HARRIS SEMICONDUCTOR

HIP4086

November 1996

80V, 0.5A Three Phase Driver

Features

- **Independently Drives 6 N-Channel MOSFETs in Three Phase Bridge Configuration**
- **Bootstrap Supply Max Voltage to 95VDC**
- **Bias Supply Operation from 7V to 15V**
- **1.25A Peak Turn-Off Current**
- **User-Programmable Dead Time (0.25μs to 4.5μs)**
- **Charge-Pump and Bootstrap Maintain Upper Bias Supplies**
- **Programmable Bootstrap Refresh Time**
- **Drives 1000pF Load with Typical Rise Time of 20ns and Fall Time of 10ns**
- **DIS (Disable) Overrides Input Control**
- **Input Logic Thresholds Compatible with 5V to 15V Logic Levels**
- **Dead Time Disable Capability**
- **Programmable Undervoltage Set Point**

Applications

- **Brushless Motors**
- **AC Motor Drives**
- **Switched Reluctance Motor Drives**
- **Battery Powered Vehicles**

Description

The HIP4086 is a Three Phase Bridge N-Channel MOSFET driver IC. The HIP4086 is specifically targeted for PWM motor control. It makes bridge based designs simple and flexible. Like the HIP4081, the HIP4086 has a flexible input protocol for driving every possible switch combination. Unlike the HIP4081, the user can override the shoot-through protection for switched reluctance applications. The HIP4086 has reduced drive current compared to the HIP4081 (0.5A vs 2.5A) and a much wider range of programmable dead times (0.25μs to 4.5μs) - like the HIP4082. The HIP4086 is suitable for applications requiring DC to 100kHz. Unlike the previous family members, the HIP4086 has a programmable undervoltage set point.

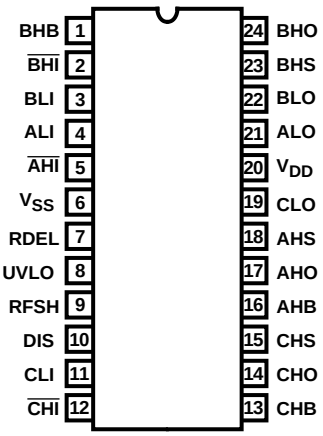
Also refer to the HIP4083, three phase upper only MOSFET driver, for a lower current solution optimized for smaller motors.

Ordering Information

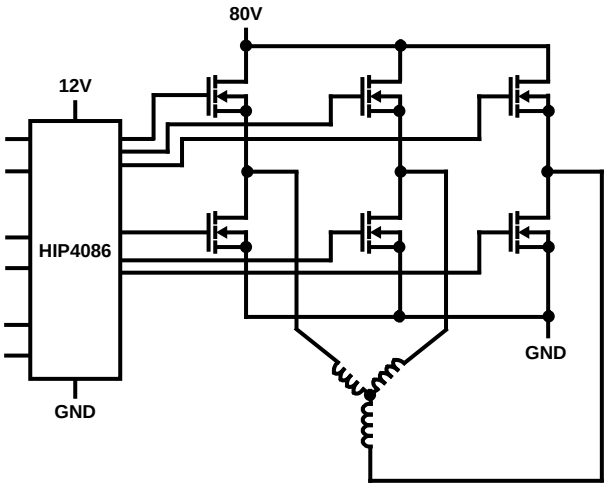
PART NUMBER	TEMP. RANGE (^{O}C)	PACKAGE	PKG. NO.
HIP4086AB	-40 to 125	24 Pin SOIC	M24.3
HIP4086AP	-40 to 125	24 Pin PDIP	E24.3

Pinout

HIP4086
(PDIP, SOIC)
TOP VIEW



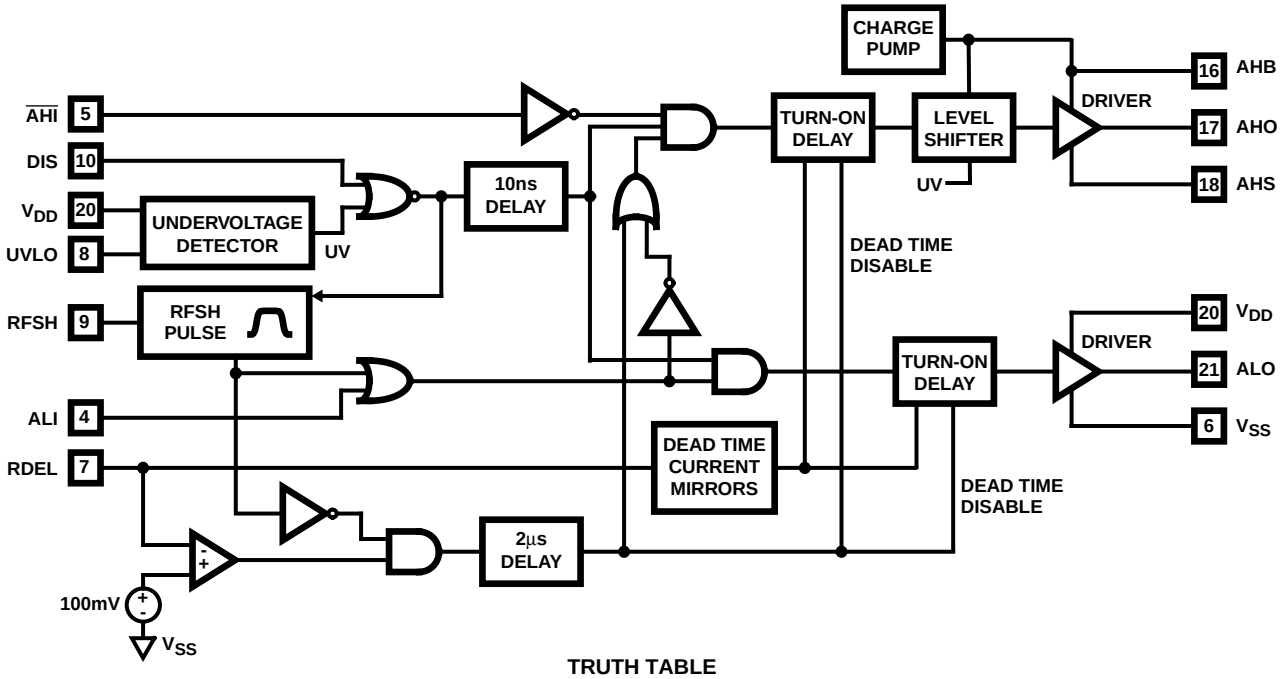
Application Block Diagram



CAUTION: These devices are sensitive to electrostatic discharge. Users should follow proper IC Handling Procedures.

File Number **4220.1**

Functional Block Diagram (1/3 of HIP4086)

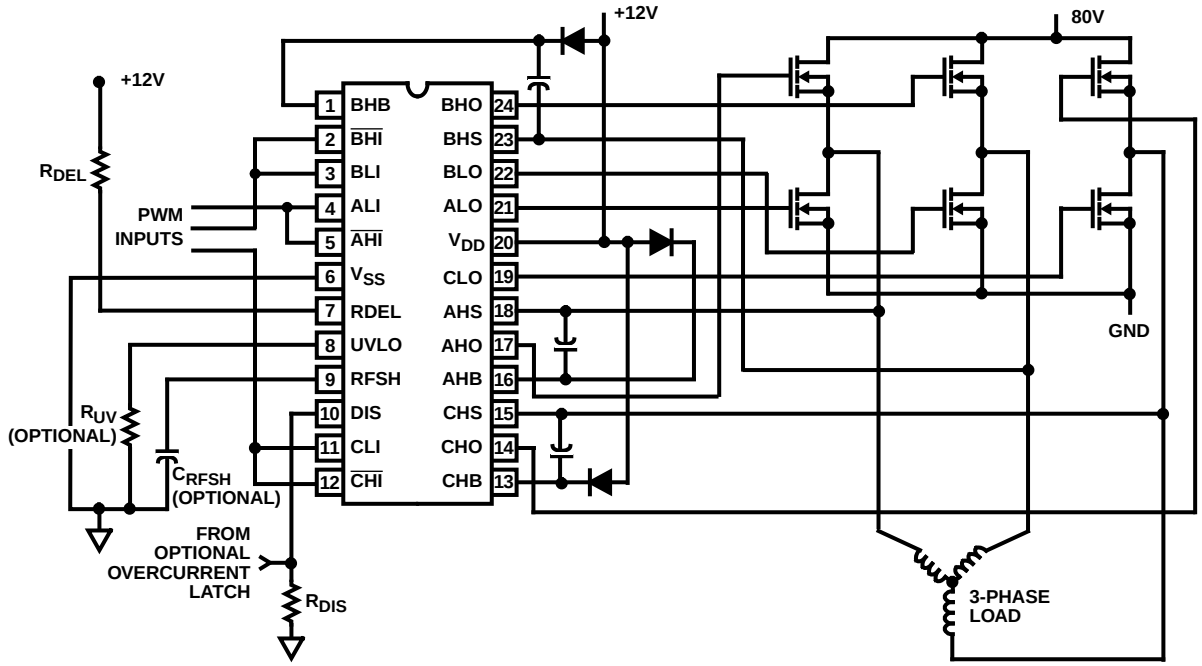


TRUTH TABLE

INPUT					OUTPUT	
ALI, BLI, CLI	$\overline{AHI}$, $\overline{BHI}$, $\overline{CHI}$	UV	DIS	RDEL	ALO, BLO, CLO	AHO, BHO, CHO
X	X	X	1	X	0	0
X	X	1	X	X	0	0
1	X	0	0	>100mV	1	0
0	0	0	0	X	0	1
0	1	0	0	X	0	0
1	0	0	0	<100mV	1	1

NOTE: X signifies that input can be either a “1” or “0”.

Typical Application (PWM Mode Switching)



Pin Descriptions

PIN NUMBER	SYMBOL	DESCRIPTION
17 1 13	AHB BHB CHB (xHB)	High-Side Bootstrap supplies. One external bootstrap diode and one capacitor are required for each. Connect cathode of bootstrap diode and positive side of bootstrap capacitor to each xHB pin.
5 2 12	$\overline{AHI}$ $\overline{BHI}$ $\overline{CHI}$ ($\overline{xHI}$)	High-Side Logic Level Inputs. Logic at these three pins controls the three high side output drivers, AHO (Pin 17), BHO (Pin 24) and CHO (Pin 14). When $\overline{xHI}$ is low, xHO is high. When $\overline{xHI}$ is high, xHO is low. Unless the dead time is disabled by connecting RDEL (Pin 7) to ground, the low side input of each phase will override the corresponding high side input on that phase - see Truth Table on previous page. If RDEL is tied to ground, dead time is disabled and the outputs follow the inputs. Care must be taken to avoid shoot-through in this application. DIS (Pin 10) also overrides the high side inputs. $\overline{xHI}$ can be driven by signal levels of 0V to 15V (no greater than V_{DD}). An internal 100µA pull-up to V_{DD} will hold each $\overline{xHI}$ high if the pins are not driven.
4 3 11	ALI BLI CLI (xLI)	Low-Side Logic Level Inputs. Logic at these three pins controls the three low side output drivers ALO (Pin 21), BLO (Pin 22) and CLO (Pin 19). If the upper inputs are grounded then the lower inputs control both xLO and xHO drivers, with the dead time set by the resistor at RDEL (Pin 7). DIS (Pin 10) high level input overrides xLI, forcing all outputs low. xLI can be driven by signal levels of 0V to 15V (no greater than V_{DD}). An internal 100µA pull-up to V_{DD} will hold xLI high if these pins are not driven.
6	V_{SS}	Ground. Connect the sources of the Low-Side power MOSFETs to this pin.
7	RDEL	Dead Time Setting. Connect a resistor from this pin to V_{DD} to set timing current that defines the dead time between drivers - see Figure 17. All drivers turn-off with no adjustable delay, so the RDEL resistor guarantees no shoot-through by delaying the turn-on of all drivers. When RDEL is tied to V_{SS}, both upper and lowers can be commanded on simultaneously. While not necessary in most applications, a decoupling capacitor of 0.1µF or smaller may be connected between RDEL and V_{SS}.
8	UVLO	Undervoltage Setting. A resistor can be connected between this pin and V_{SS} to program the undervoltage set point, see Figure 18. With this pin not connected, the undervoltage disable is typically 6.6V. When this pin is tied to V_{DD}, the undervoltage disable is typically 6.2V.
9	RFSH	Refresh Pulse Setting. An external capacitor can be connected from this pin to V_{SS} to increase the length of the start up refresh pulse - see Figure 16. If this pin is not connected, the refresh pulse is typically 1.5µs.
10	DIS	Disable Input. Logic level input that when taken high sets all six outputs low. DIS high overrides all other inputs. With DIS low, the outputs are controlled by the other inputs. DIS can be driven by signal levels of 0V to 15V (no greater than V_{DD}). An internal 100µA pull-up to V_{DD} will hold DIS high if this pin is not driven.
17 24 14	AHO BHO CHO (xHO)	High-Side Outputs. Connect to the gates of the High-Side power MOSFETs in each phase.
15 23 15	AHS BHS CHS (xHS)	High-Side Source Connection. Connect the sources of the High-Side power MOSFETs to these pins. The negative side of the bootstrap capacitors should also be connected to these pins.
20	V_{DD}	Positive Supply. Decouple this pin to V_{SS} (Pin 6).
21 22 19	ALO BLO CLO (xLO)	Low-Side Outputs. Connect the gates of the Low-Side power MOSFETs to these pins.

NOTE: x = A, B and C.

Absolute Maximum Ratings

Supply Voltage, V_{DD} . . . . . -0.3V to 16V
Logic I/O Voltages . . . . . -0.3V to V_{DD} +0.3V
Voltage on xHS . . . . . -6V (Transient) to 85V (-40^{o}C to 150^{o}C)
Voltage on xHB . . . . . V_{xHS} -0.3V to V_{xHS} +V_{DD}
Voltage on xLO . . . . . V_{SS} -0.3V to V_{DD} +0.3V
Voltage on xHO . . . . . V_{xHS} -0.3V to V_{xHB} +0.3V
Phase Slew Rate 20V/ns

Thermal Information

Thermal Resistance (Typical, Note 1)	θ_{JA} (^{o}C/W)
SOIC Package	75
DIP Package	65

Storage Temperature Range . . . . . -65^{o}C to 150^{o}C
Operating Max. Junction Temperature . . . . . 150^{o}C
Lead Temperature (Soldering 10s) . . . . . 300^{o}C
(SOIC - Lead Tips Only)

Operating Conditions

Supply Voltage, V_{DD} . . . . . +7V to +15V
Voltage on xHB . . . . . V_{xHS} + V_{DD}
Voltage on xHS . . . . . 0V to 80V

Operating Ambient Temperature Range . . . . . -40^{o}C to 125^{o}C
Operating Junction Temperature Range . . . . . -40^{o}C to 150^{o}C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTES:

1. θ_{JA} is measured with the component mounted on an evaluation PC board in free air.
2. All voltages are relative to V_{SS} unless otherwise specified.
3. x = A, B and C. For example, xHS refers to AHS, BHS and CHS.

Electrical Specifications

V_{DD} = V_{xHB} = 12V, V_{SS} = V_{xHS} = 0V, R_{DEL} = 20K, R_{UV} = ∞, Gate Capacitance(C_{GATE}) = 1000pF

PARAMETER	TEST CONDITIONS	T_J = 25^{o}C			T_J = -40^{o}C TO 150^{o}C		UNITS
		MIN	TYP	MAX	MIN	MAX	
SUPPLY CURRENTS AND UNDER VOLTAGE PROTECTION							
V_{DD} Quiescent Current	$\overline{xHI}$ = 5V, xLI = 5V	2.7	3.4	4.2	2.1	4.3	mA
V_{DD} Operating Current	f = 20kHz, 50% Duty Cycle	6.3	8.25	10.5	5	11	mA
xHB On Quiescent Current	$\overline{xHI}$ = 0V	-	40	80	-	100	µA
xHB Off Quiescent Current	$\overline{xHI}$ = V_{DD}	0.6	0.8	1.3	0.5	1.4	mA
xHB Operating Current	f = 20kHz, 50% Duty Cycle	0.7	0.9	1.3	-	2.0	mA
Qpump Output Voltage	No Load	11.5	12.5	14	10.5	14.5	V
Qpump Output Current	V_{xHS} = 12V, V_{xHB} = 22V	50	100	130	-	140	µA
xHB, xHS Leakage Current	V_{xHS} = 80V, V_{xHB} = 93V	7	24	45	-	50	µA
V_{DD} Rising Undervoltage Threshold	R_{UV} open	6.2	7.1	8.0	6.1	8.1	V
V_{DD} Falling Undervoltage Threshold	R_{UV} open	5.75	6.6	7.5	5.6	7.6	V
Minimum Undervoltage Threshold	R_{UV} = V_{DD}	5	6.2	6.8	4.9	6.9	V
INPUT PINS: ALI, BLI, CLI, $\overline{AHI}$, $\overline{BHI}$, $\overline{CHI}$, AND DIS							
Low Level Input Voltage		-	-	1.0	-	0.8	V
High Level Input Voltage		2.5	-	-	2.7	-	V
Input Voltage Hysteresis		-	35	-	-	-	mV
Low Level Input Current	V_{IN} = 0V	60	100	135	55	140	µA
High Level Input Current	V_{IN} = 5V	-1	-	+1	-10	+10	µA
GATE DRIVER OUTPUT PINS: ALO, BLO, CLO, AHO, BHO, AND CHO							
Low Level Output Voltage (V_{OUT} - V_{SS})	$I_{SINKING}$ = 30mA	-	100	-	-	200	mV
Peak Turn-On Current	V_{OUT} = 0V	0.3	0.5	0.7	-	1.0	A
Peak Turn-Off Current	V_{OUT} = 12V	0.7	1.1	1.5	0.5	1.7	A

Switching Specifications $V_{DD} = V_{xHB} = 12V$, $V_{SS} = V_{xHS} = 0V$, $C_{GATE} = 1000pF$, $R_{DEL} = 10k$

PARAMETER	TEST CONDITIONS	$T_J = 25^oC$			$T_J = -40^oC$ TO 150^oC		UNITS
		MIN	TYP	MAX	MIN	MAX	
TURN-ON DELAY AND PROPAGATION DELAY							
Dead Time	R_{DEL} = 100K	3.8	4.5	6	3	7	µs
	R_{DEL} = 10K	0.38	0.5	0.65	0.3	0.7	µs
Dead Time Channel Matching	R_{DEL} = 10K	-	7	15	-	20	%
Lower Turn-Off Propagation Delay (xLI-xLO)	No Load	-	30	45	-	65	ns
Upper Turn-Off Propagation Delay ($\overline{xHI}$-xHO)	No Load	-	75	90	-	100	ns
Lower Turn-On Propagation Delay (xLI-xLO)	No Load	-	45	75	-	90	ns
Upper Turn-On Propagation Delay ($\overline{xHI}$-xHO)	No Load	-	65	90	-	100	ns
Rise Time	C_{GATE} = 1000pF	-	20	40	-	50	ns
Fall Time	C_{GATE} = 1000pF	-	10	20	-	25	ns
Disable Turn-Off Propagation Delay (DIS - Lower Outputs)		-	55	80	-	90	ns
Disable Turn-Off Propagation Delay (DIS - Upper Outputs)		-	80	90	-	100	ns
$\overline{Disable}$ to Lower Turn-On Propagation Delay (DIS - xLO)		-	55	80	-	100	ns
$\overline{Disable}$ to Upper Enable (DIS - xHO)	R_{DEL} = 10K, C_{RFSH} Open	-	2.0	-	-	-	µs
Refresh Pulse Width (xLO)	C_{RFSH} Open	-	1.5	-	-	-	µs

Timing Diagrams

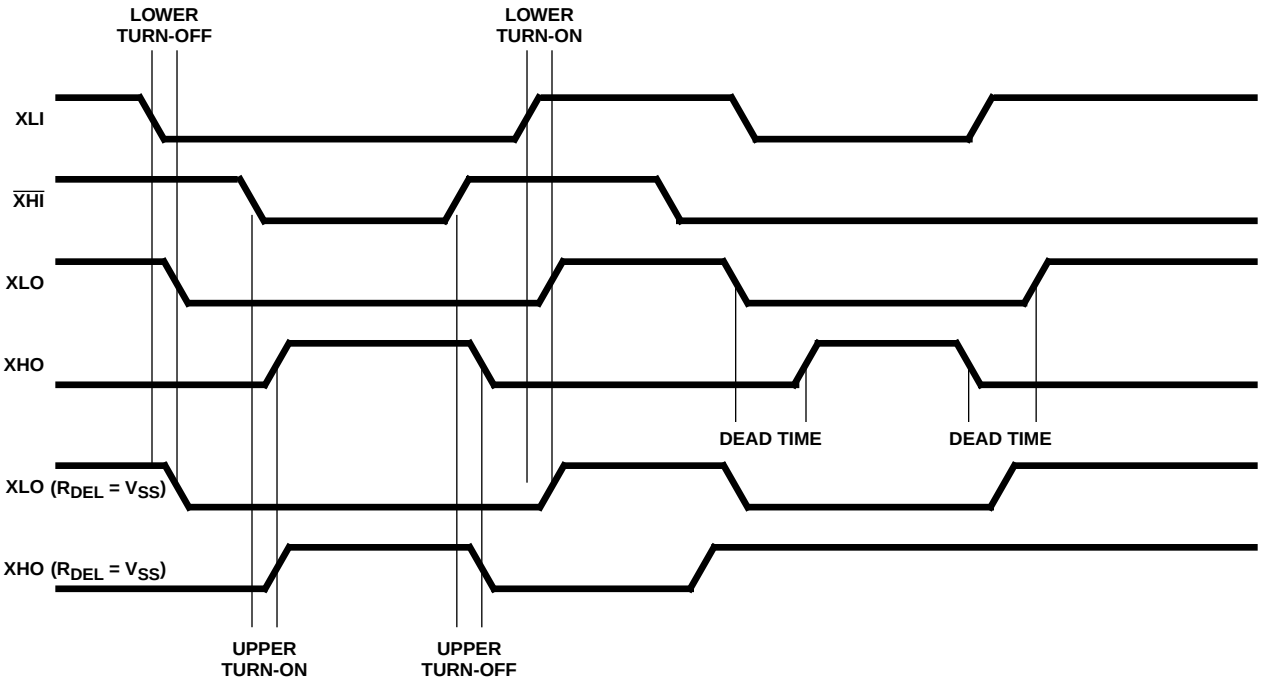


FIGURE 1.

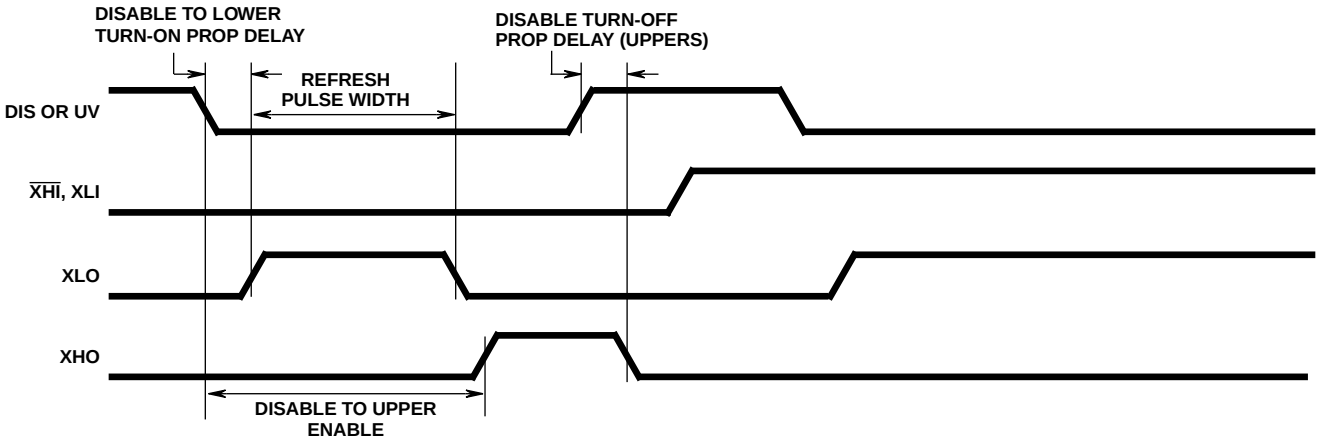


FIGURE 2. DISABLE FUNCTION

NOTES:

4. X means any “A”, “B”, or “C” phase.
5. With RDEL resistor tied to V_{DD}, lowers and uppers cannot be turned on at the same time. Low side logic overrides high side logic unless RDEL < 100mV.

Typical Performance Curves

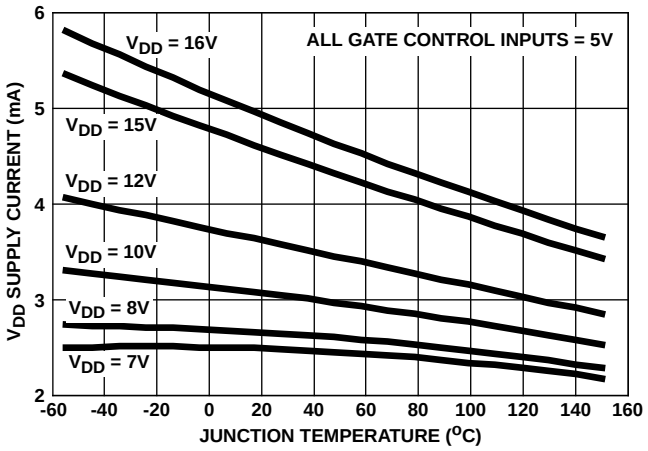


FIGURE 3. V_{DD} SUPPLY CURRENT vs V_{DD} SUPPLY VOLTAGE

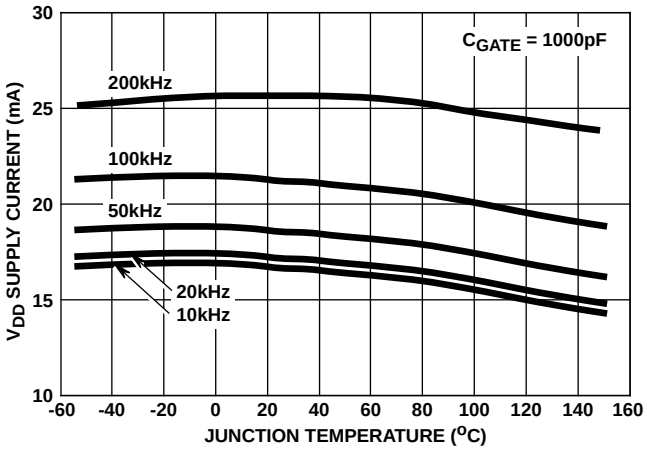


FIGURE 4. V_{DD} SUPPLY CURRENT vs SWITCHING FREQUENCY

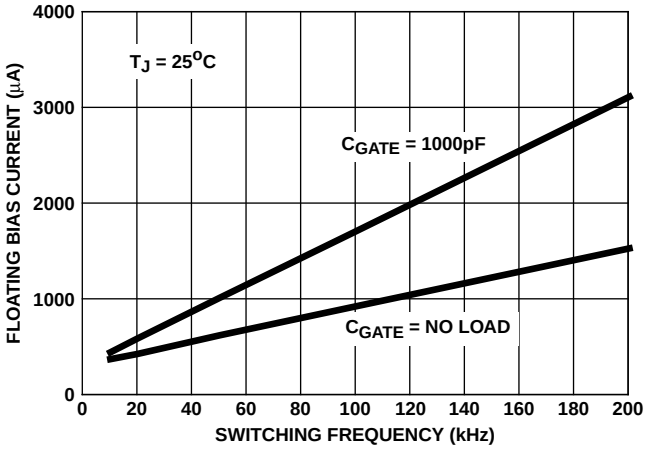


FIGURE 5. FLOATING I_{XHB} BIAS CURRENT

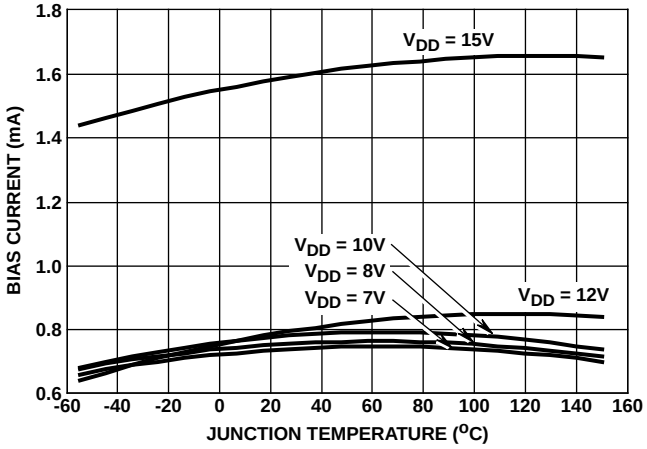


FIGURE 6. OFF-STATE I_{XHB} BIAS CURRENT

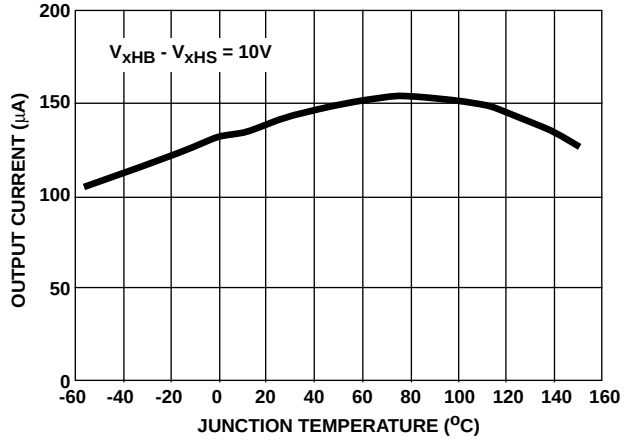


FIGURE 7. CHARGE PUMP OUTPUT CURRENT

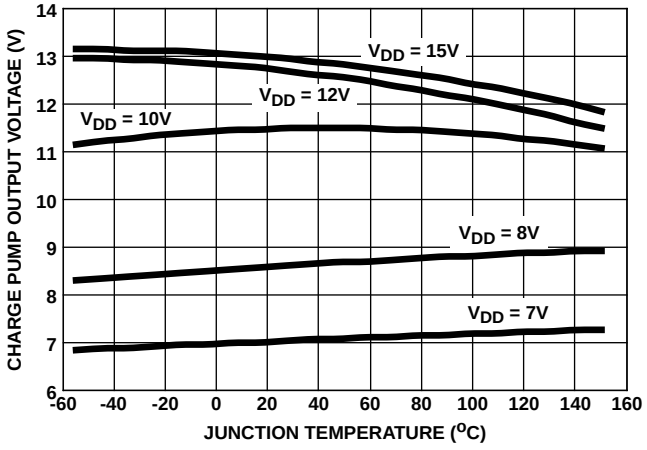


FIGURE 8. CHARGE PUMP OUTPUT VOLTAGE

Typical Performance Curves (Continued)

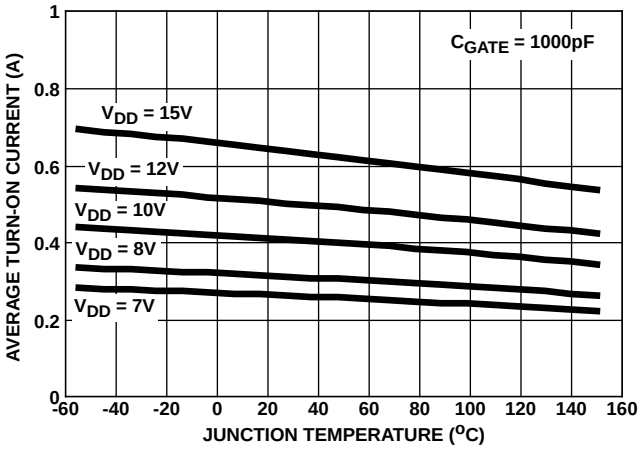


FIGURE 9. AVERAGE TURN-ON CURRENT (0 TO 5V)

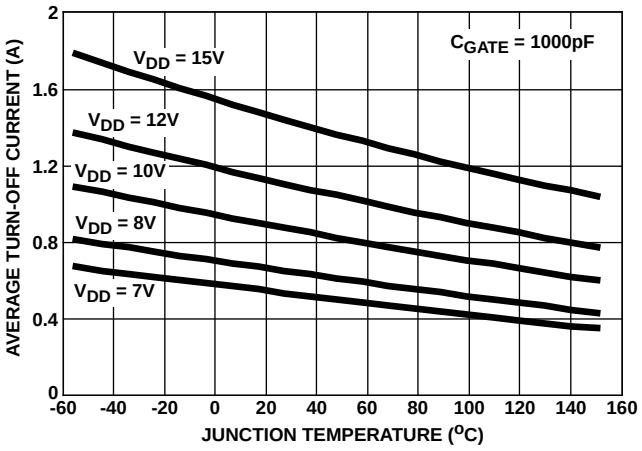


FIGURE 10. AVERAGE TURN-OFF CURRENT (V_{DD} TO 4V)

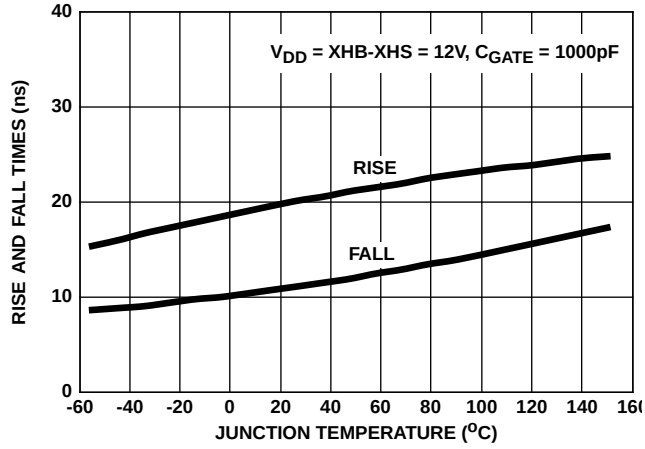


FIGURE 11. RISE AND FALL TIMES (10-90%)

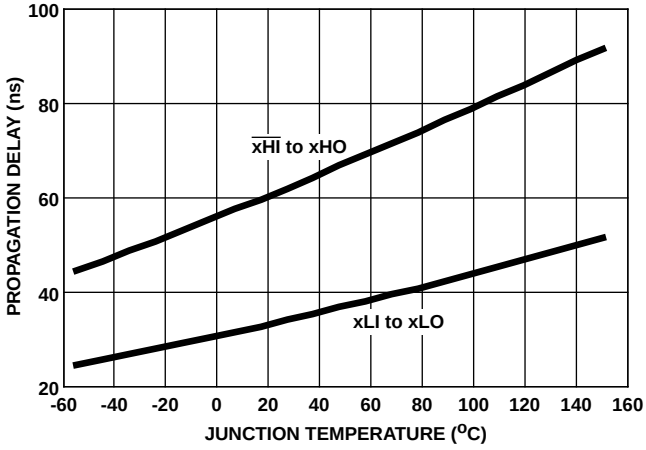


FIGURE 12. PROPAGATION DELAY

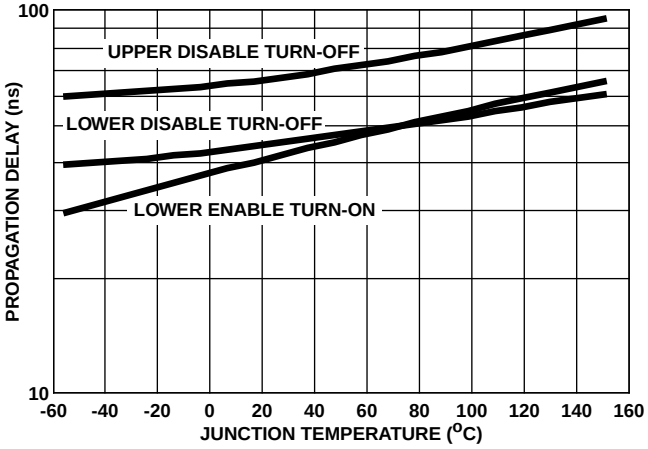


FIGURE 13. DISABLE PIN PROPAGATION DELAY

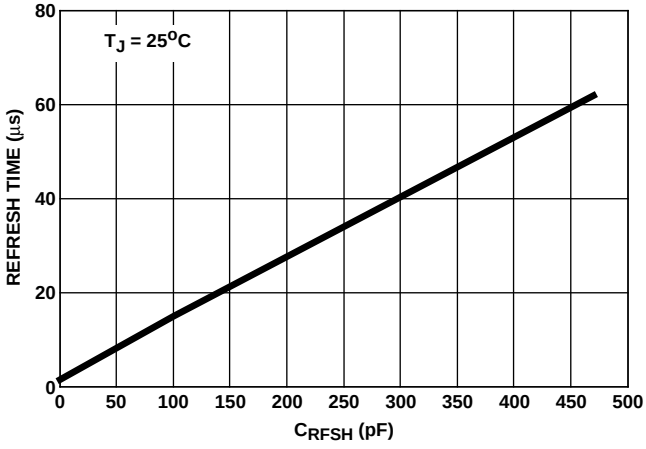


FIGURE 14. REFRESH TIME

Typical Performance Curves (Continued)

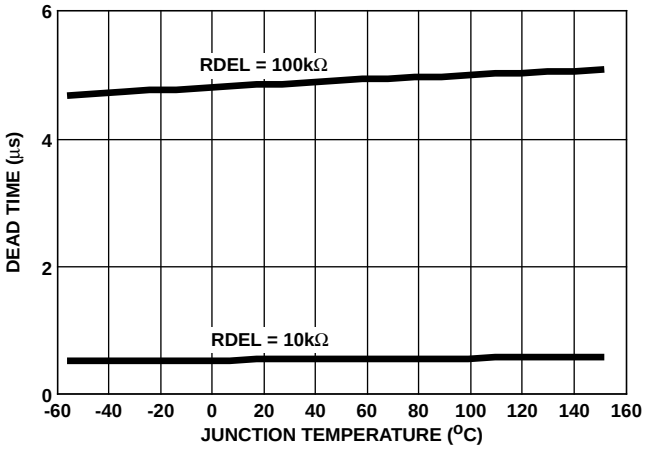


FIGURE 15. DEAD TIME

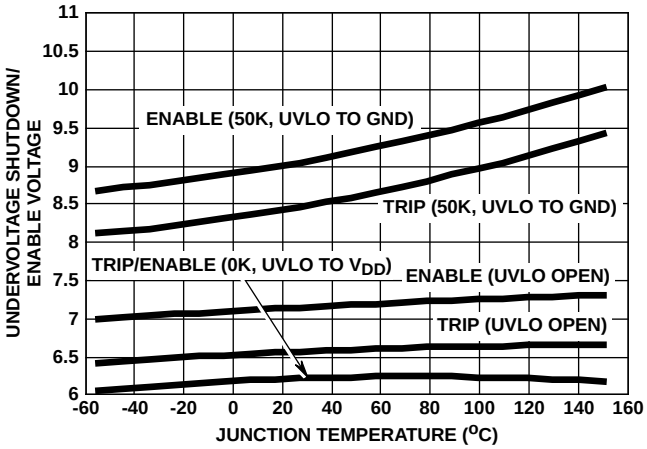


FIGURE 16. UNDERVOLTAGE THRESHOLD

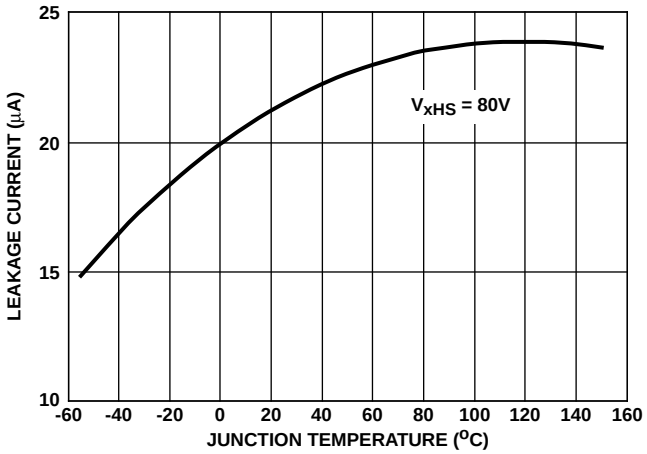
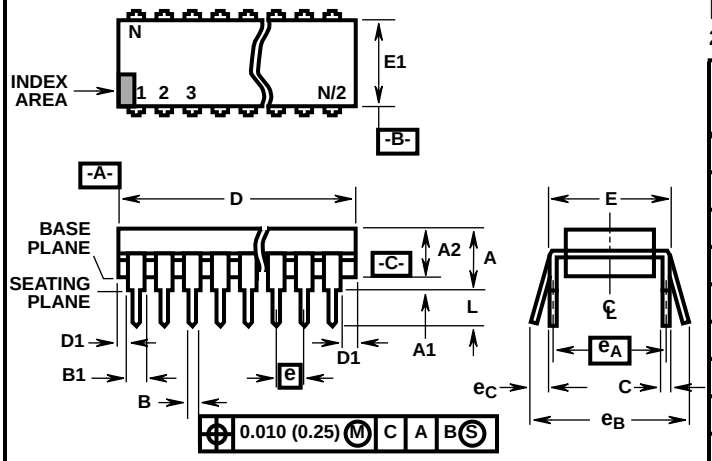


FIGURE 17. I_{xHS} LEAKAGE CURRENT

Dual-In-Line Plastic Packages (PDIP)



NOTES:

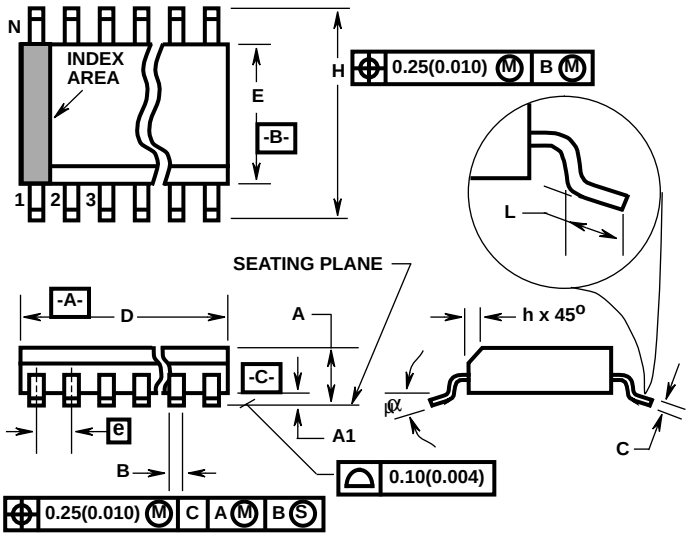
1. Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication No. 95.
4. Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
5. D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
6. E and e_A are measured with the leads constrained to be perpendicular to datum -C-.
7. e_B and e_C are measured at the lead tips with the leads unconstrained. e_C must be zero or greater.
8. B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
9. N is the maximum number of terminal positions.
10. Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

E24.3 (JEDEC MS-001-AF ISSUE D)
24 LEAD NARROW BODY DUAL-IN-LINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.210	-	5.33	4
A1	0.015	-	0.39	-	4
A2	0.115	0.195	2.93	4.95	-
B	0.014	0.022	0.356	0.558	-
B1	0.045	0.070	1.15	1.77	8
C	0.008	0.014	0.204	0.355	-
D	1.230	1.280	31.24	32.51	5
D1	0.005	-	0.13	-	5
E	0.300	0.325	7.62	8.25	6
E1	0.240	0.280	6.10	7.11	5
e	0.100 BSC		2.54 BSC		-
e_A	0.300 BSC		7.62 BSC		6
e_B	-	0.430	-	10.92	7
L	0.115	0.150	2.93	3.81	4
N	24		24		9

Rev. 0 12/93

Small Outline Plastic Packages (SOIC)



M24.3 (JEDEC MS-013-AD ISSUE C)
24 LEAD WIDE BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0926	0.1043	2.35	2.65	-
A1	0.0040	0.0118	0.10	0.30	-
B	0.013	0.020	0.33	0.51	9
C	0.0091	0.0125	0.23	0.32	-
D	0.5985	0.6141	15.20	15.60	3
E	0.2914	0.2992	7.40	7.60	4
e	0.05 BSC		1.27 BSC		-
H	0.394	0.419	10.00	10.65	-
h	0.010	0.029	0.25	0.75	5
L	0.016	0.050	0.40	1.27	6
N	24		24		7
α	0^o	8^o	0^o	8^o	-

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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.

All Harris Semiconductor products are manufactured, assembled and tested under **ISO9000** quality systems certification.

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