MIC94060/1/2/3

High Side Power Switches

Features

- 1.7V to 5.5V Input Voltage Range
- 2A Continuous Operating Current
- 77 mΩ (typ.) $R_{DS(ON)}$
- Built-In Level Shift for Control Logic; Can be Operated by 1.5V Logic
- Low 2 µA Quiescent Current
- Soft-Start: MIC94062, MIC94063
- Micropower Shutdown <1 µA
- Load Discharge Circuit: MIC94061, MIC94063
- 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 MIC94060, MIC94061, MIC94062, and MIC94063 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 over 2A of continuous current. The MIC94061 and MIC94063 feature an active load discharge circuit which ensures capacitive loads retain no charge when the main switch is in an OFF state.

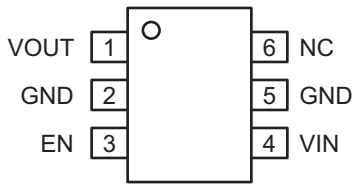
MIC94060-61 feature rapid turn-on while MIC94062-63 provide a slew-rate controlled soft-start turn-on of 800 µs (typical) to prevent in-rush current from glitching supply rails.

An active pull-down on the enable input keeps MIC94060-63 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.

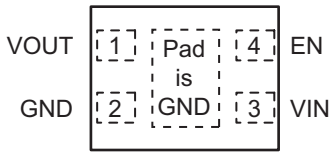
MIC94060-63's operating voltage range makes them suitable for 1-cell Lithium ion and 2- to 3-cell NiMH/NiCad/Alkaline powered systems, as well as all 5V applications. Their low operating current of 2 µA and low shutdown current of <1 µA maximize battery life.

Package Types

MIC94060/1/2/3
6-Lead SC-70 (C6)
(Top View)



MIC94060/1/2/3
4-Lead UDFN (MT)
(Top View)



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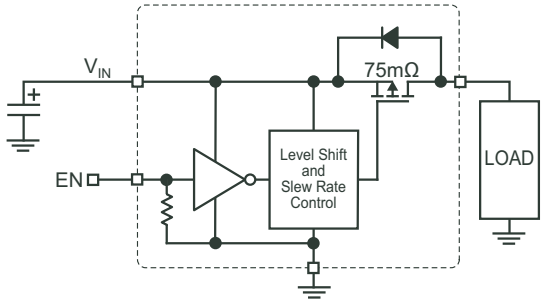
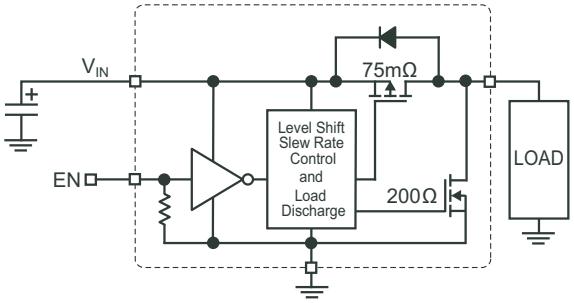
Typical Application Circuits

MIC94060/MIC94062
Load Switch Application



MIC94061/MIC94063
Load Switch with Capacitive Load Discharge



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1.0 ELECTRICAL CHARACTERISTICS

Absolute Maximum Ratings †

Input Voltage (V_{IN}) ..... +6V
Enable Voltage (V_{EN}) ..... +6V
Continuous Drain Current (I_D) (Note 1)
T_A = 25°C ..... ±2A
T_A = 85°C ..... ±1.4A
Pulsed Drain Current (I_{DP}) (Note 2) ..... ±6A
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. Human body model, 1.5 kΩ in series with 100 pF.

ELECTRICAL CHARACTERISTICS

Electrical Characteristics: V_{IN} = 5V; T_A = +25°C, **bold** values valid for –40°C ≤ T_A ≤ +85°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_{IN} = 1.7V to 4.5V, I_D = –250 µA
Enable Input Current	I_{EN}	—	2	4	µA	V_{IN} = V_{EN} = 5.5V
OFF State Leakage Current	I_{VIN}	—	—	1	µA	VIN = +5.5V, VEN = 0V
P-Channel Drain to Source ON Resistance, SC-70 Package	$R_{DS(ON)}$	—	77	110	mΩ	V_{IN}=+4.5V, I_D=–100 mA, V_{EN}=1.5V
		—	85	115		V_{IN}=+3.6V, I_D=–100 mA, V_{EN}=1.5V
		—	100	140		V_{IN}=+2.5V, I_D=–100 mA, V_{EN}=1.5V
		—	145	200		V_{IN}=+1.8V, I_D=–100 mA, V_{EN}=1.5V
		—	155	215		V_{IN}=+1.7V, I_D=–100 mA, V_{EN}=1.5V
P-Channel Drain to Source ON Resistance, UDFN Package	$R_{DS(ON)}$	—	85	115	mΩ	V_{IN}=+4.5V, I_D=–100 mA, V_{EN}=1.5V
		—	100	140		V_{IN}=+3.6V, I_D=–100 mA, V_{EN}=1.5V
		—	145	200		V_{IN}=+2.5V, I_D=–100 mA, V_{EN}=1.5V
		—	155	215		V_{IN}=+1.8V, I_D=–100 mA, V_{EN}=1.5V
		—	165	225		V_{IN}=+1.7V, I_D=–100 mA, V_{EN}=1.5V
Turn-Off Resistance	R_{SHDN}	—	200	300	Ω	V_{IN} = +3.6V, I_{TEST} = 1 mA, V_{EN} = 0V, MIC94061, 63

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ELECTRICAL CHARACTERISTICS (CONTINUED)

Electrical Characteristics: V_{IN} = 5V; T_A = +25°C, **bold** values valid for –40°C ≤ T_A ≤ +85°C, unless noted.

Parameter	Symbol	Min.	Typ.	Max.	Units	Conditions
Dynamic						
Turn-On Delay Time	t_{ON_DLY}	—	0.85	1.5	µs	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94060, 61
		—	700	1200		V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94062, 63
Turn-On Rise Time	t_{ON_RISE}	0.5	1	5	µs	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94060, 61
		500	800	1500		V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94062, 63
Turn-Off Delay Time	t_{OFF_DLY}	—	100	200	ns	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94060, 61
		—	60	200		V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94062, 63
Turn-Off Fall Time	t_{OFF_FALL}	—	60	100	ns	V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94060, 61
		—	60	100		V_{IN} = +3.6V, I_D = –100 mA, V_{EN} = 1.5V, MIC94062, 63

TEMPERATURE SPECIFICATIONS

Parameters	Sym.	Min.	Typ.	Max.	Units	Conditions
Temperature Ranges						
Junction Temperature Range	T_J	–40	—	+125	°C	—
Storage Temperature Range	T_S	–55	—	+150	°C	—
Package Thermal Resistances						
Thermal Resistance, SC-70 6-Ld	θ_{JA}	—	240	—	°C/W	—
Thermal Resistance, UDFN 4-Ld	θ_{JA}	—	172	—	°C/W	—
Thermal Resistance, UDFN 4-Ld	θ_{JC}	—	134	—	°C/W	—

Note 1: The maximum allowable power dissipation is a function of ambient temperature, the maximum allowable junction temperature and the thermal resistance from junction to air (i.e., T_A, T_J, θ_{JA}). Exceeding the maximum allowable power dissipation will cause the device operating junction temperature to exceed the maximum +125°C rating. Sustained junction temperatures above +125°C can impact the device reliability.

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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.

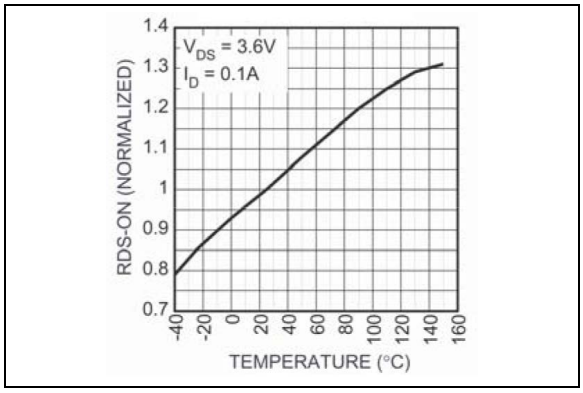

FIGURE 2-1: *$R_{DS(ON)}$ Variance with Temperature.*

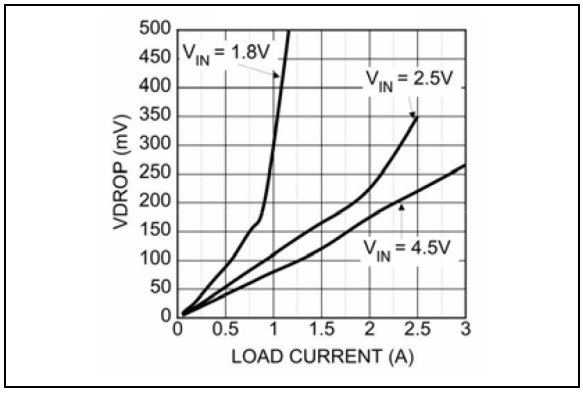

FIGURE 2-4: *Voltage Drop vs. Load Current.*

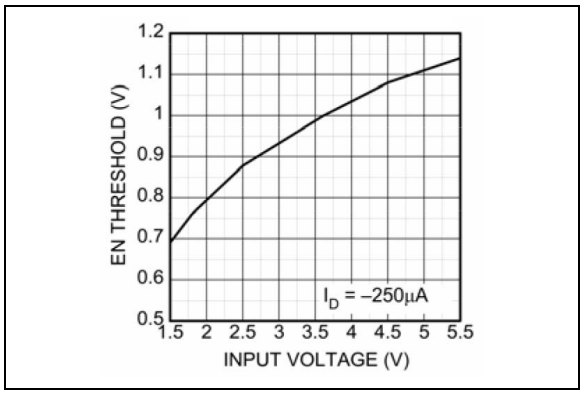

FIGURE 2-2: *EN Threshold Voltage vs. Input Voltage.*

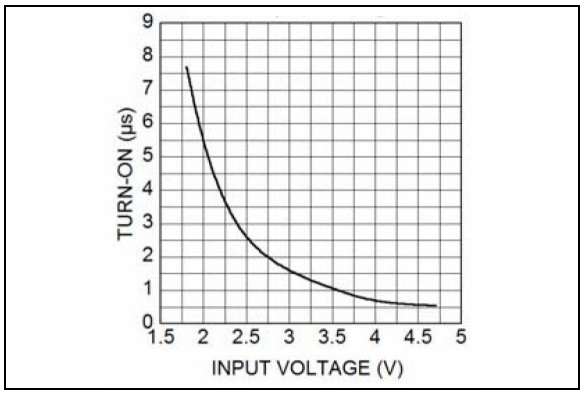

FIGURE 2-5: *MIC94060/61 Turn-On Delay vs. Input Voltage.*

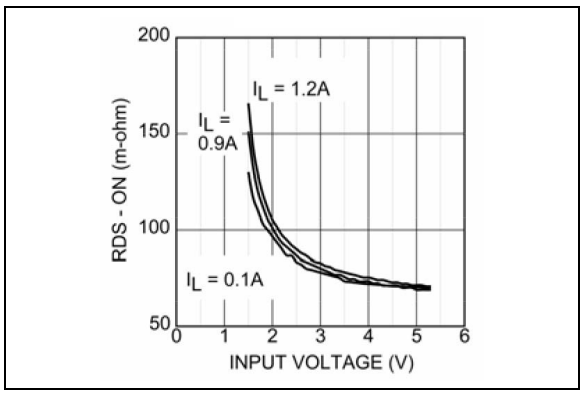

FIGURE 2-3: *On-Resistance vs. Input Voltage.*

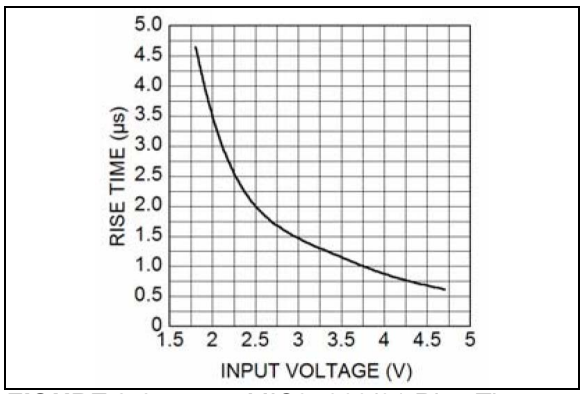

FIGURE 2-6: *MIC94060/61 Rise Time vs. Input Voltage.*

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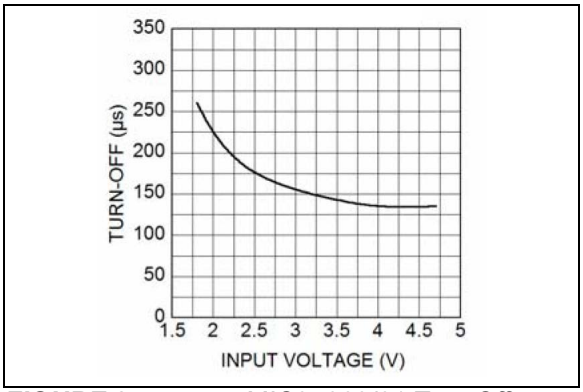

FIGURE 2-7: *MIC94060/61 Turn-Off Delay vs. Input Voltage.*

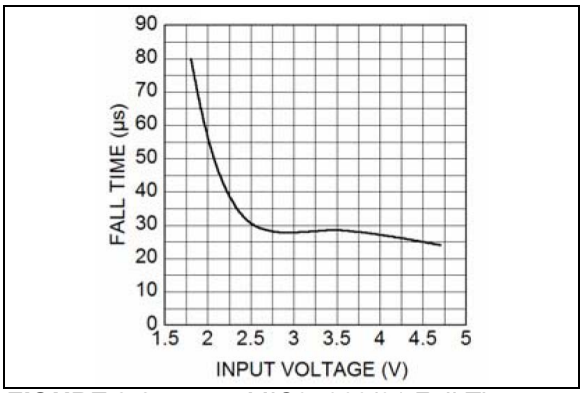

FIGURE 2-8: *MIC94060/61 Fall Time vs. Input Voltage.*

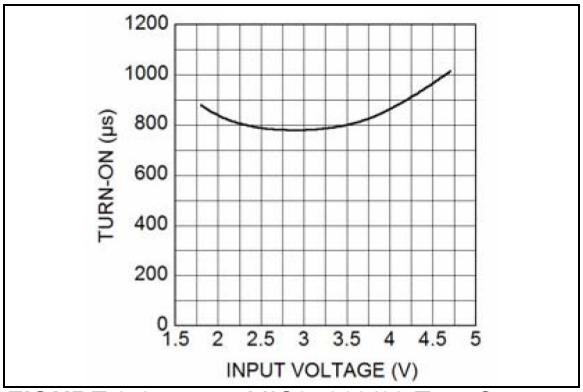

FIGURE 2-9: *MIC94062/63 Turn-On Delay vs. Input Voltage.*

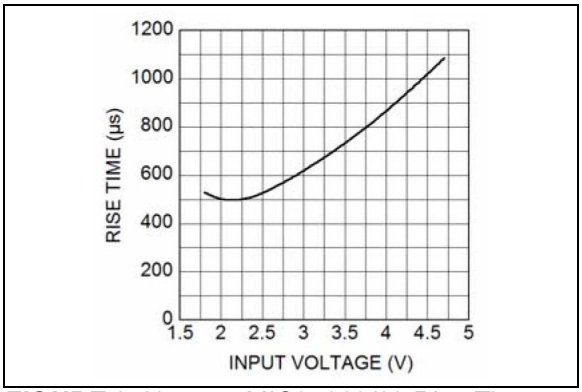

FIGURE 2-10: *MIC94062/63 Rise Time vs. Input Voltage.*

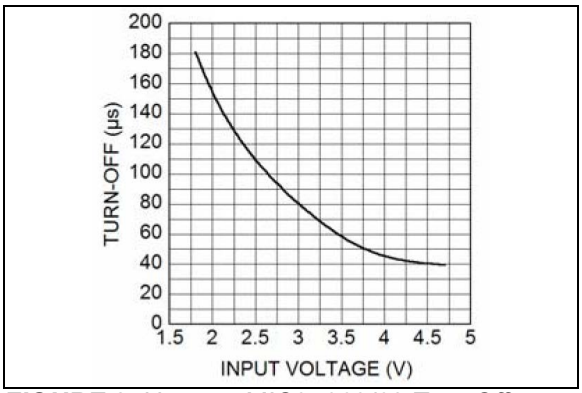

FIGURE 2-11: *MIC94062/63 Turn-Off Delay vs. Input Voltage.*

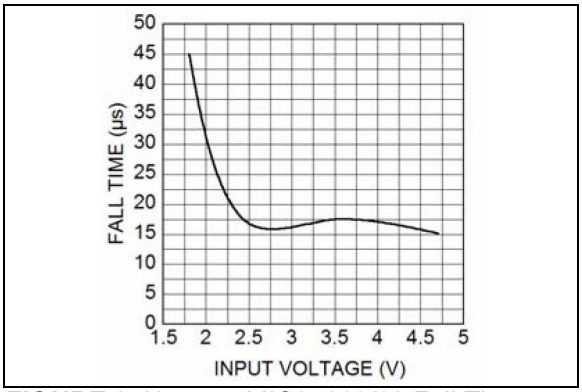

FIGURE 2-12: *MIC94062/63 Fall Time vs. Input Voltage.*

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MIC94060

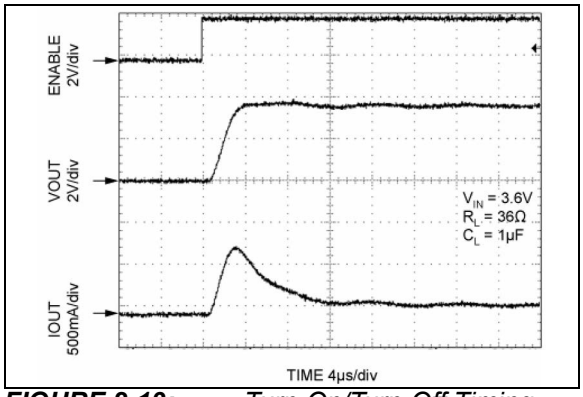

FIGURE 2-13: *Turn-On/Turn-Off Timing.*

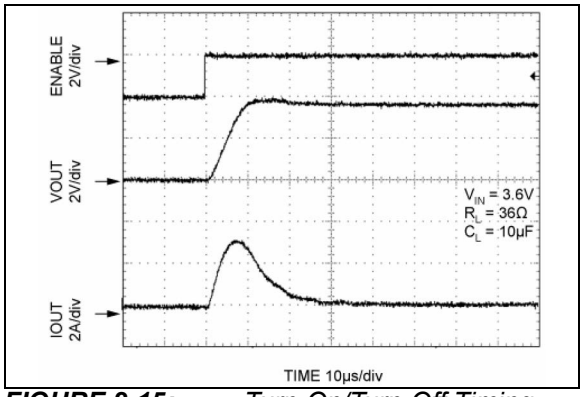

FIGURE 2-15: *Turn-On/Turn-Off Timing.*

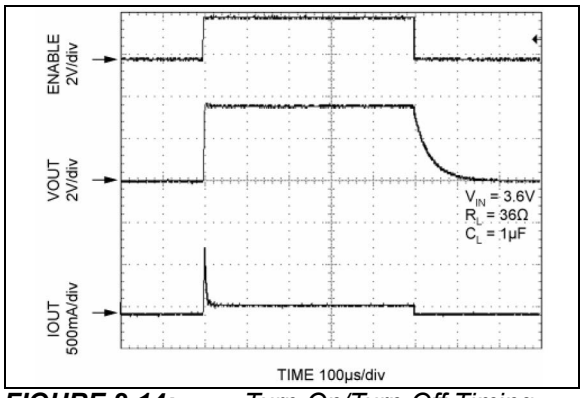

FIGURE 2-14: *Turn-On/Turn-Off Timing.*

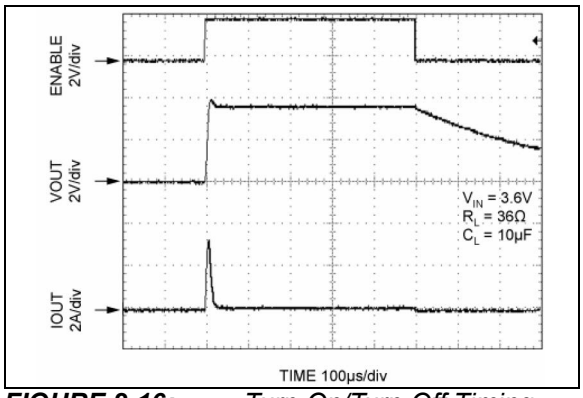

FIGURE 2-16: *Turn-On/Turn-Off Timing.*

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MIC94061

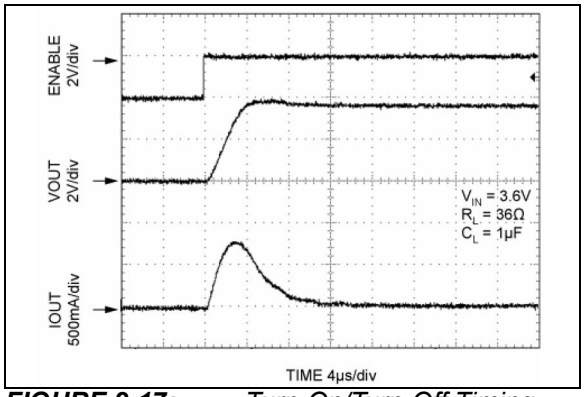

FIGURE 2-17: *Turn-On/Turn-Off Timing.*

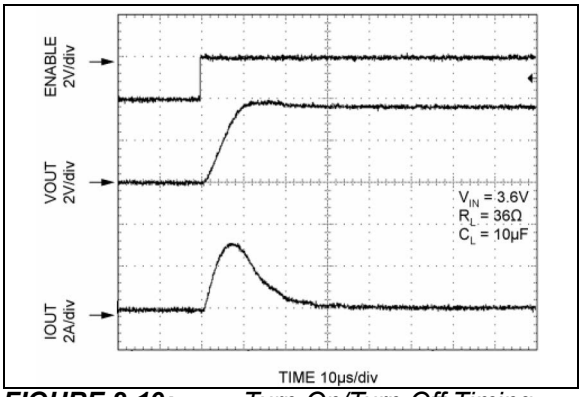

FIGURE 2-19: *Turn-On/Turn-Off Timing.*

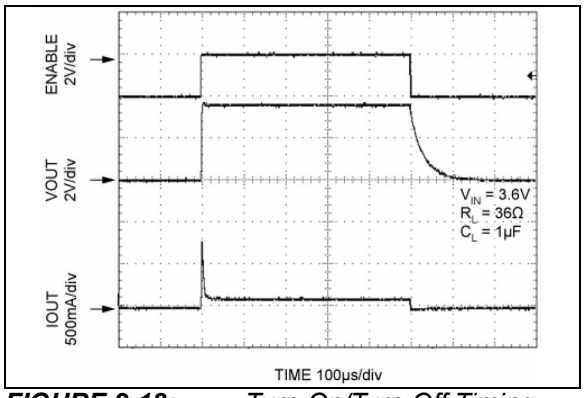

FIGURE 2-18: *Turn-On/Turn-Off Timing.*

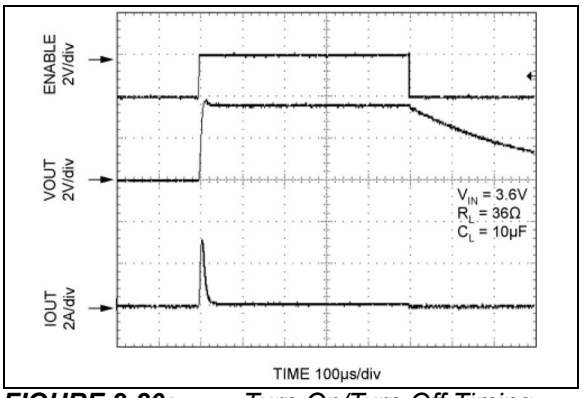

FIGURE 2-20: *Turn-On/Turn-Off Timing.*

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MIC94062

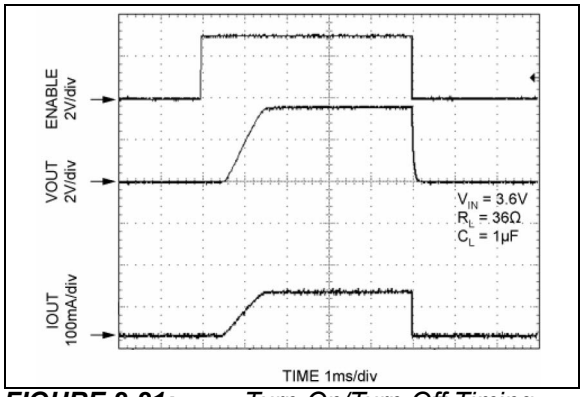

FIGURE 2-21: *Turn-On/Turn-Off Timing.*

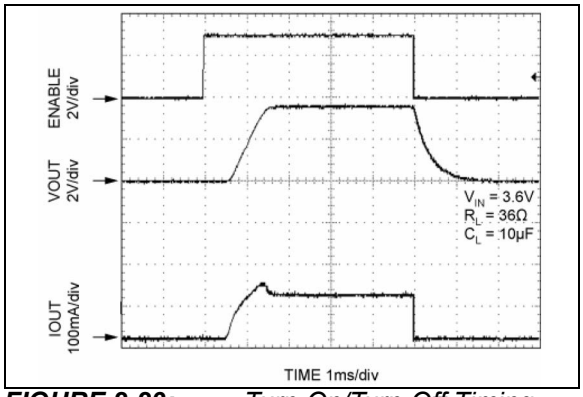

FIGURE 2-23: *Turn-On/Turn-Off Timing.*

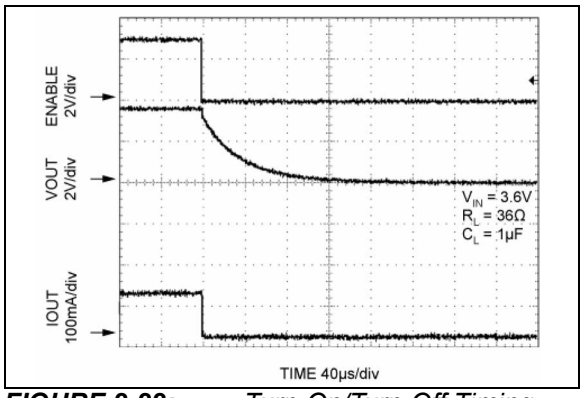

FIGURE 2-22: *Turn-On/Turn-Off Timing.*

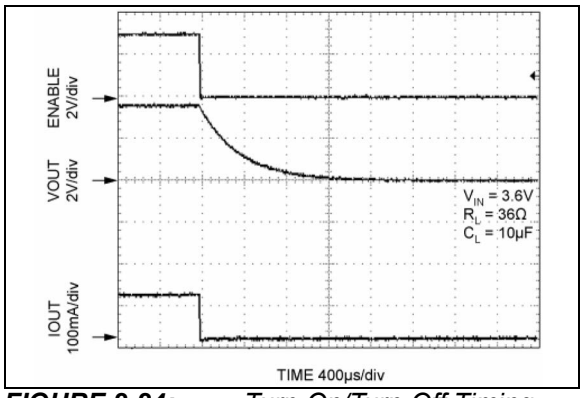

FIGURE 2-24: *Turn-On/Turn-Off Timing.*

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MIC94063

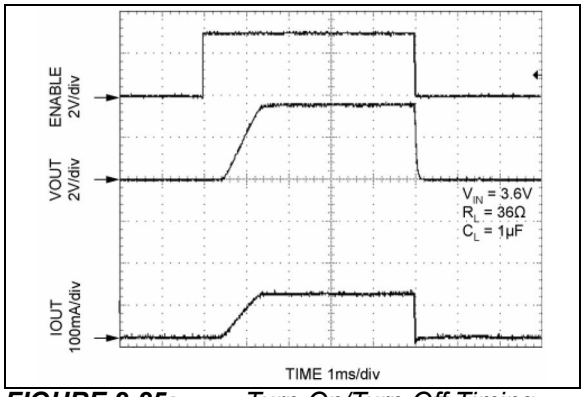

FIGURE 2-25: *Turn-On/Turn-Off Timing.*

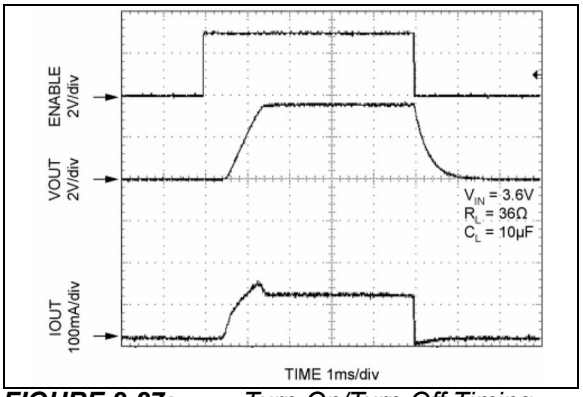

FIGURE 2-27: *Turn-On/Turn-Off Timing.*

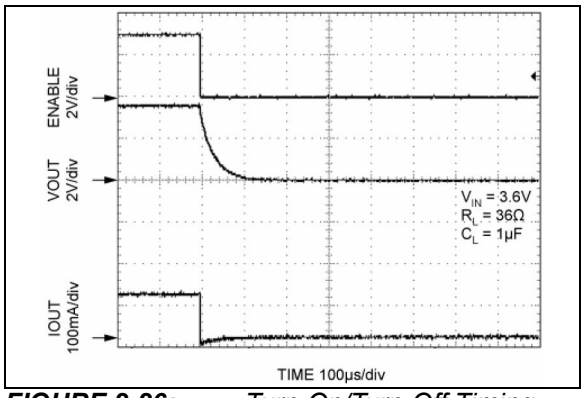

FIGURE 2-26: *Turn-On/Turn-Off Timing.*

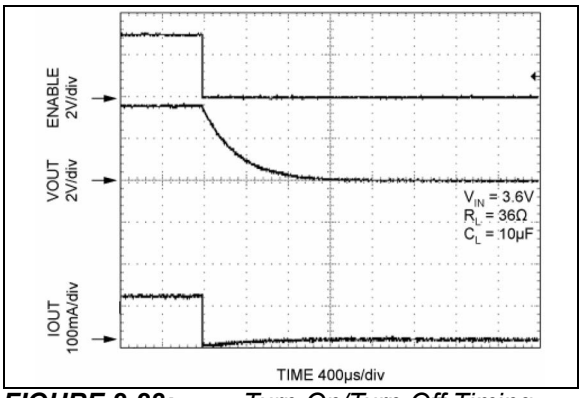

FIGURE 2-28: *Turn-On/Turn-Off Timing.*

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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.

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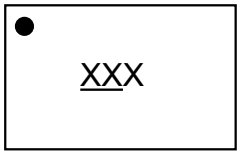
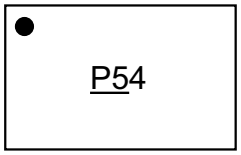
4.0 PACKAGING INFORMATION

4.1 Package Marking Information

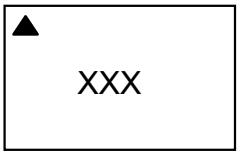
6-Lead SC70*



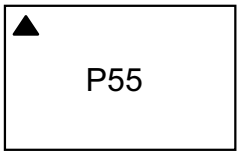
Example



4-Lead UDFN*



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.	

TABLE 4-1: MARKING CODES

Part Number	Marking Code	Soft-Start	Load Discharge
MIC94060YC6	P54	No	No
MIC94061YC6	P55	No	Yes
MIC94062YC6	P56	Yes	No
MIC94063YC6	P57	Yes	Yes
MIC94060YMT	P54	No	No
MIC94061YMT	P55	No	Yes
MIC94062YMT	P56	Yes	No
MIC94063YMT	P57	Yes	Yes

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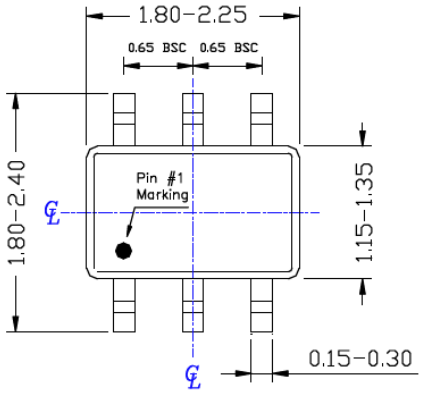
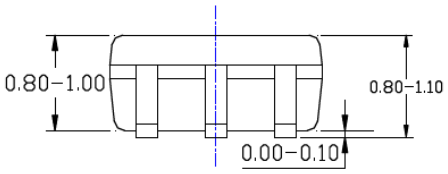
6-Lead SC-70 Package Outline & Recommended Land Pattern

TITLE
6 LEAD SC70 PACKAGE OUTLINE & RECOMMENDED LAND PATTERN

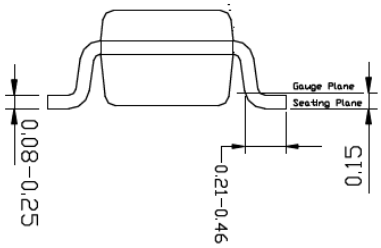
DRAWING #	SC70-6LD-PL-1	UNIT	MM



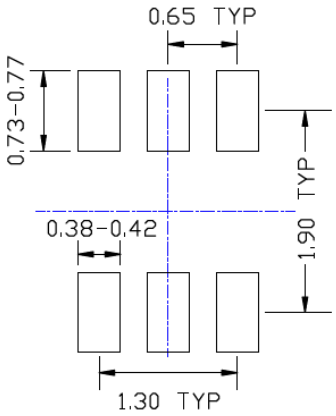
TOP VIEW



SIDE VIEW



END VIEW



RECOMMENDED LAND PATTERN

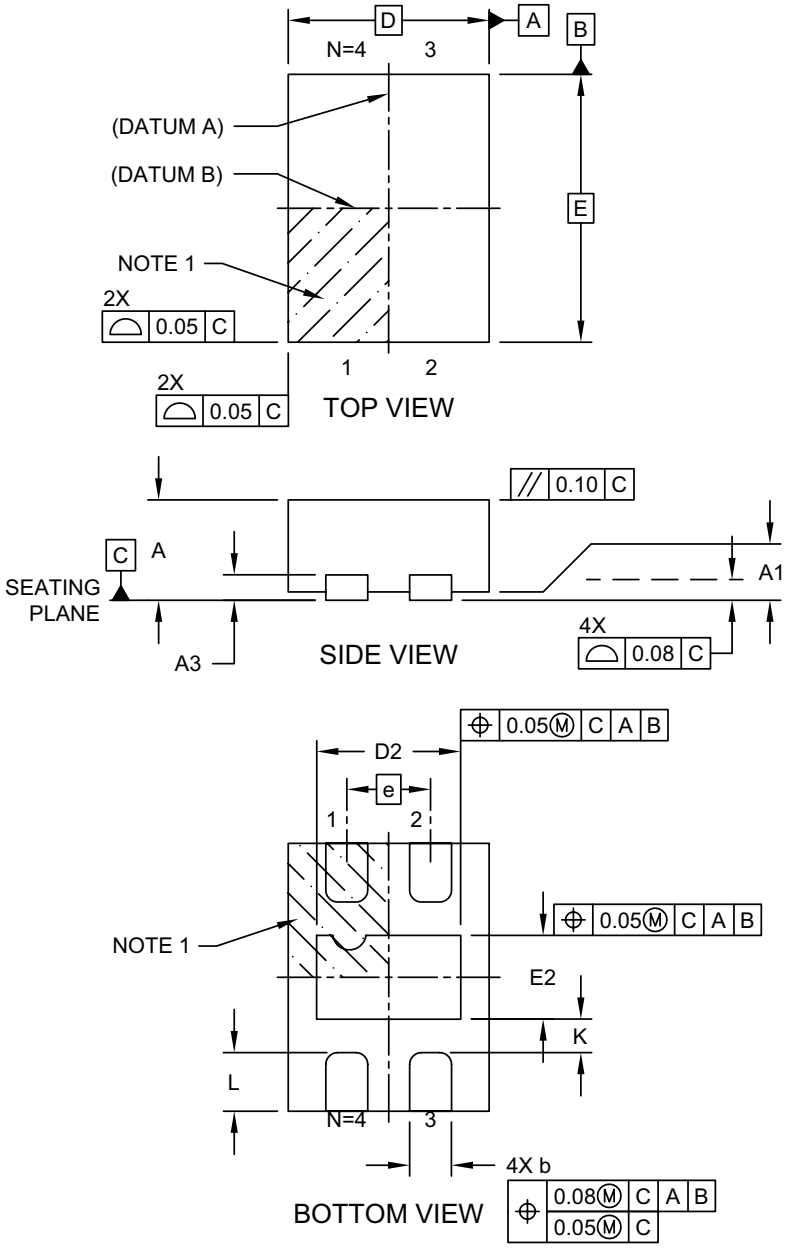
NOTE:
1. ALL DIMENSIONS ARE IN MILLIMETERS.
2. DIMENSIONS ARE INCLUSIVE OF PLATING.
3. DIMENSIONS ARE EXCLUSIVE OF MOLD FLASH & METAL BURR.

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

4-Lead UDFN Package Outline and Recommended Land Pattern

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



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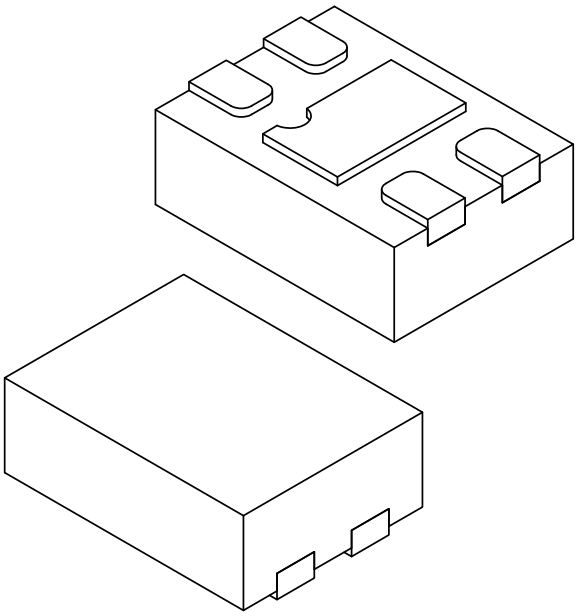
4-Lead Ultra Thin Dual Flat, No Lead Package (HGA) - 1.2x1.6x0.6 mm Body [UDFN]
Micrel Legacy Package TMLF1216D-04L

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.

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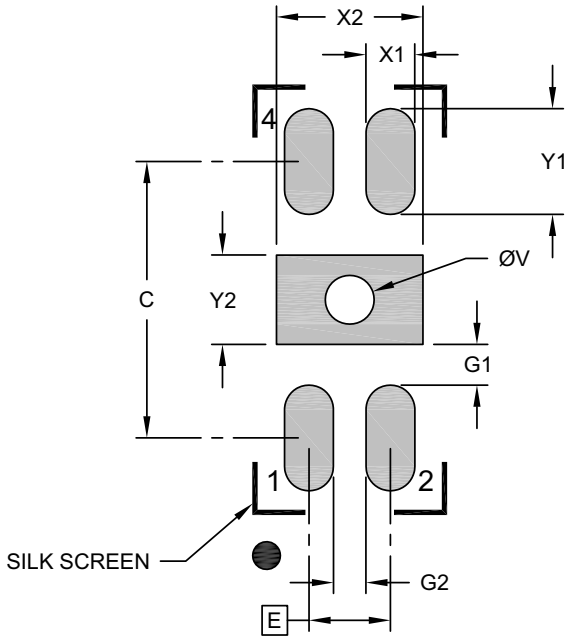
4-Lead Ultra Thin Dual Flat, No Lead Package (HGA) - 1.2x1.6x0.6 mm Body [UDFN]
Micrel Legacy Package TMLF1216D-04L

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

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APPENDIX A: REVISION HISTORY

Revision A (March 2021)

- Converted Micrel document MIC94060/1/2/3 to Microchip data sheet template DS20006517A.
- Minor grammatical text changes throughout.

Revision B (January 2022)

- Updated package marking drawing in Section 4.1, Package Marking Information.

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NOTES:

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PRODUCT IDENTIFICATION SYSTEM

To order or obtain information, e.g., on pricing or delivery, contact your local Microchip representative or sales office.

Device	X	XX	-XX
Part No.	Junction Temp. Range	Package	Media Type

Device:	MIC94060:	High Side Power Switch
	MIC94061:	High Side Power Switch with Load Discharge
	MIC94062:	High Side Power Switch with Soft-Start
	MIC94063:	High Side Power Switch with Soft-Start and Load Discharge
Junction Temperature Range:	Y =	–40°C to +125°C
Package:	C6 =	6-Lead SC-70
	MT =	4-Lead 1.6 mm x 1.2 mm UDFN
Media Type:	TR =	3,000/Reel (SC-70 Package)
	TR =	5,000/Reel (UDFN Package)

Examples:

a) MIC94060YC6-TR: MIC94060, –40°C to +125°C Temperature Range, 6-Lead SC-70, 3,000/Reel

b) MIC94061YMT-TR: MIC94061, –40°C to +125°C Temperature Range, 4-Lead UDFN, 5,000/Reel

c) MIC94062YC6-TR: MIC94062, –40°C to +125°C Temperature Range, 6-Lead SC-70, 3,000/Reel

d) MIC94063YMT-TR: MIC94063, –40°C to +125°C Temperature Range, 4-Lead UDFN, 5,000/Reel

e) MIC94060YMT-TR: MIC94060, –40°C to +125°C Temperature Range, 4-Lead UDFN, 5,000/Reel

f) MIC94061YC6-TR: MIC94061 –40°C to +125°C Temperature Range, 6-Lead SC-70, 3,000/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 option.

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