

## 100V, 1.25A Peak, High Frequency Half-Bridge Drivers

The ISL89400, ISL89401 are 100V, high frequency, half-bridge N-Channel power MOSFET driver ICs. They are based on the popular HIP2100, HIP2101 half-bridge drivers, but offer several performance improvements. The ISL89400 has additional input hysteresis for superior operation in noisy environments and the inputs of the ISL89401 (like those of the ISL89400) can now safely swing to the  $V_{DD}$  supply rail. Finally, both parts are available in a very compact 9 Ld DFN package and an 8 Ld SOIC to minimize the required PCB footprint.

### Ordering Information

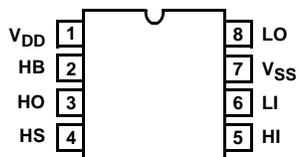
PART NUMBER (Note)	PART MARKING	TEMP. RANGE (°C)	PACKAGE (Pb-Free)	PKG. DWG. #
ISL89400AR3Z*	9400	-40 to +125	9 Ld 3x3 DFN	L9.3x3
ISL89401AR3Z*	9401	-40 to +125	9 Ld 3x3 DFN	L9.3x3
ISL89400ABZ**	89400 ABZ	-40 to +125	8 Ld SOIC	M8.15
ISL89401ABZ**	89401 ABZ	-40 to +125	8 Ld SOIC	M8.15

\*Add "-T" suffix for tape and reel. \*\*Add "-TK" suffix for tape and reel. Please refer to TB347 for details on reel specifications.

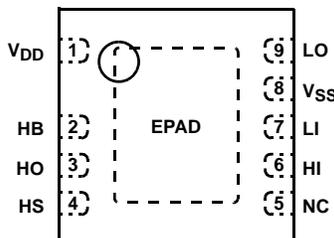
NOTE: These Intersil Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is RoHS compliant and compatible with both SnPb and Pb-free soldering operations). Intersil Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J STD-020.

### Pinouts

**ISL89400, ISL89401**  
**(8 LD SOIC)**  
TOP VIEW



**ISL89400, ISL89401**  
**(9 LD DFN)**  
TOP VIEW



NOTE: EPAD = Exposed PAD.

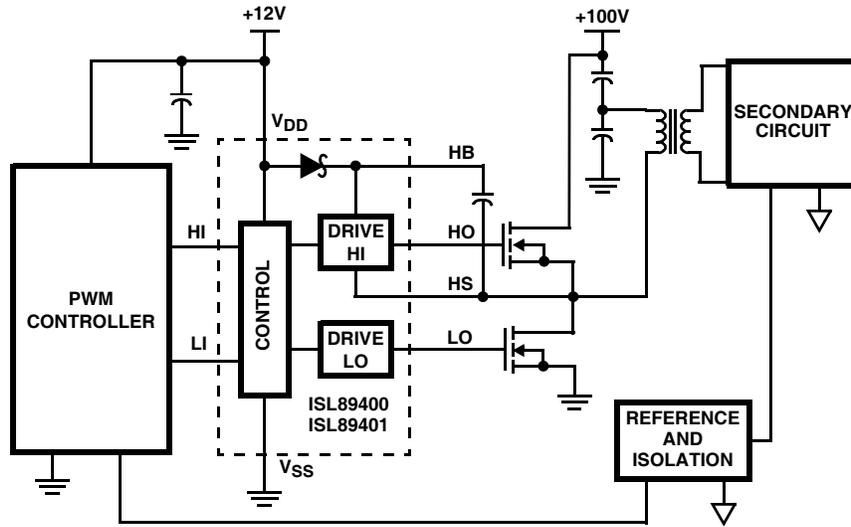
### Features

- Drives N-Channel MOSFET Half-Bridge
- Space Saving DFN Package
- DFN Package Compliant with 100V Conductor Spacing Guidelines per IPC-2221
- Pb-Free (RoHS Compliant)
- Bootstrap Supply Max Voltage to 114VDC
- On-Chip 1Ω Bootstrap Diode
- Fast Propagation Times for Multi-MHz Circuits
- Drives 1nF Load with Typical Rise/Fall Times of 16ns
- CMOS Compatible Input Thresholds (ISL89400)
- 3.3V/TTL Compatible Input Thresholds (ISL89401)
- Independent Inputs Provide Flexibility
- No Start-up Problems
- Outputs Unaffected by Supply Glitches, HS Ringing Below Ground or HS Slewing at High dV/dt
- Low Power Consumption
- Wide Supply Voltage Range (9V to 14V)
- Supply Undervoltage Protection
- 4.0Ω Typical Output Pull-up/Pull-down Resistance

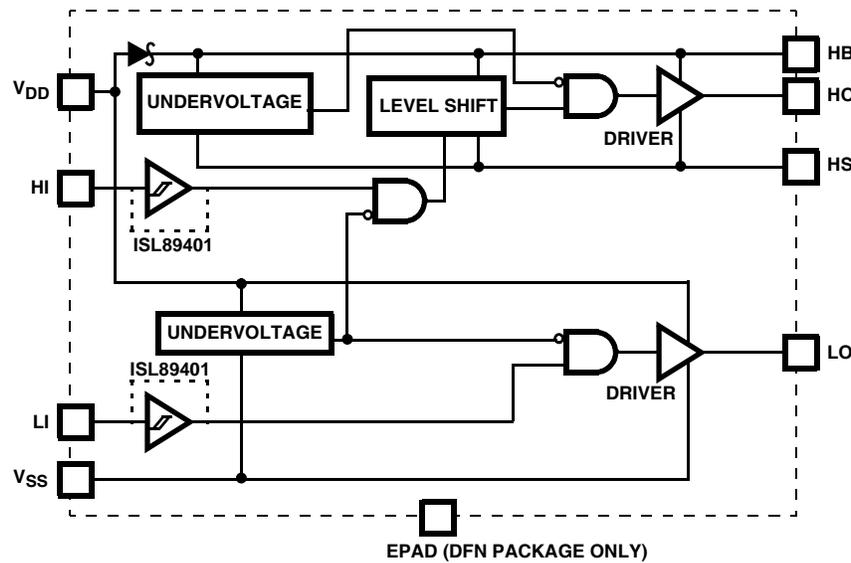
### Applications

- Telecom Half-Bridge Converters
- Telecom Full-Bridge Converters
- Two-Switch Forward Converters
- Active-Clamp Forward Converters
- Class-D Audio Amplifiers

**Application Block Diagram**



**Functional Block Diagram**



\*EPAD = EXPOSED PAD. THE EPAD IS ELECTRICALLY ISOLATED FROM ALL OTHER PINS. FOR BEST THERMAL PERFORMANCE, CONNECT THE EPAD TO THE PCB POWER GROUND PLANE.

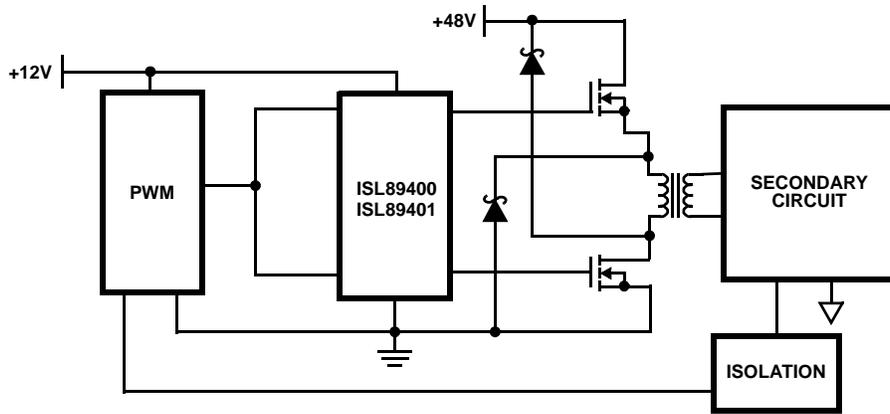


FIGURE 1. TWO-SWITCH FORWARD CONVERTER

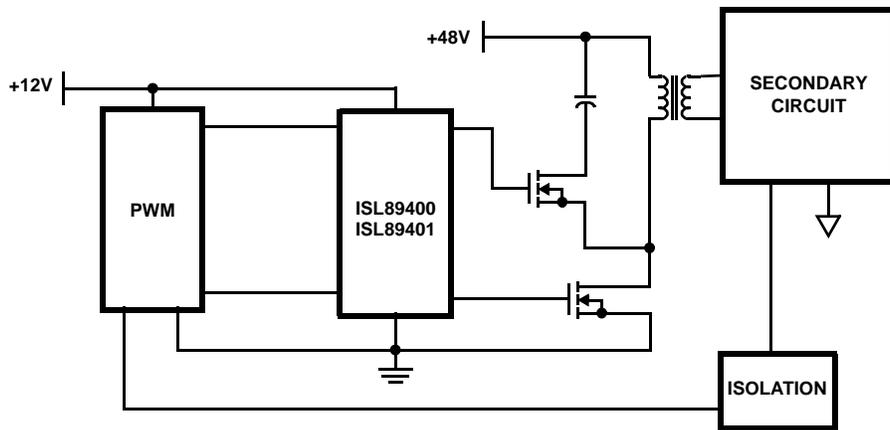


FIGURE 2. FORWARD CONVERTER WITH AN ACTIVE-CLAMP

**Absolute Maximum Ratings**

Supply Voltage,  $V_{DD}$ ,  $V_{HB} - V_{HS}$  (Notes 1, 2) . . . . . -0.3V to 18V  
 LI and HI Voltages (Note 2) . . . . . -0.3V to  $V_{DD} + 0.3V$   
 Voltage on LO (Note 2) . . . . . -0.3V to  $V_{DD} + 0.3V$   
 Voltage on HO (Note 2) . . . . .  $V_{HS} - 0.3V$  to  $V_{HB} + 0.3V$   
 Voltage on HS (Continuous) (Note 2) . . . . . -1V to 110V  
 Voltage on HB (Note 2) . . . . . 118V  
 Average Current in  $V_{DD}$  to HB Diode . . . . . 100mA

**Thermal Information**

Thermal Resistance (Typical)	$\theta_{JA}$ (°C/W)	$\theta_{JC}$ (°C/W)
9 Ld DFN (Notes 3, 5)	55	7.5
8 Ld SOIC (Note 4)	115	N/A
Max Power Dissipation at +25°C in Free Air (Notes 3, 5)	2.27W	
Storage Temperature Range	-65°C to +150°C	
Junction Temperature Range	-55°C to +150°C	
Pb-free reflow profile	see link below	
	<a href="http://www.intersil.com/pbfree/Pb-FreeReflow.asp">http://www.intersil.com/pbfree/Pb-FreeReflow.asp</a>	

**Maximum Recommended Operating Conditions**

Supply Voltage,  $V_{DD}$  . . . . . 9V to 14V  
 Voltage on HS . . . . . -1V to 100V  
 Voltage on HS . . . . . (Repetitive Transient) -5V to 105V  
 Voltage on HB . .  $V_{HS} + 8V$  to  $V_{HS} + 14V$  and  $V_{DD} - 1V$  to  $V_{DD} + 100V$   
 HS Slew Rate. . . . . <50V/ns

*CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions may adversely impact product reliability and result in failures not covered by warranty.*

**NOTES:**

1. The ISL89400 and ISL89401 are capable of derated operation at supply voltages exceeding 14V. Figure 22 shows the high-side voltage derating curve for this mode of operation.
2. All voltages referenced to  $V_{SS}$ , unless otherwise specified.
3.  $\theta_{JA}$  is measured in free air with the component mounted on a high effective thermal conductivity test board with “direct attach” features.
4.  $\theta_{JA}$  is measured with the component mounted on a high effective thermal conductivity test board in free air. See Tech Brief TB379 for details.
5. For  $\theta_{JC}$ , the “case temp” is measured at the center of the exposed metal pad on the package underside. See Tech Brief TB379 for details.

**Electrical Specifications**

$V_{DD} = V_{HB} = 12V$ ,  $V_{SS} = V_{HS} = 0V$ , No Load on LO or HO, unless otherwise specified. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.

PARAMETERS	SYMBOL	TEST CONDITIONS	$T_J = +25^\circ C$			$T_J = -40^\circ C$ to $+125^\circ C$		UNITS
			MIN	TYP	MAX	MIN	MAX	
<b>SUPPLY CURRENTS</b>								
$V_{DD}$ Quiescent Current	$I_{DD}$	ISL89400; LI = HI = 0V	-	0.1	0.25	-	0.3	mA
$V_{DD}$ Quiescent Current	$I_{DD}$	ISL89401; LI = HI = 0V	-	0.3	0.45	-	0.55	mA
$V_{DD}$ Operating Current	$I_{DDO}$	ISL89400; f = 500kHz	-	1.6	2.2	-	2.7	mA
$V_{DD}$ Operating Current	$I_{DDO}$	ISL89401; f = 500kHz	-	1.9	2.5	-	3	mA
Total HB Quiescent Current	$I_{HB}$	LI = HI = 0V	-	0.1	0.15	-	0.2	mA
Total HB Operating Current	$I_{HBO}$	f = 500kHz	-	2.0	2.5	-	3	mA
HB to $V_{SS}$ Current, Quiescent	$I_{HBS}$	LI = HI = 0V; $V_{HB} = V_{HS} = 114V$	-	0.05	1	-	10	$\mu A$
HB to $V_{SS}$ Current, Operating	$I_{HBSO}$	f = 500kHz; $V_{HB} = V_{HS} = 114V$	-	0.9	-	-	-	mA
<b>INPUT PINS</b>								
Low Level Input Voltage Threshold	$V_{IL}$	ISL89400	3.7	4.4	-	2.7	-	V
Low Level Input Voltage Threshold	$V_{IL}$	ISL89401	1.4	1.8	-	1.2	-	V
High Level Input Voltage Threshold	$V_{IH}$	ISL89400	-	6.6	7.4	-	8.4	V
High Level Input Voltage Threshold	$V_{IH}$	ISL89401	-	1.8	2.2	-	2.4	V
Input Voltage Hysteresis	$V_{IHYS}$	ISL89400	-	2.2	-	-	-	V
Input Pull-down Resistance	$R_I$		-	210	-	100	500	k $\Omega$
<b>UNDER VOLTAGE PROTECTION</b>								
$V_{DD}$ Rising Threshold	$V_{DDR}$		6.8	7.3	7.8	6.5	8.1	V
$V_{DD}$ Threshold Hysteresis	$V_{DDH}$		-	0.6	-	-	-	V
HB Rising Threshold	$V_{HBR}$		6.2	6.9	7.5	5.9	7.8	V

# ISL89400, ISL89401

**Electrical Specifications**  $V_{DD} = V_{HB} = 12V$ ,  $V_{SS} = V_{HS} = 0V$ , No Load on LO or HO, unless otherwise specified. Parameters with MIN and/or MAX limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested. **(Continued)**

PARAMETERS	SYMBOL	TEST CONDITIONS	T <sub>J</sub> = +25°C			T <sub>J</sub> = -40°C to +125°C		UNITS
			MIN	TYP	MAX	MIN	MAX	
HB Threshold Hysteresis	V <sub>HBH</sub>		-	0.6	-	-	-	V
<b>BOOT STRAP DIODE</b>								
Low Current Forward Voltage	V <sub>DL</sub>	I <sub>VDD-HB</sub> = 100μA	-	0.5	0.6	-	0.7	V
High Current Forward Voltage	V <sub>DH</sub>	I <sub>VDD-HB</sub> = 100mA	-	0.7	0.9	-	1	V
Dynamic Resistance	R <sub>D</sub>	I <sub>VDD-HB</sub> = 100mA	-	0.8	1	-	1.5	Ω
<b>LO GATE DRIVER</b>								
Low Level Output Voltage	V <sub>OLL</sub>	I <sub>LO</sub> = 100mA	-	0.4	0.5	-	0.7	V
High Level Output Voltage	V <sub>OHL</sub>	I <sub>LO</sub> = -100mA, V <sub>OHL</sub> = V <sub>DD</sub> - V <sub>LO</sub>	-	0.4	0.5	-	0.7	V
Peak Pull-Up Current	I <sub>OHL</sub>	V <sub>LO</sub> = 0V	-	1.25	-	-	-	A
Peak Pull-Down Current	I <sub>OLL</sub>	V <sub>LO</sub> = 12V	-	1.25	-	-	-	A
<b>HO GATE DRIVER</b>								
Low Level Output Voltage	V <sub>OLH</sub>	I <sub>HO</sub> = 100mA	-	0.4	0.5	-	0.7	V
High Level Output Voltage	V <sub>OHH</sub>	I <sub>HO</sub> = -100mA, V <sub>OHH</sub> = V <sub>HB</sub> - V <sub>HO</sub>	-	0.4	0.5	-	0.7	V
Peak Pull-up Current	I <sub>OHH</sub>	V <sub>HO</sub> = 0V	-	1.25	-	-	-	A
Peak Pull-down Current	I <sub>OLH</sub>	V <sub>HO</sub> = 12V	-	1.25	-	-	-	A

**Switching Specifications**  $V_{DD} = V_{HB} = 12V$ ,  $V_{SS} = V_{HS} = 0V$ , No Load on LO or HO, Unless Otherwise Specified

PARAMETERS	SYMBOL	TEST CONDITIONS	T <sub>J</sub> = +25°C			T <sub>J</sub> = -40°C to +125°C		UNITS
			MIN	TYP	MAX	MIN	MAX	
Lower Turn-off Propagation Delay (LI Falling to LO Falling)	t <sub>LPHL</sub>		-	34	50	-	60	ns
Upper Turn-off Propagation Delay (HI Falling to HO Falling)	t <sub>HPHL</sub>		-	31	50	-	60	ns
Lower Turn-on Propagation Delay (LI Rising to LO Rising)	t <sub>LPLH</sub>		-	39	50	-	60	ns
Upper Turn-on Propagation Delay (HI Rising to HO Rising)	t <sub>HPLH</sub>		-	39	50	-	60	ns
Delay Matching: Upper Turn-Off to Lower Turn-On	t <sub>MON</sub>		1	8	-	-	16	ns
Delay Matching: Lower Turn-Off to Upper Turn-On	t <sub>MOFF</sub>		1	6	-	-	16	ns
Either Output Rise/Fall Time (10% to 90%/90% to 10%)	t <sub>RC</sub> , t <sub>FC</sub>	C <sub>L</sub> = 1nF	-	16	-	-	-	ns
Either Output Rise/Fall Time (3V to 9V/9V to 3V)	t <sub>R</sub> , t <sub>F</sub>	C <sub>L</sub> = 0.1μF	-	0.8	1.0	-	1.2	μs
Minimum Input Pulse Width that Changes the Output	t <sub>PW</sub>		-	-	-	-	50	ns
Bootstrap Diode Turn-On or Turn-Off Time	t <sub>BS</sub>		-	10	-	-	-	ns

**Pin Descriptions**

SYMBOL	DESCRIPTION
V <sub>DD</sub>	Positive supply to lower gate driver. Bypass this pin to V <sub>SS</sub> .
HB	High-side bootstrap supply. External bootstrap capacitor is required. Connect positive side of bootstrap capacitor to this pin. Bootstrap diode is on-chip.
HO	High-side output. Connect to gate of high-side power MOSFET.
HS	High-side source connection. Connect to source of high-side power MOSFET. Connect negative side of bootstrap capacitor to this pin.
HI	High-side input.
LI	Low-side input.
V <sub>SS</sub>	Chip negative supply, which will generally be ground.
LO	Low-side output. Connect to gate of low-side power MOSFET.
NC	No connect.
EPAD	Exposed pad. Connect to ground or float. The EPAD is electrically isolated from all other pins.

**Timing Diagrams**

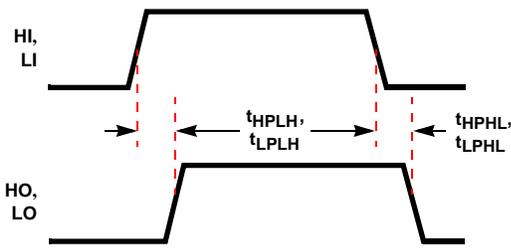


FIGURE 3. PROPAGATION DELAYS

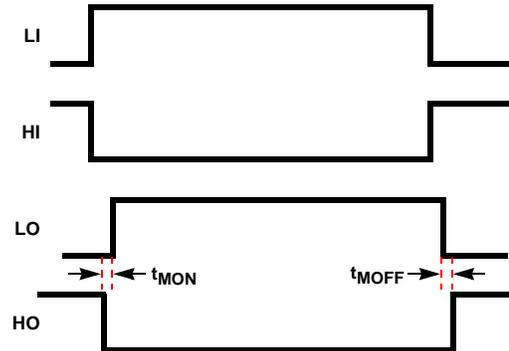


FIGURE 4. DELAY MATCHING

**Typical Performance Curves**

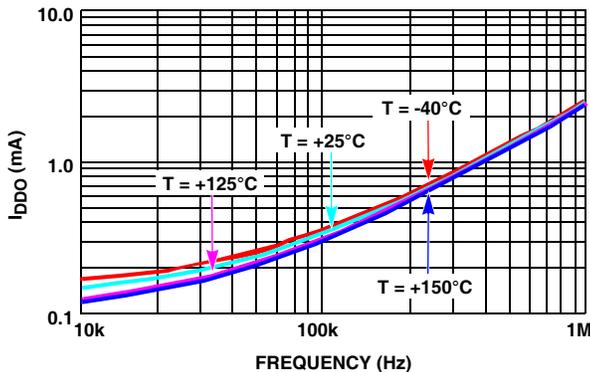


FIGURE 5. ISL89400 I<sub>DD</sub> OPERATING CURRENT vs FREQUENCY

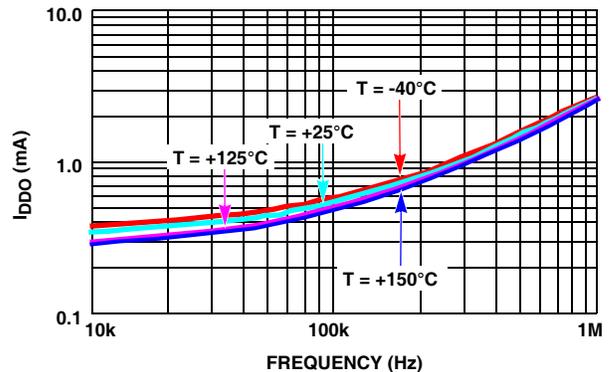


FIGURE 6. ISL89401 I<sub>DD</sub> OPERATING CURRENT vs FREQUENCY

Typical Performance Curves (Continued)

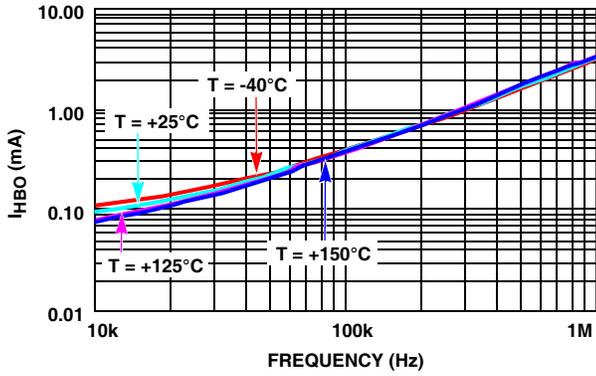


FIGURE 7.  $I_{HB}$  OPERATING CURRENT vs FREQUENCY

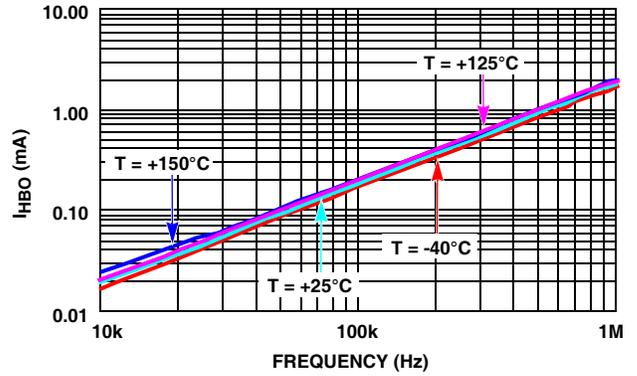


FIGURE 8.  $I_{HBS}$  OPERATING CURRENT vs FREQUENCY

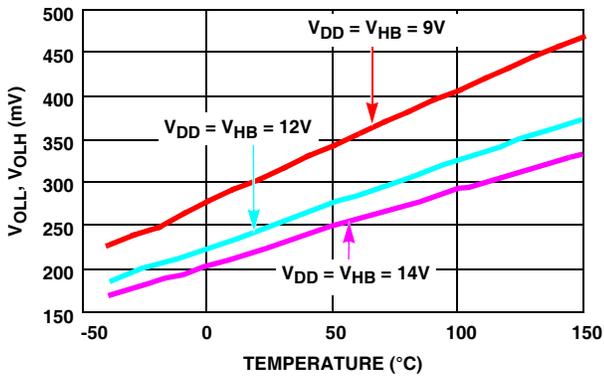


FIGURE 9. HIGH LEVEL OUTPUT VOLTAGE vs TEMPERATURE

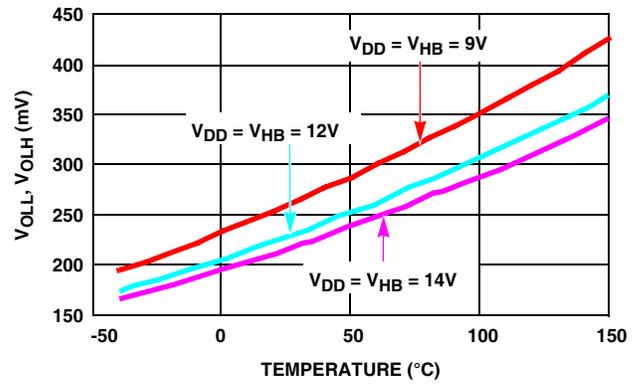


FIGURE 10. LOW LEVEL OUTPUT VOLTAGE vs TEMPERATURE

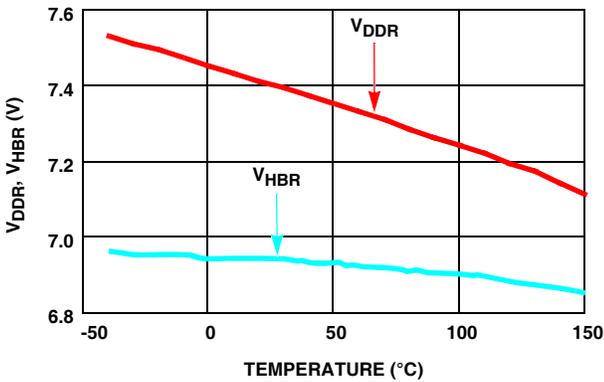


FIGURE 11. UNDERVOLTAGE LOCKOUT THRESHOLD vs TEMPERATURE

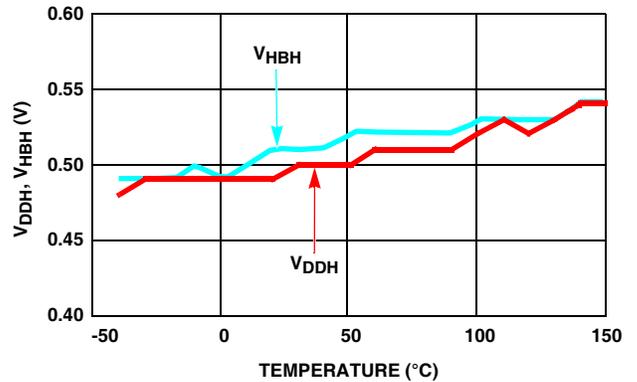


FIGURE 12. UNDERVOLTAGE LOCKOUT HYSTERESIS vs TEMPERATURE

Typical Performance Curves (Continued)

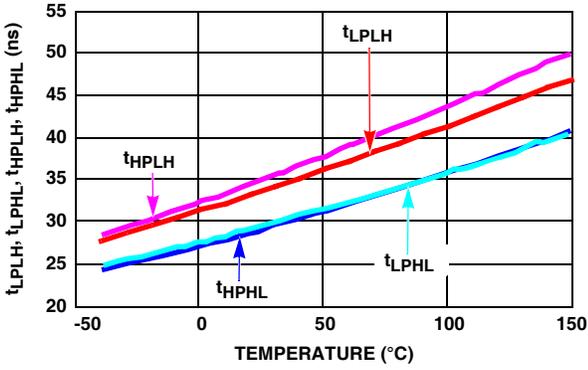


FIGURE 13. ISL89400 PROPAGATION DELAYS vs TEMPERATURE

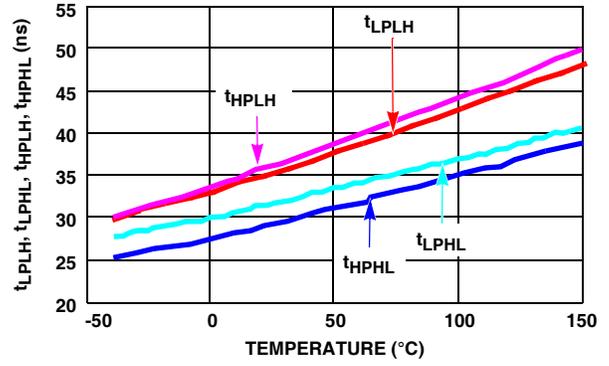


FIGURE 14. ISL89401 PROPAGATION DELAYS vs TEMPERATURE

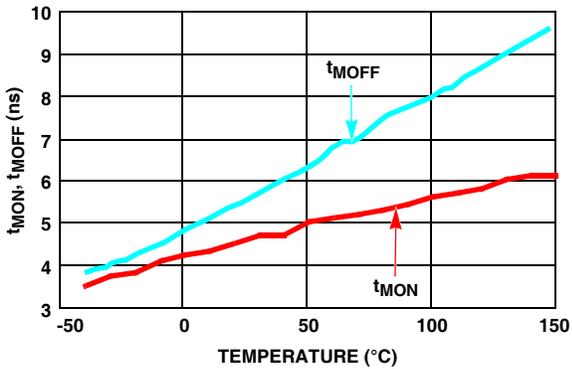


FIGURE 15. ISL89400 DELAY MATCHING vs TEMPERATURE

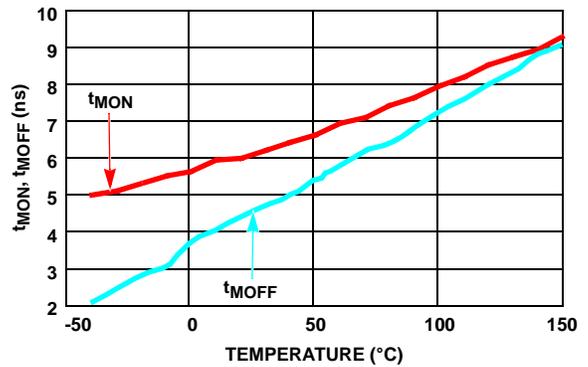


FIGURE 16. ISL89401 DELAY MATCHING vs TEMPERATURE

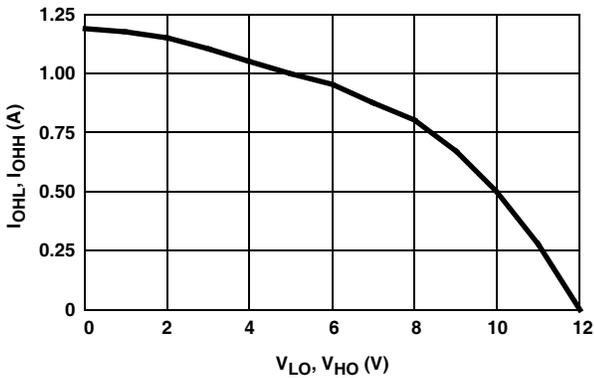


FIGURE 17. PEAK PULL-UP CURRENT vs OUTPUT VOLTAGE

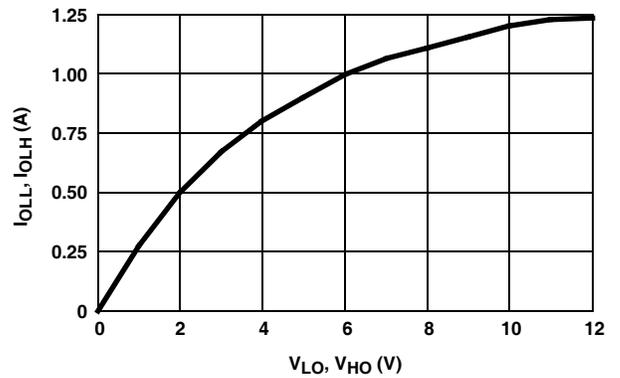


FIGURE 18. PEAK PULL-DOWN CURRENT vs OUTPUT VOLTAGE

Typical Performance Curves (Continued)

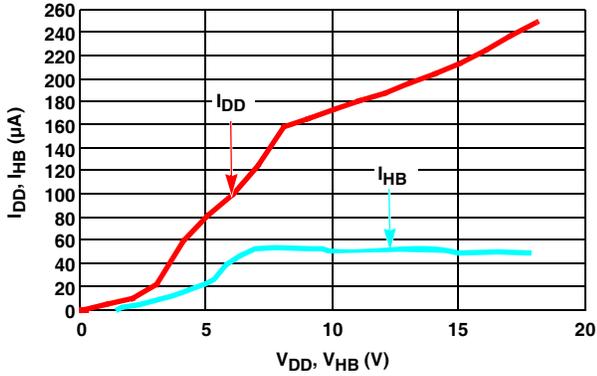


FIGURE 19. ISL89400 QUIESCENT CURRENT vs VOLTAGE

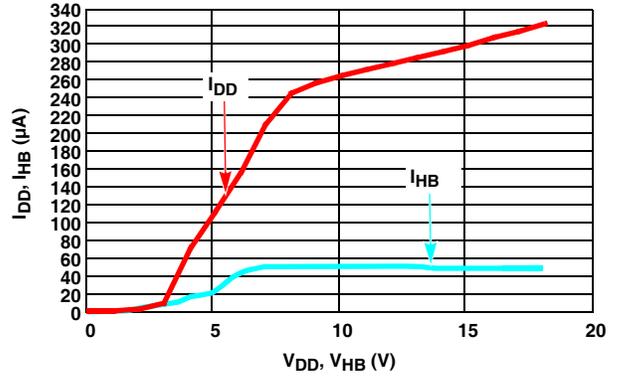


FIGURE 20. ISL89401 QUIESCENT CURRENT vs VOLTAGE

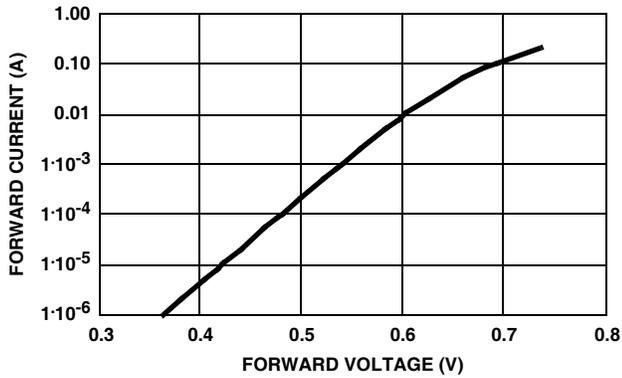


FIGURE 21. BOOTSTRAP DIODE I-V CHARACTERISTICS

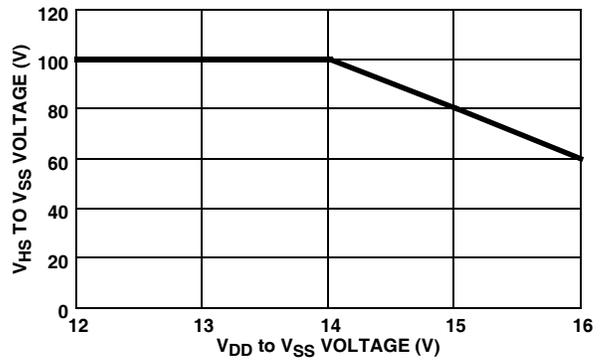
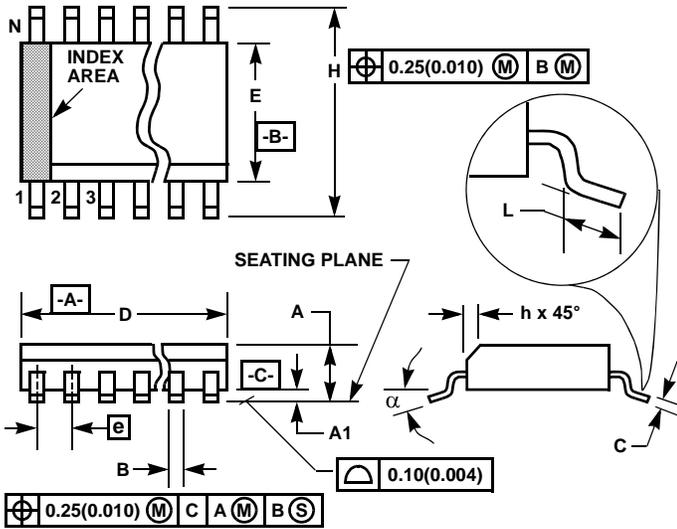


FIGURE 22. V<sub>HS</sub> VOLTAGE vs V<sub>DD</sub> VOLTAGE

Small Outline Plastic Packages (SOIC)



M8.15 (JEDEC MS-012-AA ISSUE C)  
8 LEAD NARROW BODY SMALL OUTLINE PLASTIC PACKAGE

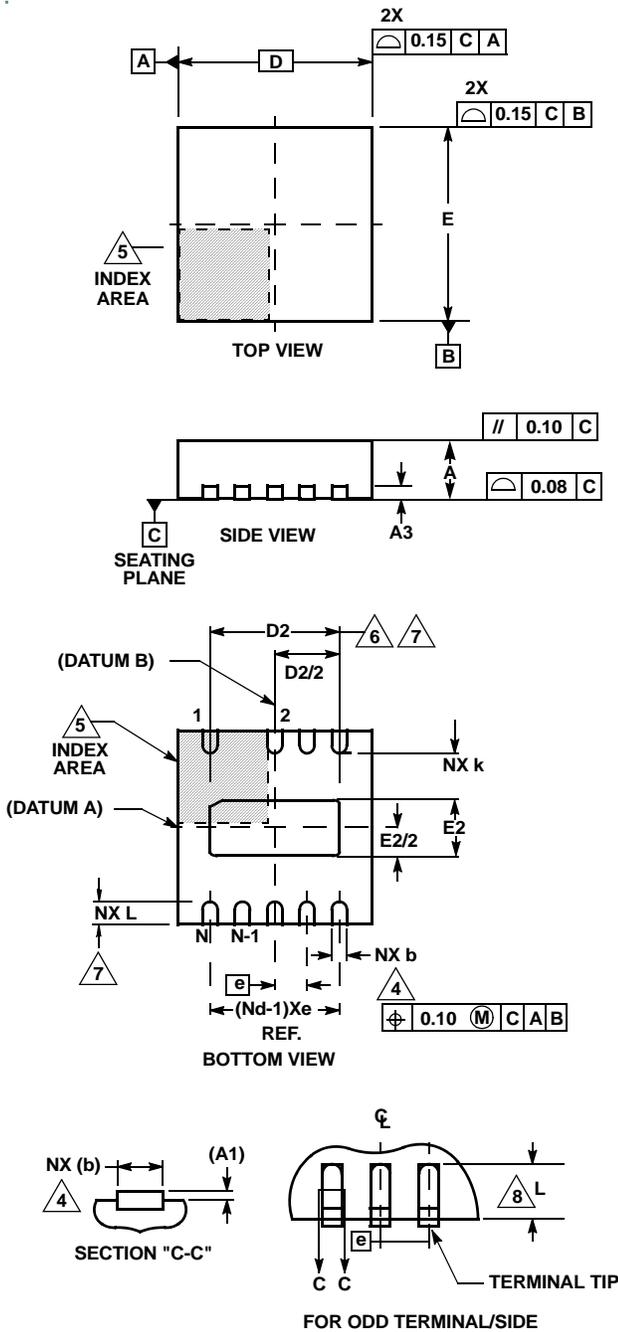
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0532	0.0688	1.35	1.75	-
A1	0.0040	0.0098	0.10	0.25	-
B	0.013	0.020	0.33	0.51	9
C	0.0075	0.0098	0.19	0.25	-
D	0.1890	0.1968	4.80	5.00	3
E	0.1497	0.1574	3.80	4.00	4
e	0.050 BSC		1.27 BSC		-
H	0.2284	0.2440	5.80	6.20	-
h	0.0099	0.0196	0.25	0.50	5
L	0.016	0.050	0.40	1.27	6
N	8		8		7
α	0°	8°	0°	8°	-

NOTES:

1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. "L" is the length of terminal for soldering to a substrate.
7. "N" is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

Rev. 1 6/05

Dual Flat No-Lead Plastic Package (DFN)



L9.3x3

9 LEAD DUAL FLAT NO-LEAD PLASTIC PACKAGE

SYMBOL	MILLIMETERS			NOTES
	MIN	NOMINAL	MAX	
A	0.80	0.90	1.00	-
A1	-	-	0.05	-
A3	0.20 REF			-
b	0.20	0.25	0.30	4, 7
D	3.00 BSC			-
D2	1.85	2.00	2.10	6, 7
E	3.00 BSC			-
E2	0.80	0.95	1.05	6, 7
e	0.50 BSC			-
k	0.60	-	-	-
L	0.25	0.35	0.45	7
N	9			2

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NOTES:

1. Dimensioning and tolerancing conform to ASME Y14.5-1994.
2. N is the number of terminals.
3. All dimensions are in millimeters. Angles are in degrees.
4. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
5. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.
6. Dimensions D2 and E2 are for the exposed pads which provide improved electrical and thermal performance.
7. Nominal dimensions are provided to assist with PCB Land Pattern Design efforts, see Intersil Technical Brief TB389.
8. COMPLIANT TO JEDEC MO-229-WEED-3 except for dimensions E2 & D2.

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