temp. Range, 6-Lead SC70, 5,000/Reel

d) MIC94071YMT-TR: MIC94071, –40°C to +125°C Temp. Range, 4-Lead UDFN, 3,000/Reel

e) MIC94072YC6-TR: MIC94072, –40°C to +125°C Temp. Range, 6-Lead SC70, 5,000/Reel

f) MIC94072YMT-TR: MIC94072, –40°C to +125°C Temp. Range, 4-Lead UDFN, 3,000/Reel

g) MIC94073YC6-TR: MIC94073, –40°C to +125°C Temp. Range, 6-Lead SC70, 5,000/Reel

h) MIC94073YMT-TR: MIC94073, –40°C to +125°C Temp. Range, 4-Lead UDFN, 3,000/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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