

## 80V/2.5A Peak, High Frequency Full Bridge FET Driver

December 1996

### Features

- Drives N-Channel FET Full Bridge Including High Side Chop Capability
- Bootstrap Supply Max Voltage to 95V<sub>DC</sub>
- Drives 1000pF Load at 1MHz in Free Air at 50°C with Rise and Fall Times of 10ns (Typ)
- User-Programmable Dead Time
- Charge-Pump and Bootstrap Maintain Upper Bias Supplies
- DIS (Disable) Pin Pulls Gates Low
- Input Logic Thresholds Compatible with 5V to 15V Logic Levels
- Very Low Power Consumption

### Applications

- Medium/Large Voice Coil Motors
- Full Bridge Power Supplies
- Class D Audio Power Amplifiers
- High Performance Motor Controls
- Noise Cancellation Systems
- Battery Powered Vehicles
- Peripherals
- U.P.S.

### Description

The HIP4080 is a high frequency, medium voltage Full Bridge N-Channel FET driver IC, available in 20 lead plastic SOIC and DIP packages. The HIP4080 includes an input comparator, used to facilitate the "hysteresis" and PWM modes of operation. Its HEN (high enable) lead can force current to freewheel in the bottom two external power MOSFETs, maintaining the upper power MOSFETs off. Since it can switch at frequencies up to 1MHz, the HIP4080 is well suited for driving Voice Coil Motors, switching amplifiers in class D high-frequency switching audio amplifiers and power supplies.

HIP4080 can also drive medium voltage brush motors, and two HIP4080s can be used to drive high performance stepper motors, since the short minimum "on-time" can provide fine micro-stepping capability.

Short propagation delays of approximately 55ns maximizes control loop crossover frequencies and dead-times which can be adjusted to near zero to minimize distortion, resulting in precise control of the driven load.

The similar HIP4081 IC allows independent control of all 4 FETs in an Full Bridge configuration.

See also, Application Note AN9324 for the HIP4080.

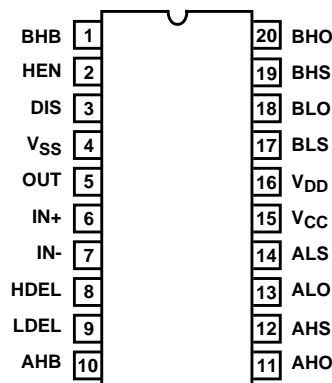
Similar part, HIP4080A, includes under voltage circuitry which doesn't require the circuitry shown in Figure 30 of this data sheet.

### Ordering Information

PART NUMBER	TEMP. RANGE (°C)	PACKAGE	PKG. NO.
HIP4080IP	-40 to 85	20 Lead PDIP	E20.3
HIP4080IB	-40 to 85	20 Lead SOIC	M20.3

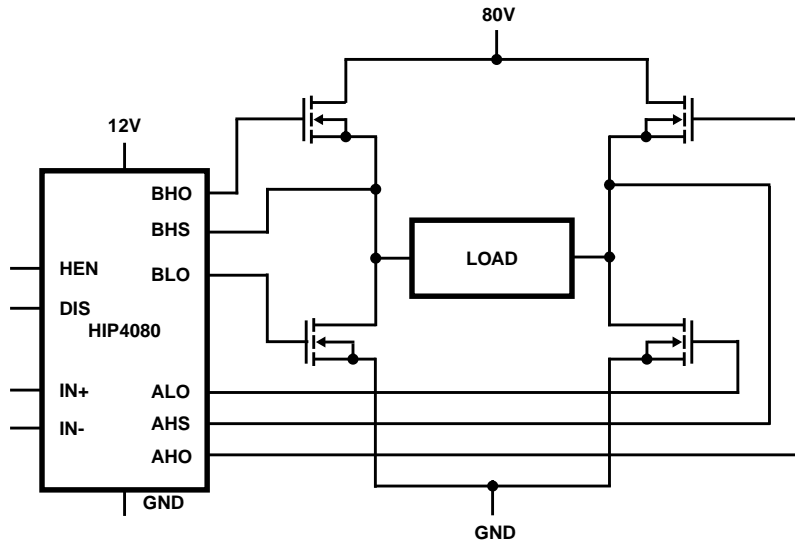
### Pinout

HIP4080 (PDIP, SOIC)  
TOP VIEW

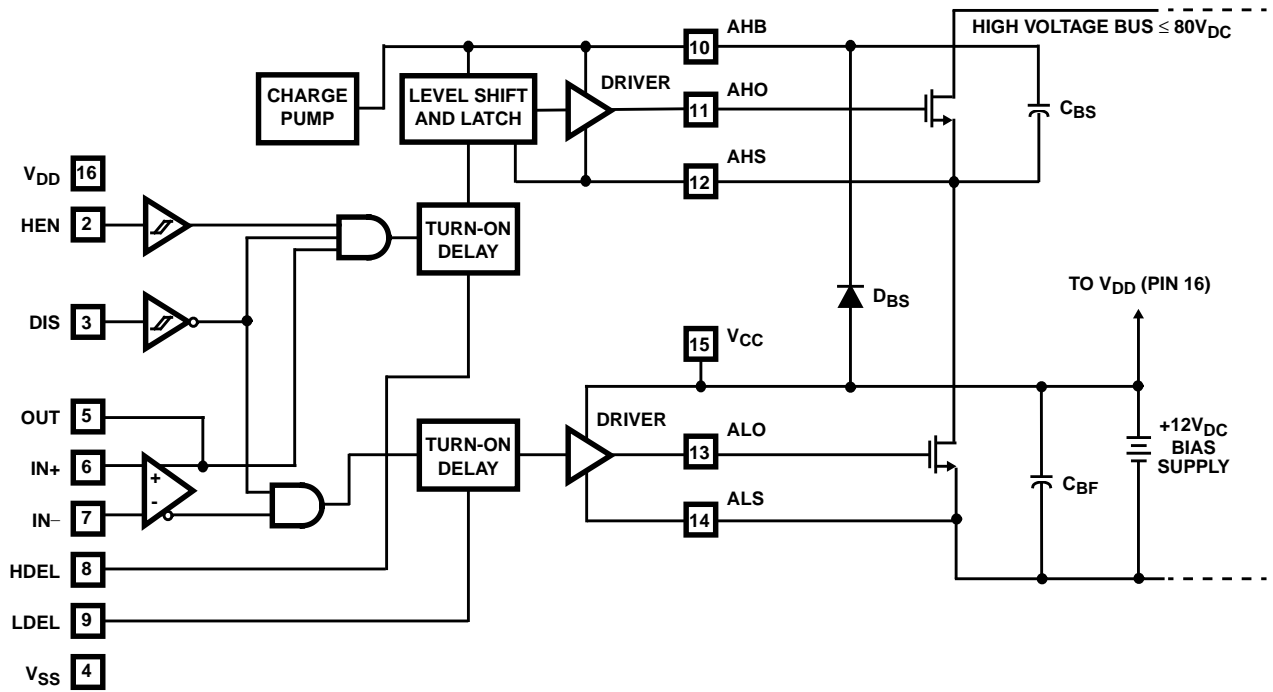


# HIP4080

## Application Block Diagram

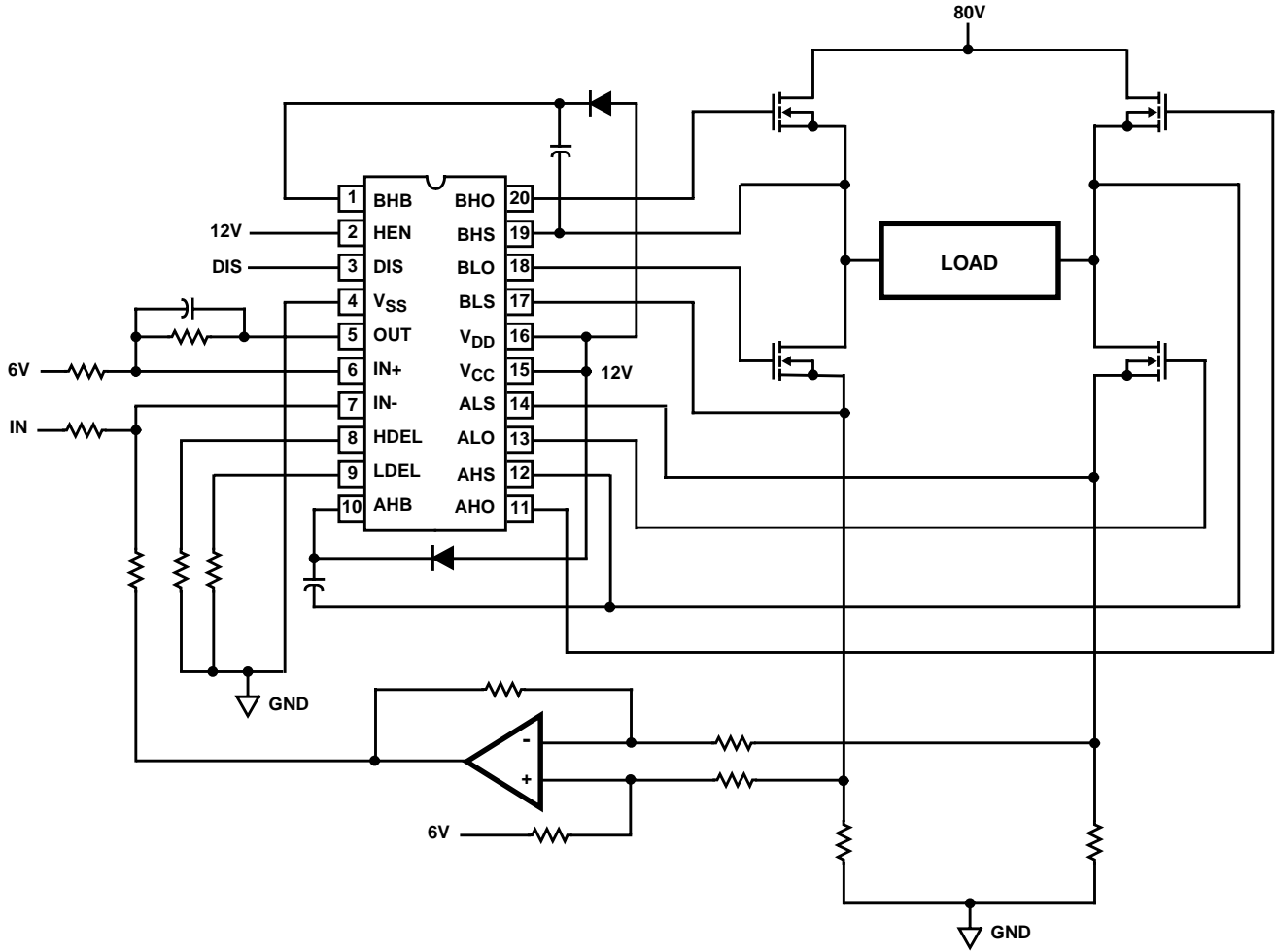


## Functional Block Diagram (1/2 HIP4080)



# HIP4080

## Typical Application (Hysteresis Mode Switching)



# HIP4080

## Absolute Maximum Ratings

Supply Voltage,  $V_{DD}$  and  $V_{CC}$  ..... -0.3V to 16V  
 Logic I/O Voltages ..... -0.3V to  $V_{DD} + 0.3V$   
 Voltage on AHS, BHS ..... -6.0V (Transient) to 80V (25°C to 125°C)  
 Voltage on AHS, BHS ..... -6.0V (Transient) to 70V (-55°C to 125°C)  
 Voltage on ALS, BLS ..... -2.0V (Transient) to +2.0V (Transient)  
 Voltage on AHB, BHB  $V_{AHS}$ , BHS -0.3V to  $V_{AHS}$ , BHS +16V  
 Voltage on ALO, BLO .....  $V_{ALS}$ , BLS -0.3V to  $V_{CC} + 0.3V$   
 Voltage on AHO, BHO .....  $V_{AHS}$ , BHS -0.3V to  $V_{AHB}$ , BHB +0.3V  
 Input Current, HDEL and LDEL ..... -5mA to 0mA  
 Phase Slew Rate ..... 20V/ns  
 NOTE: All Voltages relative to pin 4,  $V_{SS}$ , unless otherwise specified.

## Thermal Information

Thermal Resistance (Typical, Note 1)  $\theta_{JA}$  (°C/W)  
 SOIC Package ..... 85  
 PDIP Package ..... 75  
 Maximum Power Dissipation at 85°C  
 SOIC Package ..... 470mW  
 DIP Package ..... 530mW  
 Storage Temperature Range ..... -65°C to 150°C  
 Operating Max. Junction Temperature ..... 125°C  
 Lead Temperature (Soldering 10s) ..... 300°C  
 (SOIC - Lead Tips Only)

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.

NOTE:

- $\theta_{JA}$  is measured with the component mounted on an evaluation PC board in free air.

## Operating Conditions

Supply Voltage,  $V_{DD}$  and  $V_{CC}$  ..... +8V to +15V  
 Voltage on ALS, BLS ..... -1.0V to +1.0V  
 Voltage on AHB, BHB .....  $V_{AHS}$ , BHS +5V to  $V_{AHS}$ , BHS +15V  
 Input Current, HDEL and LDEL ..... -500 $\mu$ A to -50 $\mu$ A  
 Operating Ambient Temperature Range ..... -40°C to 85°C

**Electrical Specifications**  $V_{DD} = V_{CC} = V_{AHB} = V_{BHB} = 12V$ ,  $V_{SS} = V_{ALS} = V_{BLS} = V_{AHS} = V_{BHS} = 0V$ ,  $R_{HDEL} = R_{LDEL} = 100k$ , and  $T_A = 25^\circ C$ , Unless Otherwise Specified

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 AND CHARGE PUMPS</b>								
$V_{DD}$ Quiescent Current	$I_{DD}$	IN- = 2.5V, Other Inputs = 0V	8	10.5	13	7	14	mA
$V_{DD}$ Operating Current	$I_{DDO}$	Outputs switching f = 500kHz	9	11	14	8	15	mA
$V_{CC}$ Quiescent Current	$I_{CC}$	IN- = 2.5V, Other Inputs = 0V, $I_{ALO} = I_{BLO} = 0$	-	25	80	-	100	$\mu$ A
$V_{CC}$ Operating Current	$I_{CCO}$	f = 500kHz, No Load	1	1.5	2.0	0.8	3	mA
AHB, BHB Quiescent Current - Qpump Output Current	$I_{AHB}$ , $I_{BHB}$	IN- = 2.5V, Other Inputs = 0V, $I_{AHO} =$ $I_{BHO} = 0$ , $V_{DD} = V_{CC} = V_{AHB} =$ $V_{BHB} = 10V$	-50	-30	-15	-60	-10	$\mu$ A
AHB, BHB Operating Current	$I_{AHB}$ , $I_{BHB}$	f = 500kHz, No Load	0.5	0.9	1.3	0.4	1.7	mA
AHS, BHS, AHB, BHB Leakage Current	$I_{HLK}$	$V_{AHS} = V_{BHS} = V_{AHB} = V_{BHB} = 95V$	-	0.02	1.0	-	10	$\mu$ A
AHB-AHS, BHB-BHS Qpump Output Voltage	$V_{AHB} - V_{AHS}$ $V_{BHB} - V_{BHS}$	$I_{AHB} = I_{AHS} = 0$ , No Load	11.5	12.6	14.0	10.5	14.5	V
<b>INPUT COMPARATOR PINS: IN+, IN-, OUT</b>								
Offset Voltage	$V_{OS}$	Over Common Mode Voltage Range	-10	0	+10	-15	+15	mV
Input Bias Current	$I_{IB}$		0	0.5	2	0	4	$\mu$ A
Input Offset Current	$I_{OS}$		-1	0	+1	-2	+2	$\mu$ A
Input Common Mode Voltage Range	CMVR		1	-	$V_{DD}$ -1.5	1	$V_{DD}$ -1.5	V
Voltage Gain	AVOL		10	25	-	10	-	V/mV
OUT High Level Output Voltage	$V_{OH}$	IN+ > IN-, $I_{OH} = -300\mu A$	$V_{DD}$ -0.4	-	-	$V_{DD}$ -0.5	-	V
OUT Low Level Output Voltage	$V_{OL}$	IN+ < IN-, $I_{OL} = 300\mu A$	-	-	0.3	-	0.4	V
High Level Output Current	$I_{OH}$	$V_{OUT} = 6V$	-9	-7	-4	-11	-2	mA
Low Level Output Current	$I_{OL}$	$V_{OUT} = 6V$	8	10	12	5	14	mA
<b>INPUT PINS: DIS</b>								
Low Level Input Voltage	$V_{IL}$	Full Operating Conditions	-	-	1.0	-	0.8	V
High Level Input Voltage	$V_{IH}$	Full Operating Conditions	2.5	-	-	2.7	-	V
Input Voltage Hysteresis			-	35	-	-	-	mV

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**Electrical Specifications**  $V_{DD} = V_{CC} = V_{AHB} = V_{BHB} = 12V$ ,  $V_{SS} = V_{ALS} = V_{BLS} = V_{AHS} = V_{BHS} = 0V$ ,  $R_{HDEL} = R_{LDEL} = 100K$ , and  $T_A = 25^{\circ}C$ , Unless Otherwise Specified **(Continued)**

PARAMETERS	SYMBOL	TEST CONDITIONS	$T_J = 25^{\circ}C$			$T_J = -40^{\circ}C$ TO $125^{\circ}C$		UNITS
			MIN	TYP	MAX	MIN	MAX	
Low Level Input Current	$I_{IL}$	$V_{IN} = 0V$ , Full Operating Conditions	-130	-100	-75	-135	-65	$\mu A$
High Level Input Current	$I_{IH}$	$V_{IN} = 5V$ , Full Operating Conditions	-1	-	+1	-10	+10	$\mu A$
<b>INPUT PINS: HEN</b>								
Low Level Input Voltage	$V_{IL}$	Full Operating Conditions	-	-	1.0	-	0.8	V
High Level Input Voltage	$V_{IH}$	Full Operating Conditions	2.5	-	-	2.7	-	V
Input Voltage Hysteresis			-	35	-	-	-	mV
Low Level Input Current	$I_{IL}$	$V_{IN} = 0V$ , Full Operating Conditions	-260	-200	-150	-270	-130	$\mu A$
High Level Input Current	$I_{IH}$	$V_{IN} = 5V$ , Full Operating Conditions	-1	-	+1	-10	+10	$\mu A$
<b>TURN-ON DELAY PINS: LDEL AND HDEL</b>								
LDEL, HDEL Voltage	$V_{HDEL}, V$	$I_{HDEL} = I_{LDEL} = -100\mu A$	4.9	5.1	5.3	4.8	5.4	V
<b>GATE DRIVER OUTPUT PINS: ALO, BLO, AHO, AND BHO</b>								
Low Level Output Voltage	$V_{OL}$	$I_{OUT} = 100mA$	.70	0.85	1.0	0.5	1.1	V
High Level Output Voltage	$V_{CC} - V_{OH}$	$I_{OUT} = -100mA$	0.8	0.95	1.1	0.5	1.2	V
Peak Pull-up Current	$I_{O+}$	$V_{OUT} = 0V$	1.7	2.6	3.8	1.4	4.1	A
Peak Pull-down Current	$I_{O-}$	$V_{OUT} = 12V$	1.7	2.4	3.3	1.3	3.6	A

**Switching Specifications**  $V_{DD} = V_{CC} = V_{AHB} = V_{BHB} = 12V$ ,  $V_{SS} = V_{ALS} = V_{BLS} = V_{AHS} = V_{BHS} = 0V$ ,  $R_{HDEL} = R_{LDEL} = 10K$ ,  $C_L = 1000pF$ , and  $T_A = 25^{\circ}C$ , Unless Otherwise Specified

PARAMETERS	SYMBOL	TEST CONDITIONS	$T_J = 25^{\circ}C$			$T_J = -40^{\circ}C$ TO $125^{\circ}C$		UNITS
			MIN	TYP	MAX	MIN	MAX	
Lower Turn-off Propagation Delay (IN+/IN- to ALO/BLO)	$T_{LPHL}$		-	40	70	-	90	ns
Upper Turn-off Propagation Delay (IN+/IN- to AHO/BHO)	$T_{HPHL}$		-	50	80	-	110	ns
Lower Turn-on Propagation Delay (IN+/IN- to ALO/BLO)	$T_{LPLH}$	$R_{HDEL} = R_{LDEL} = 10K$	-	45	70	-	90	ns
Upper Turn-on Propagation Delay (IN+/IN- to AHO/BHO)	$T_{HPLH}$	$R_{HDEL} = R_{LDEL} = 10K$	-	70	110	-	140	ns
Rise Time	$T_r$		-	10	25	-	35	ns
Fall Time	$T_f$		-	10	25	-	35	ns
Turn-on Input Pulse Width	$T_{PWIN-ON}$	$R_{HDEL} = R_{LDEL} = 10K$	50	-	-	50	-	ns
Turn-off Input Pulse Width	$T_{PWIN-OFF}$	$R_{HDEL} = R_{LDEL} = 10K$	40	-	-	40	-	ns
Disable Turn-off Propagation Delay (DIS - Lower Outputs)	$T_{DISLOW}$		-	45	75	-	95	ns
Disable Turn-off Propagation Delay (DIS - Upper Outputs)	$T_{DISHIGH}$		-	55	85	-	105	ns
Disable to Lower Turn-on Propagation Delay (DIS - ALO and BLO)	$T_{DLPLH}$		-	35	70	-	90	ns
Refresh Pulse Width (ALO and BLO)	$T_{REF-PW}$		160	260	380	140	420	ns
Disable to Upper Enable (DIS - AHO and BHO)	$T_{UEN}$		-	335	500	-	550	ns
HEN-AHO, BHO Turn-off, Propagation Delay	$T_{HEN-PHL}$	$R_{HDEL} = R_{LDEL} = 10K$	-	35	70	-	90	ns
HEN-AHO, BHO Turn-on, Propagation Delay	$T_{HEN-PLH}$	$R_{HDEL} = R_{LDEL} = 10K$	-	60	90	-	110	ns

## TRUTH TABLE

INPUT			OUTPUT			
IN+ > IN-	HEN	DIS	ALO	AHO	BLO	BHO
X	X	1	0	0	0	0
1	1	0	0	1	1	0
0	1	0	1	0	0	1
1	0	0	0	0	1	0
0	0	0	1	0	0	0

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## Pin Descriptions

PIN NUMBER	SYMBOL	DESCRIPTION
1	BHB	B High-side Bootstrap supply. External bootstrap diode and capacitor are required. Connect cathode of bootstrap diode and positive side of bootstrap capacitor to this pin. Internal charge pump supplies 30μA out of this pin to maintain bootstrap supply. Internal circuitry clamps the bootstrap supply to approximately 12.8V.
2	HEN	High-side Enable input. Logic level input that when low overrides IN+/IN- (Pins 6 and 7) to put AHO and BHO drivers (Pins 11 and 20) in low output state. When HEN is high AHO and BHO are controlled by IN+/IN- inputs. The pin can be driven by signal levels of 0V to 15V (no greater than V <sub>DD</sub> ). An internal 100μA pull-up to V <sub>DD</sub> will hold HEN high, so no connection is required if high-side and low-side outputs are to be controlled by IN+/IN- inputs.
3	DIS	DISable input. Logic level input that when taken high sets all four outputs low. DIS high overrides all other inputs. When DIS is taken low the outputs are controlled by the other inputs. The pin can be driven by signal levels of 0V to 15V (no greater than V <sub>DD</sub> ). An internal 100μA pull-up to V <sub>DD</sub> will hold DIS high if this pin is not driven.
4	V <sub>SS</sub>	Chip negative supply, generally will be ground.
5	OUT	OUTput of the input control comparator. This output can be used for feedback and hysteresis.
6	IN+	Non-inverting input of control comparator. If IN+ is greater than IN- (Pin 7) then ALO and BHO are low level outputs and BLO and AHO are high level outputs. If IN+ is less than IN- then ALO and BHO are high level outputs and BLO and AHO are low level outputs. DIS (Pin 3) high level will override IN+/IN- control for all outputs. HEN (Pin 2) low level will override IN+/IN- control of AHO and BHO. When switching in four quadrant mode, dead time in a half bridge leg is controlled by HDEL and LDEL (Pins 8 and 9).
7	IN-	Inverting input of control comparator. See IN+ (Pin 6) description.
8	HDEL	High-side turn-on DELay. Connect resistor from this pin to V <sub>SS</sub> to set timing current that defines the turn-on delay of both high-side drivers. The low-side drivers turn-off with no adjustable delay, so the HDEL resistor guarantees no shoot-through by delaying the turn-on of the high-side drivers. HDEL reference voltage is approximately 5.1V.
9	LDEL	Low-side turn-on DELay. Connect resistor from this pin to V <sub>SS</sub> to set timing current that defines the turn-on delay of both low-side drivers. The high-side drivers turn-off with no adjustable delay, so the LDEL resistor guarantees no shoot-through by delaying the turn-on of the low-side drivers. LDEL reference voltage is approximately 5.1V.
10	AHB	A High-side Bootstrap supply. External bootstrap diode and capacitor are required. Connect cathode of bootstrap diode and positive side of bootstrap capacitor to this pin. Internal charge pump supplies 30μA out of this pin to maintain bootstrap supply. Internal circuitry clamps the bootstrap supply to approximately 12.8V.
11	AHO	A High-side Output. Connect to gate of A High-side power MOSFET.
12	AHS	A High-side Source connection. Connect to source of A High-side power MOSFET. Connect negative side of bootstrap capacitor to this pin.
13	ALO	A Low-side Output. Connect to gate of A Low-side power MOSFET.
14	ALS	A Low-side Source connection. Connect to source of A Low-side power MOSFET.
15	V <sub>CC</sub>	Positive supply to gate drivers. Must be same potential as V <sub>DD</sub> (Pin 16). Connect to anodes of two bootstrap diodes.
16	V <sub>DD</sub>	Positive supply to lower gate drivers. Must be same potential as V <sub>CC</sub> (Pin 15). De-couple this pin to V <sub>SS</sub> (Pin 4).
17	BLS	B Low-side Source connection. Connect to source of B Low-side power MOSFET.
18	BLO	B Low-side Output. Connect to gate of B Low-side power MOSFET.
19	BHS	B High-side Source connection. Connect to source of B High-side power MOSFET. Connect negative side of bootstrap capacitor to this pin.
20	BHO	B High-side Output. Connect to gate of B High-side power MOSFET.

Timing Diagrams

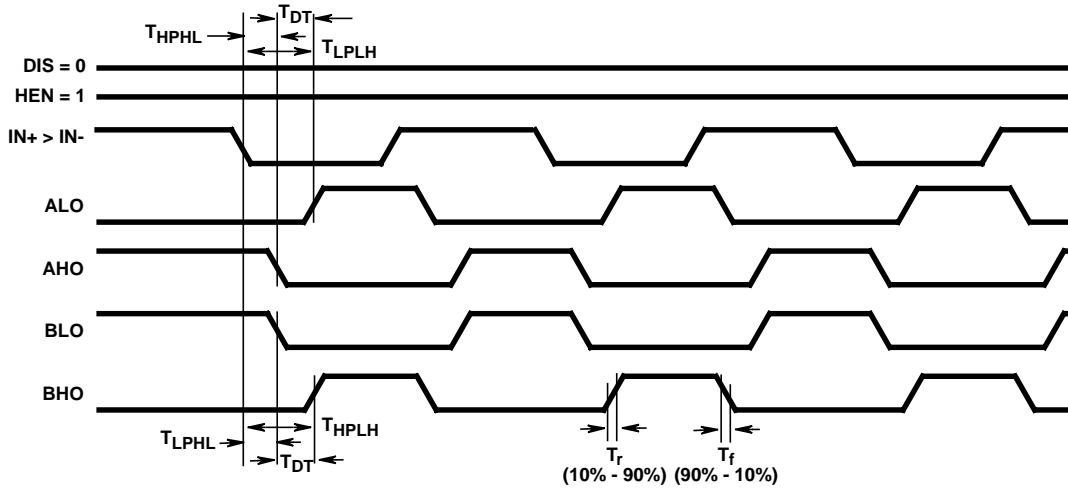


FIGURE 1. BI-STATE MODE

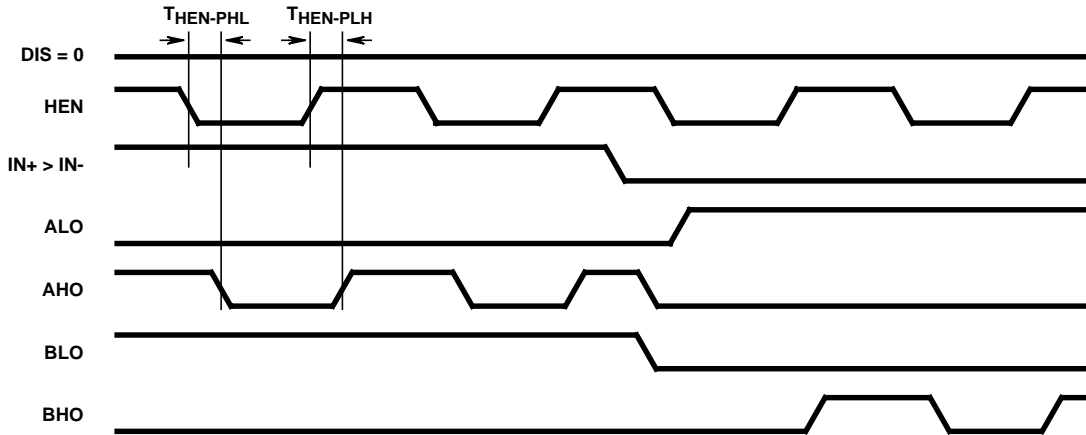


FIGURE 2. HIGH SIDE CHOP MODE

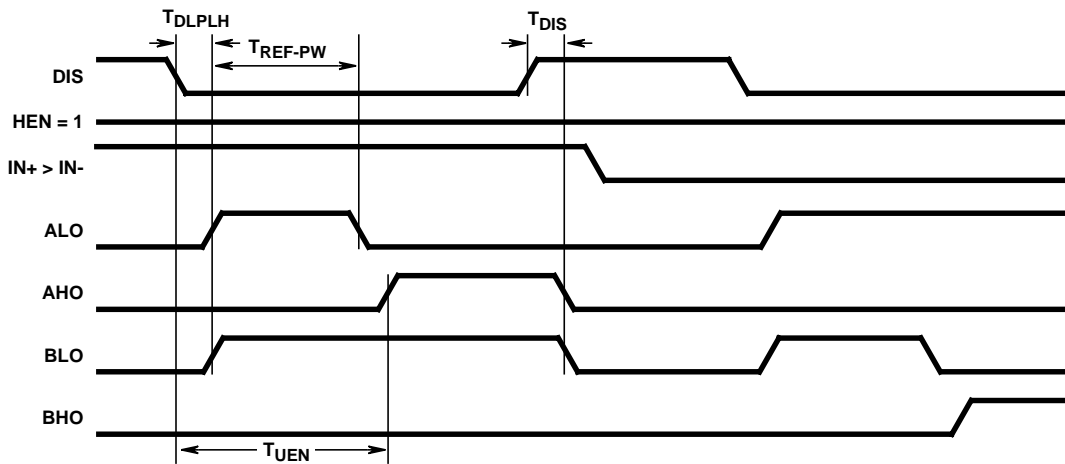


FIGURE 3. DISABLE FUNCTION

**Typical Performance Curves**  $V_{DD} = V_{CC} = V_{AHB} = V_{BHB} = 12V$ ,  $V_{SS} = V_{ALS} = V_{BLS} = V_{AHS} = V_{BHS} = 0V$ ,  
 $R_{HDEL} = R_{LDEL} = 100K$ , and  $T_A = 25^\circ C$ , Unless Otherwise Specified

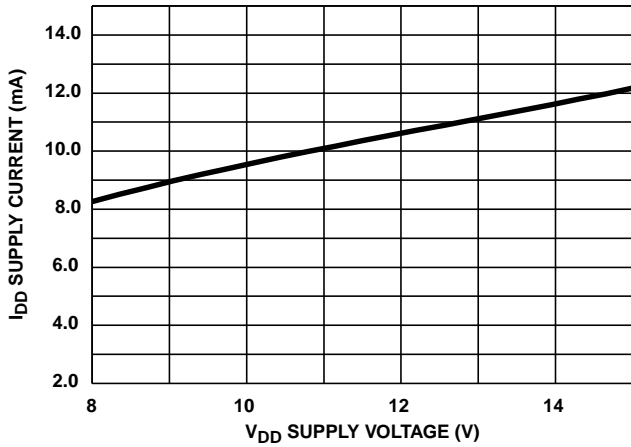


FIGURE 4. QUIESCENT  $I_{DD}$  SUPPLY CURRENT vs  $V_{DD}$  SUPPLY VOLTAGE

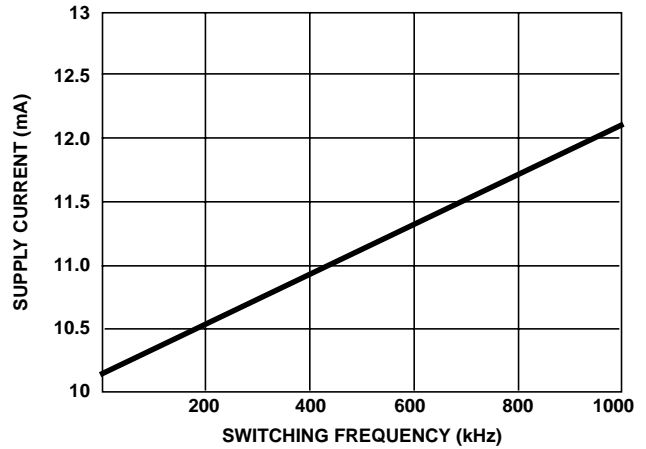


FIGURE 5.  $I_{DD0}$ , NO-LOAD  $I_{DD}$  SUPPLY CURRENT vs FREQUENCY (kHz)

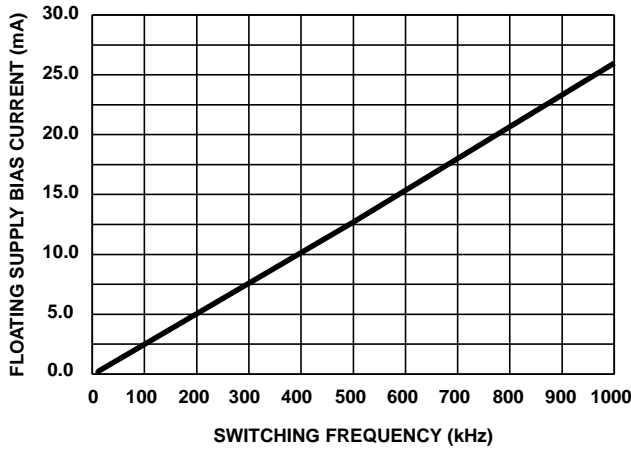


FIGURE 6. SIDE A, B FLOATING SUPPLY BIAS CURRENT vs FREQUENCY (LOAD = 1000pF)

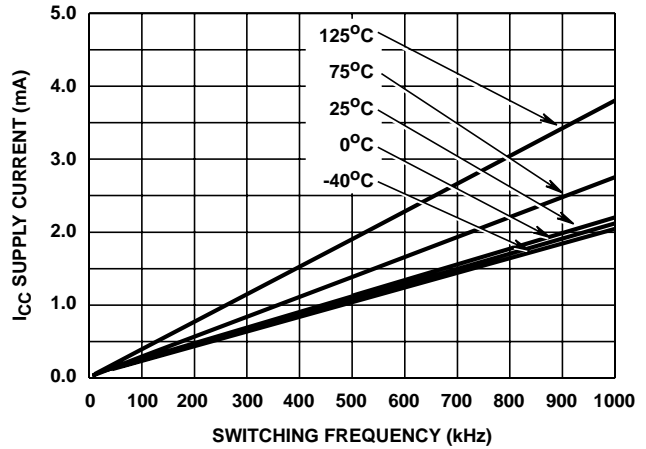


FIGURE 7.  $I_{CC0}$ , NO-LOAD  $I_{CC}$  SUPPLY CURRENT vs FREQUENCY (kHz) TEMPERATURE

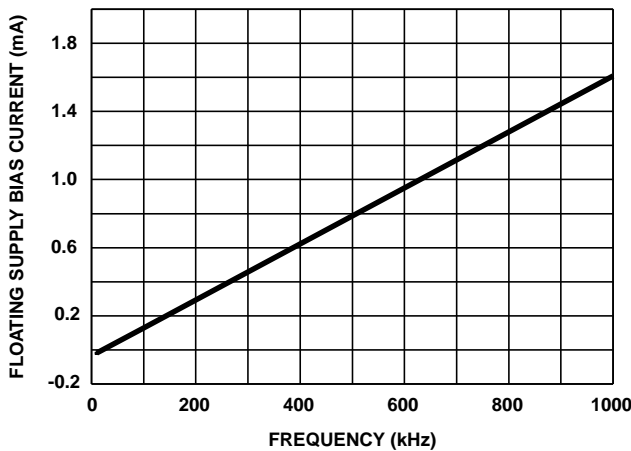


FIGURE 8.  $I_{AHB}$ ,  $I_{BHB}$ , NO-LOAD FLOATING SUPPLY BIAS CURRENT vs FREQUENCY

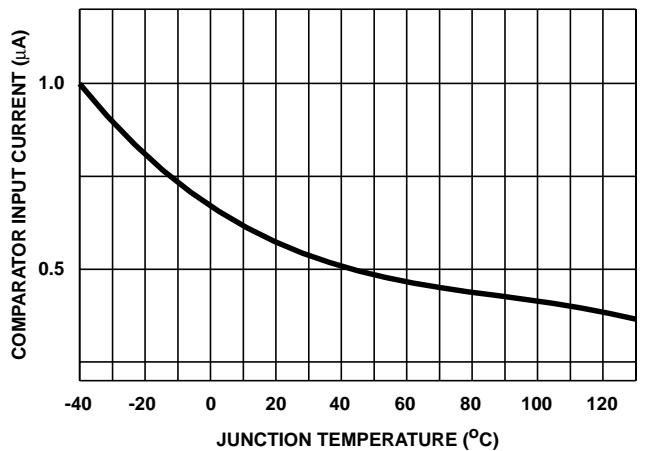


FIGURE 9. COMPARATOR INPUT CURRENT  $I_L$  vs TEMPERATURE AT  $V_{CM} = 5V$



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**Typical Performance Curves**  $V_{DD} = V_{CC} = V_{AHB} = V_{BHB} = 12V$ ,  $V_{SS} = V_{ALS} = V_{BLS} = V_{AHS} = V_{BHS} = 0V$ ,  
 $R_{HDEL} = R_{LDEL} = 100K$ , and  $T_A = 25^\circ C$ , Unless Otherwise Specified (Continued)

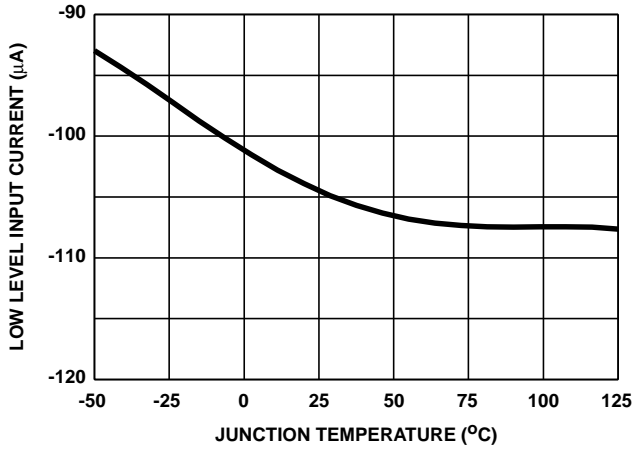


FIGURE 10. DIS LOW LEVEL INPUT CURRENT  $I_{IL}$  vs TEMPERATURE

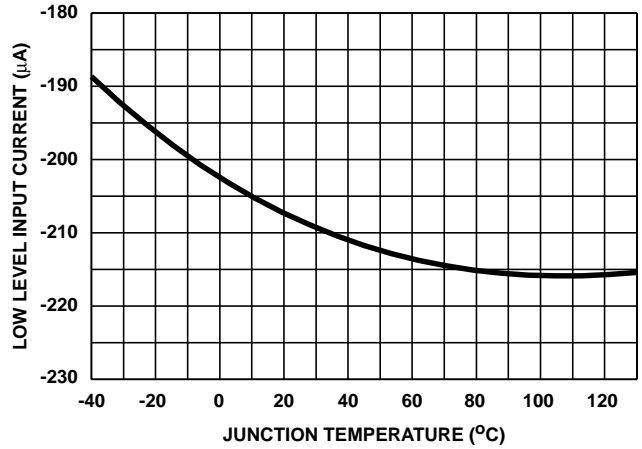


FIGURE 11. HEN LOW LEVEL INPUT CURRENT  $I_{IL}$  vs TEMPERATURE

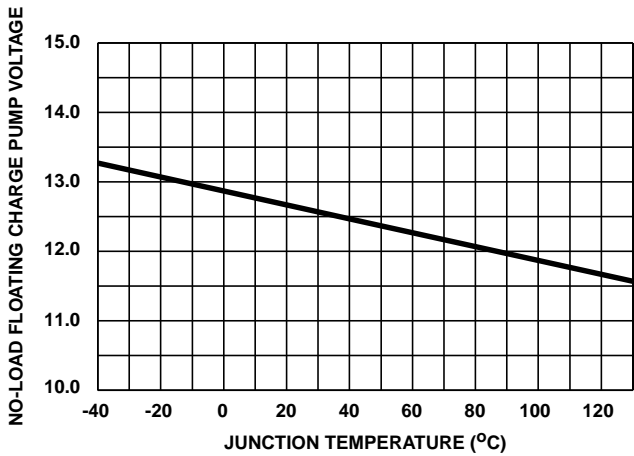


FIGURE 12. AHB - AHS, BHB - BHS NO-LOAD CHARGE PUMP VOLTAGE vs TEMPERATURE



FIGURE 13. UPPER DISABLE TURN-OFF PROPAGATION DELAY  $T_{DISHIGH}$  vs TEMPERATURE

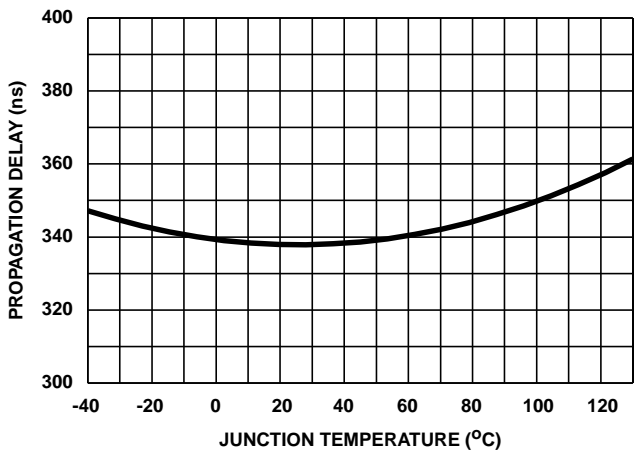


FIGURE 14. DISABLE TO UPPER ENABLE  $T_{UEN}$  PROPAGATION DELAY vs TEMPERATURE

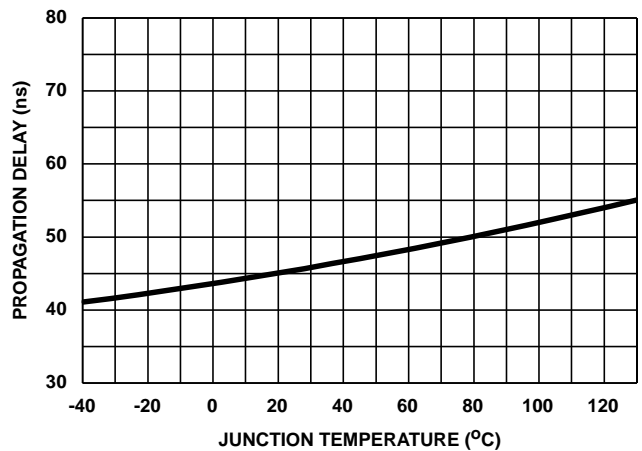


FIGURE 15. LOWER DISABLE TURN-OFF PROPAGATION DELAY  $T_{DISLOW}$  vs TEMPERATURE

**Typical Performance Curves**  $V_{DD} = V_{CC} = V_{AHB} = V_{BHB} = 12V$ ,  $V_{SS} = V_{ALS} = V_{BLS} = V_{AHS} = V_{BHS} = 0V$ ,  
 $R_{HDEL} = R_{LDEL} = 100K$ , and  $T_A = 25^\circ C$ , Unless Otherwise Specified (Continued)

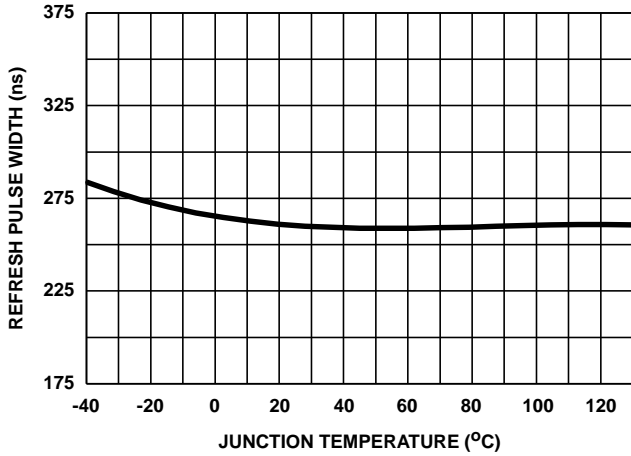


FIGURE 16.  $T_{REF-PW}$  REFRESH PULSE WIDTH vs TEMPERATURE

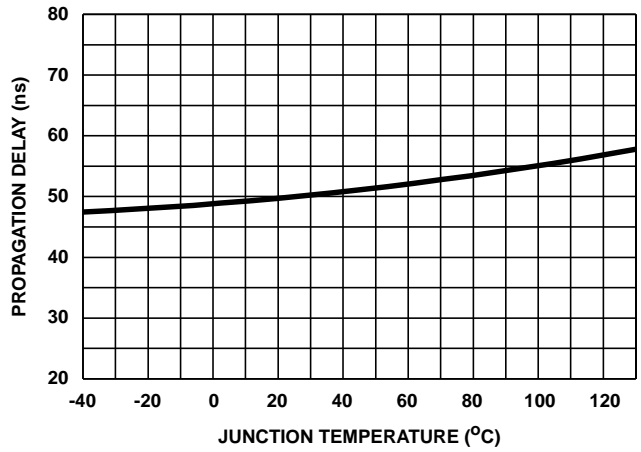


FIGURE 17. DISABLE TO LOWER ENABLE  $T_{DLPLH}$  PROPAGATION DELAY vs TEMPERATURE

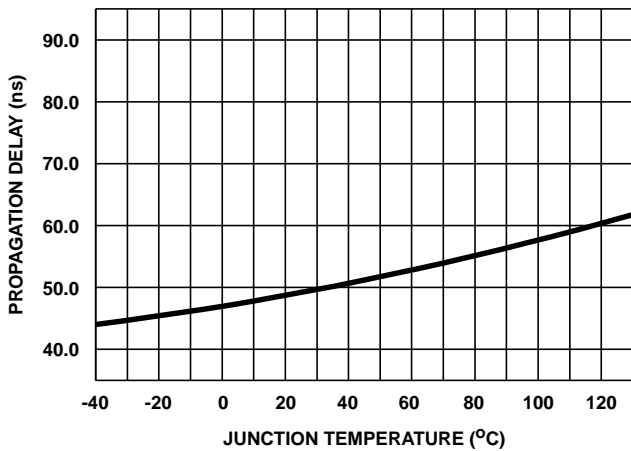


FIGURE 18. UPPER TURN-OFF PROPAGATION DELAY  $T_{HPHL}$  vs TEMPERATURE

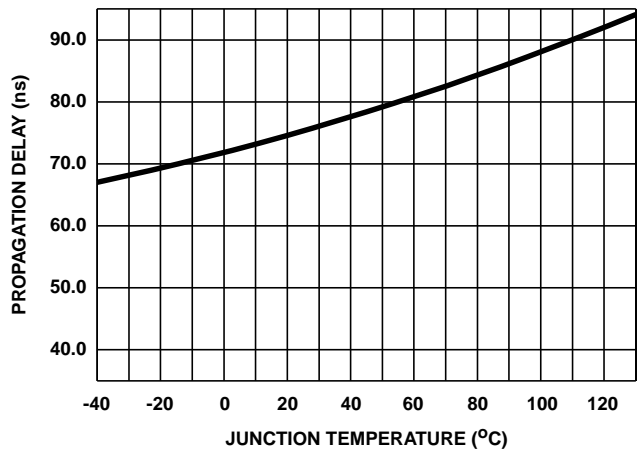


FIGURE 19. UPPER TURN-ON PROPAGATION DELAY  $T_{HPLH}$  vs TEMPERATURE

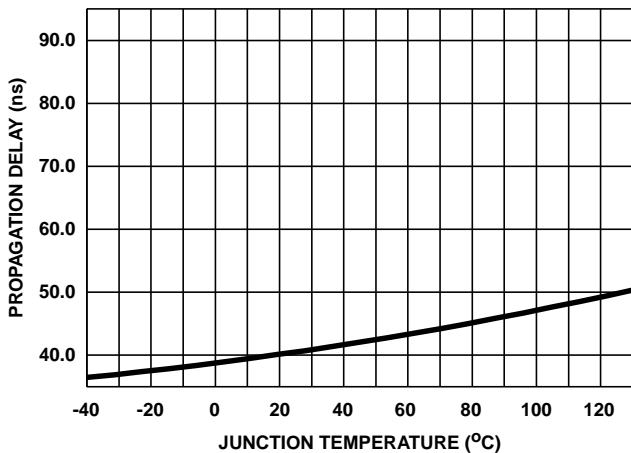


FIGURE 20. LOWER TURN-OFF PROPAGATION DELAY  $T_{LPHL}$  vs TEMPERATURE

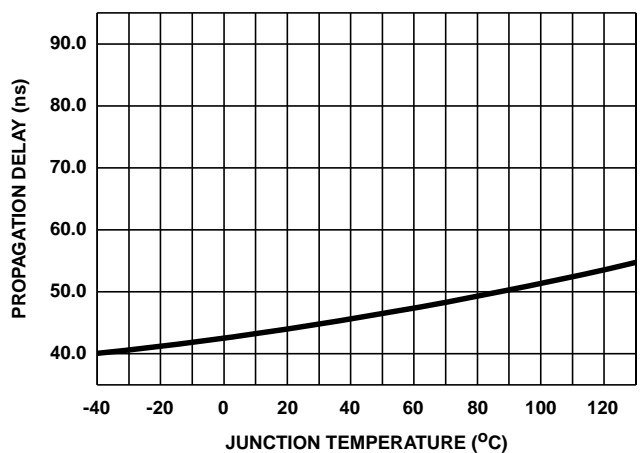


FIGURE 21. LOWER TURN-ON PROPAGATION DELAY  $T_{LPLH}$  vs TEMPERATURE

**Typical Performance Curves**  $V_{DD} = V_{CC} = V_{AHB} = V_{BHB} = 12V$ ,  $V_{SS} = V_{ALS} = V_{BLS} = V_{AHS} = V_{BHS} = 0V$ ,  
 $R_{HDEL} = R_{LDEL} = 100K$ , and  $T_A = 25^\circ C$ , Unless Otherwise Specified (Continued)

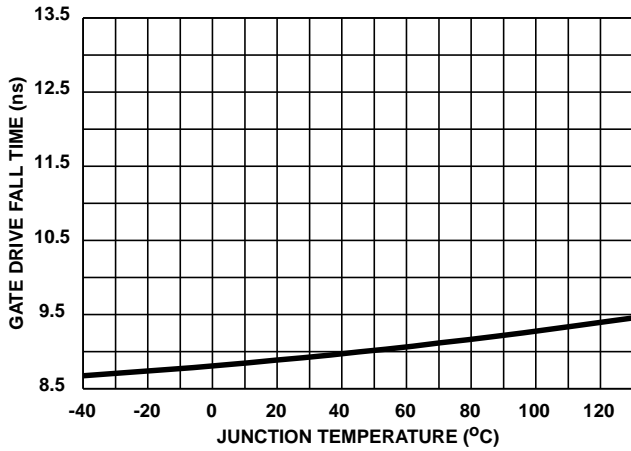


FIGURE 22. GATE DRIVE FALL TIME  $T_F$  vs TEMPERATURE

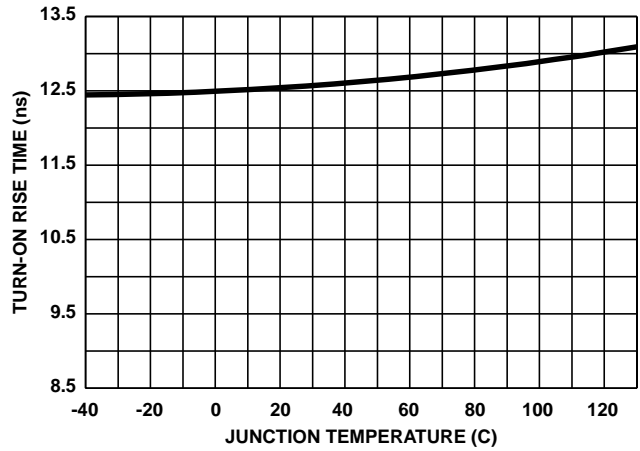


FIGURE 23. GATE DRIVE RISE TIME  $T_R$  vs TEMPERATURE

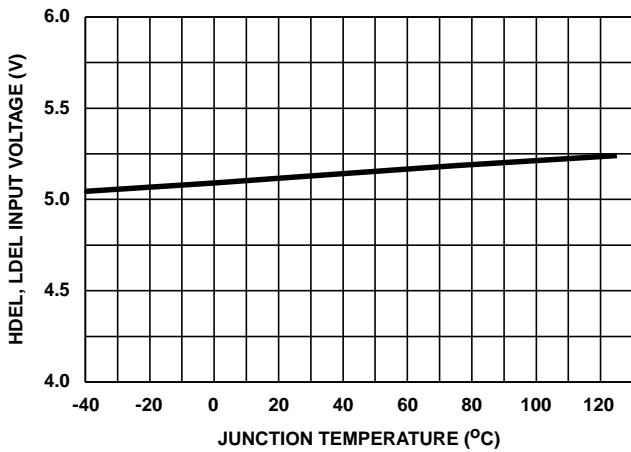


FIGURE 24.  $V_{LDEL}$ ,  $V_{HDEL}$  VOLTAGE vs TEMPERATURE

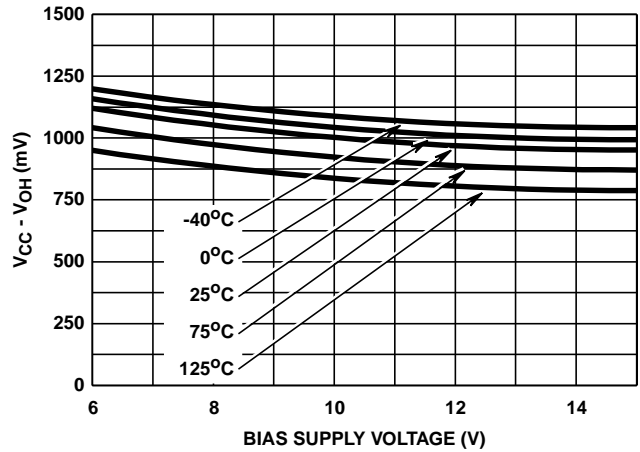


FIGURE 25. HIGH LEVEL OUTPUT VOLTAGE,  $V_{CC} - V_{OH}$  vs BIAS SUPPLY AND TEMPERATURE AT 100mA

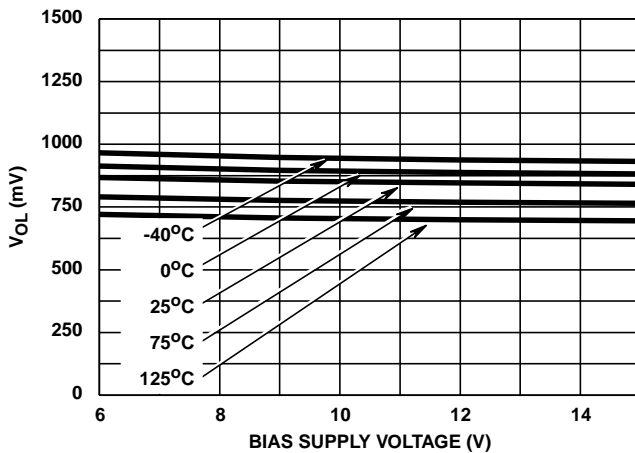


FIGURE 26. LOW LEVEL OUTPUT VOLTAGE  $V_{OL}$  vs BIAS SUPPLY AND TEMPERATURE AT 100mA

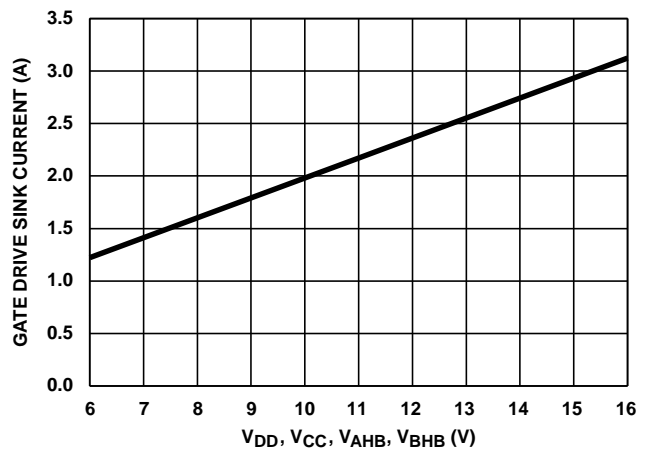


FIGURE 27. PEAK PULLDOWN CURRENT  $I_O$  vs BIAS SUPPLY VOLTAGE

**Typical Performance Curves**  $V_{DD} = V_{CC} = V_{AHB} = V_{BHB} = 12V$ ,  $V_{SS} = V_{ALS} = V_{BLS} = V_{AHS} = V_{BHS} = 0V$ ,  
 $R_{HDEL} = R_{LDEL} = 100K$ , and  $T_A = 25^{\circ}C$ , Unless Otherwise Specified (Continued)

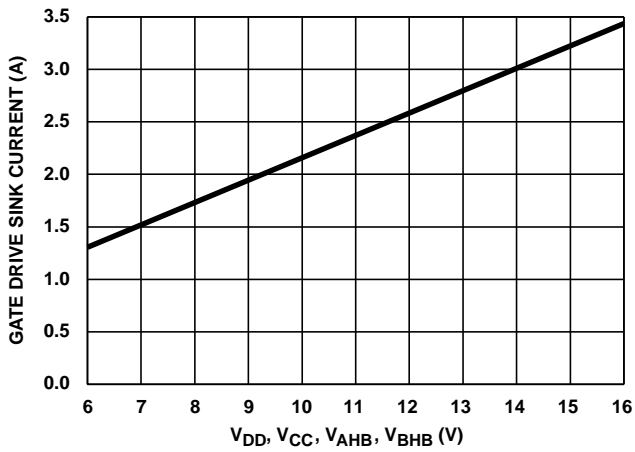


FIGURE 28. PEAK PULLUP CURRENT  $I_{O+}$  vs SUPPLY VOLTAGE

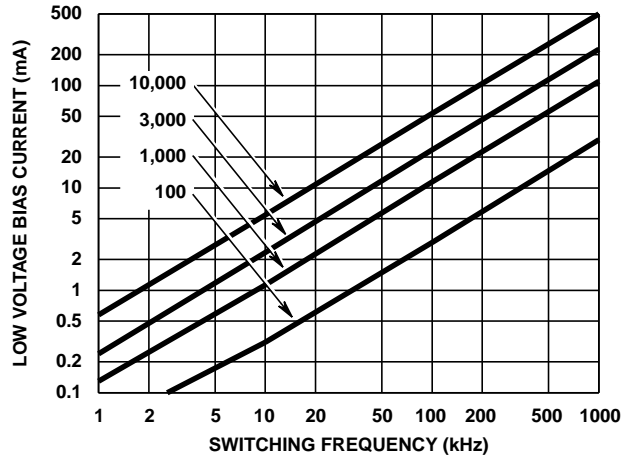


FIGURE 29. LOW VOLTAGE BIAS CURRENT  $I_{DD}$  AND  $I_{CC}$  (LESS QUIESCENT COMPONENT) vs FREQUENCY AND GATE LOAD CAPACITANCE

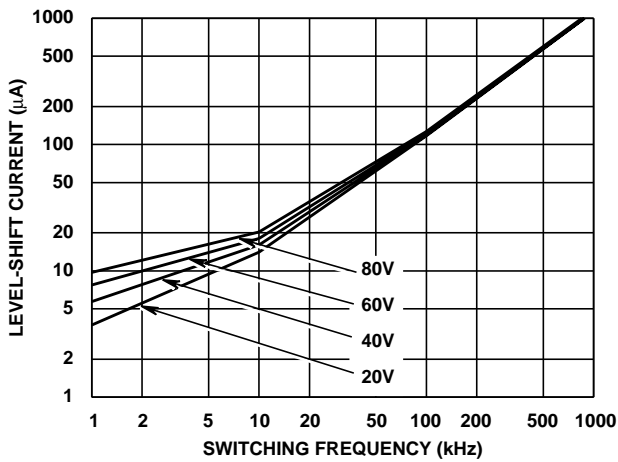


FIGURE 30. HIGH VOLTAGE LEVEL-SHIFT CURRENT vs FREQUENCY AND BUS VOLTAGE

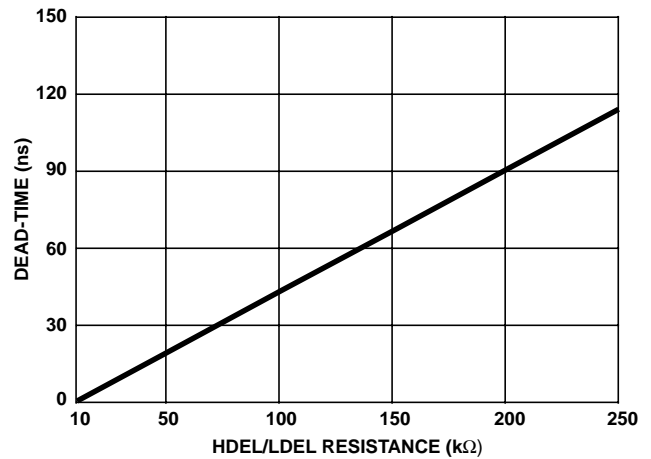


FIGURE 31. MINIMUM DEAD-TIME vs DEL RESISTANCE

**HIP4080 Power-up Application Information**

The HIP4080 H-Bridge Driver IC requires external circuitry to assure reliable start-up conditions of the upper drivers. If not addressed in the application, the H-Bridge power MOSFETs may be exposed to shoot-through current, possibly leading to MOSFET failure. Following the instructions below will result in reliable start-up.

The HIP4080 does not have an input protocol like the HIP4081 that keeps both lower power MOSFETs off other than through the DIS pin. IN+ and IN- are inputs to a comparator that control the bridge in such a way that only one of the lower power devices is on at a time, assuming DIS is low. However, keeping both lower MOSFETs off can be accom-

plished by controlling the lower turn-on delay pin, LDEL, while the chip is enabled, as shown in Figure 32. Pulling LDEL to V<sub>DD</sub> will indefinitely delay the lower turn-on delays through the input comparator and will keep the lower MOSFETs off. With the lower MOSFETs off and the chip enabled, i.e. DIS = low, IN+ or IN- can be switched through a full cycle, properly setting the upper driver outputs. Once this is accomplished, LDEL is released to its normal operating point. It is critical that IN+/IN- switch a full cycle while LDEL is held high, to avoid shoot-through. This start-up procedure can be initiated by the supply voltage and/or the chip enable command by the circuit in Figure 32.

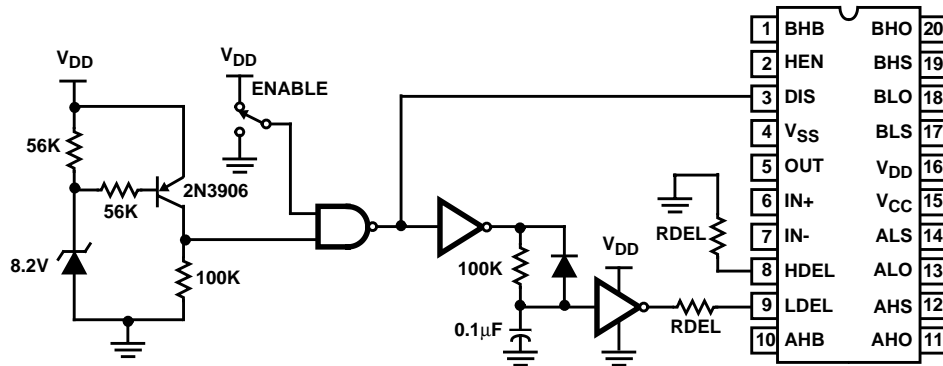
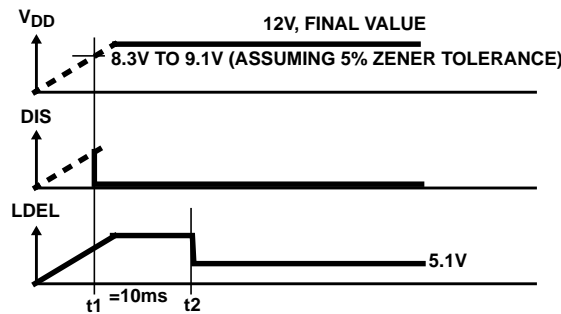


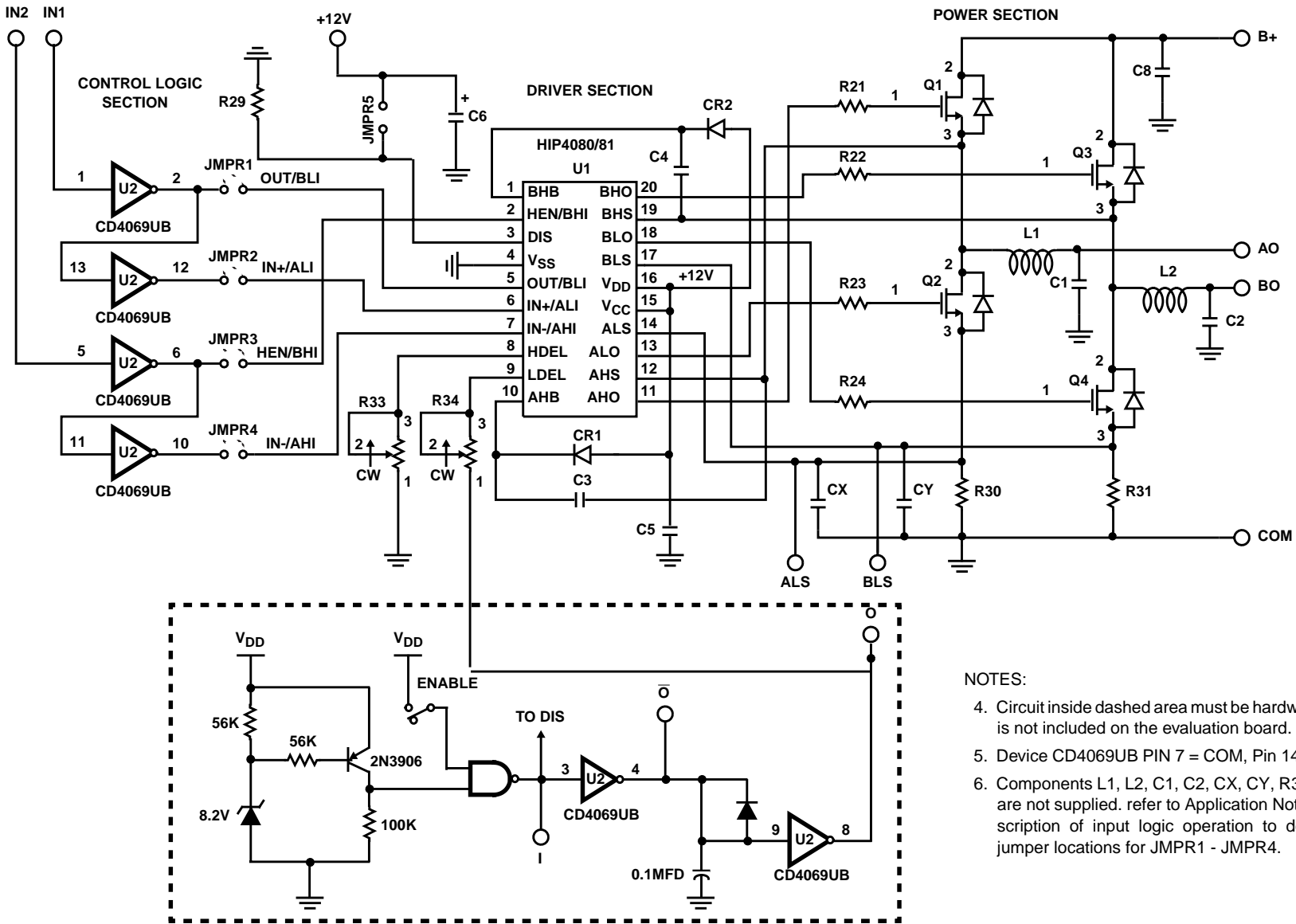
FIGURE 32.



NOTES:

2. Between t1 and t2 the IN+ and IN- inputs must cause the OUT pin to go through one complete cycle (transition order is not important). If the ENABLE pin is low after the under-voltage circuit is satisfied, the ENABLE pin will initiate the 10ms time delay during which the IN+ and IN- pins must cycle at least once.
3. Another product, HIP4080A, incorporates undervoltage circuitry which eliminates the need for the above power up circuitry.

FIGURE 33. TIMING DIAGRAM FOR FIGURE 32



- NOTES:
4. Circuit inside dashed area must be hardwired and is not included on the evaluation board.
  5. Device CD4069UB PIN 7 = COM, Pin 14 = +12V.
  6. Components L1, L2, C1, C2, CX, CY, R30, R31, are not supplied. refer to Application Note for description of input logic operation to determine jumper locations for Jmpr1 - Jmpr4.

FIGURE 34. HIP4080 EVALUATION PC BOARD SCHEMATIC

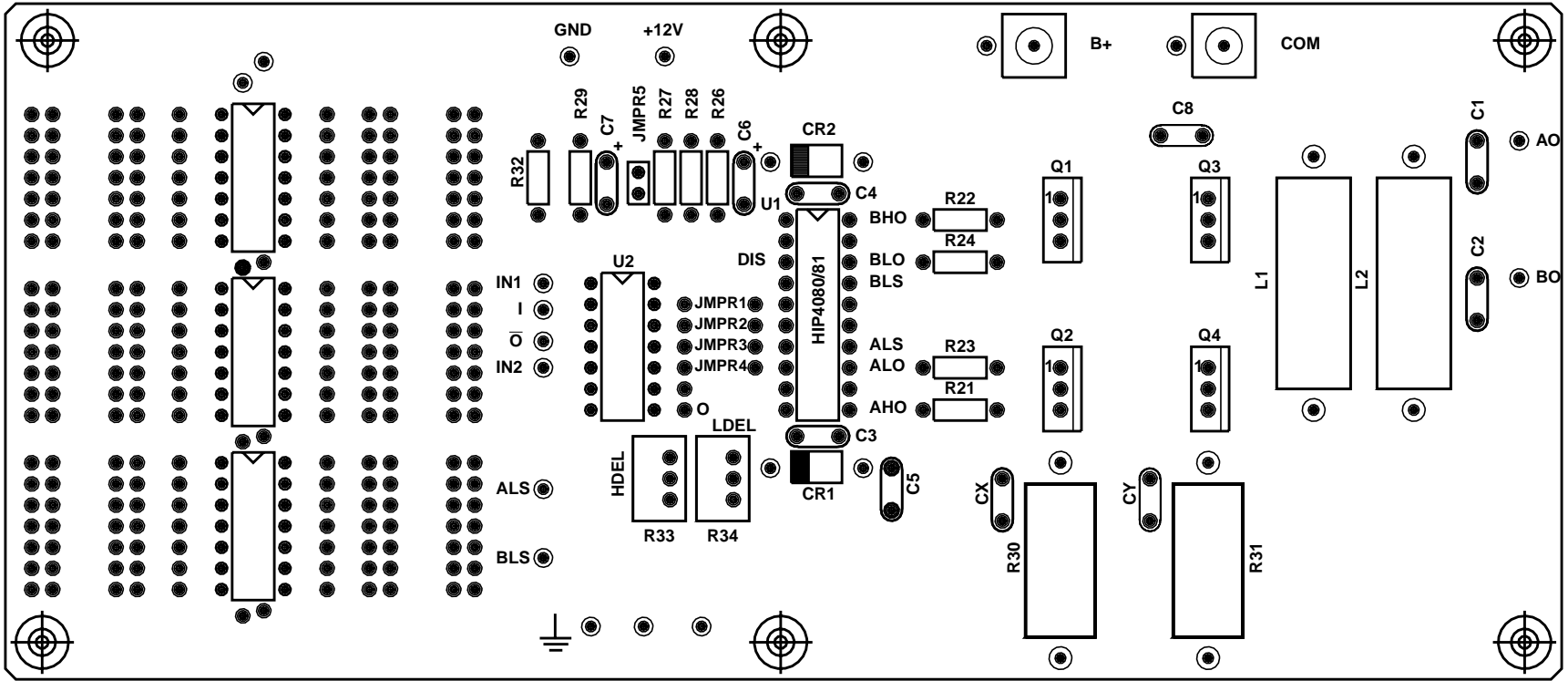


FIGURE 35. HIP4080 EVALUATION BOARD SILKSCREEN

**Supplemental Information for HIP4080 and HIP4081 Power-Up Application**

The HIP4080 and HIP4081 H-Bridge Driver ICs require external circuitry to assure reliable start-up conditions of the upper drivers. If not addressed in the application, the H-bridge power MOSFETs may be exposed to shoot-through current, possibly leading to MOSFET failure. Following the instructions below will result in reliable start-up.

**HIP4081**

The HIP4081 has four inputs, one for each output. Outputs ALO and BLO are directly controlled by input ALI and BLI. By holding ALI and BLI low during start-up no shoot-through conditions can occur. To set the latches to the upper drivers such that the driver outputs, AHO and BHO, are off, the DIS pin must be toggled from low to high after power is applied. This is accomplished with a simple resistor divider, as shown below in Figure 36. As the  $V_{DD}/V_{CC}$  supply ramps from zero up, the DIS voltage is below its input threshold of 1.7V due to the R1/R2 resistor divider. When  $V_{DD}/V_{CC}$  exceeds approximately 9V to 10V, DIS becomes greater than the input threshold and the chip disables all outputs. It is critical that ALI and BLI be held low prior to DIS reaching its threshold

level of 1.7V while  $V_{DD}/V_{CC}$  is ramping up, so that shoot through is avoided. After power is up the chip can be enabled by the ENABLE signal which pulls the DIS pin low.

**HIP4080**

The HIP4080 does not have an input protocol like the HIP4081 that keeps both lower power MOSFETs off other than through the DIS pin. IN+ and IN- are inputs to a comparator that control the bridge in such a way that only one of the lower power devices is on at a time, assuming DIS is low. However, keeping both lower MOSFETs off can be accomplished by controlling the lower turn-on delay pin, LDEL, while the chip is enabled, as shown in Figure 37. Pulling LDEL to  $V_{DD}$  will indefinitely delay the lower turn-on delays through the input comparator and will keep the lower MOSFETs off. With the lower MOSFETs off and the chip enabled, i.e., DIS = low, IN+ or IN- can be switched through a full cycle, properly setting the upper driver outputs. Once this is accomplished, LDEL is released to its normal operating point. It is critical that IN+/IN- switch a full cycle while LDEL is held high, to avoid shoot-through. This start-up procedure can be initiated by the supply voltage and/or the chip enable command by the circuit in Figure 37.

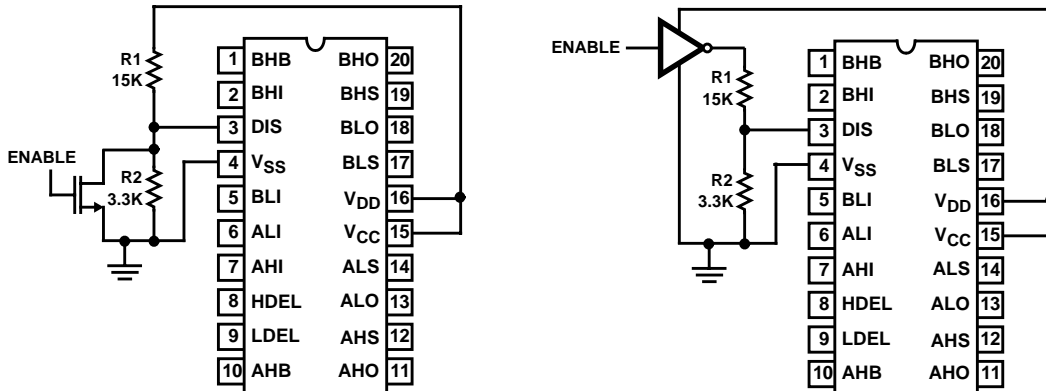


FIGURE 36.

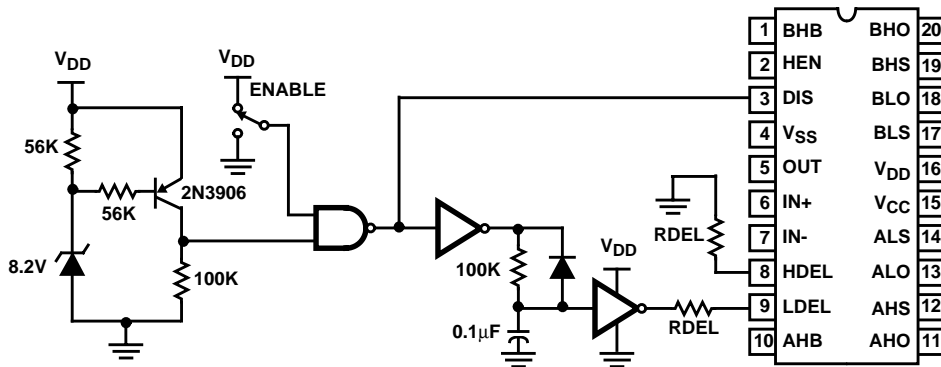
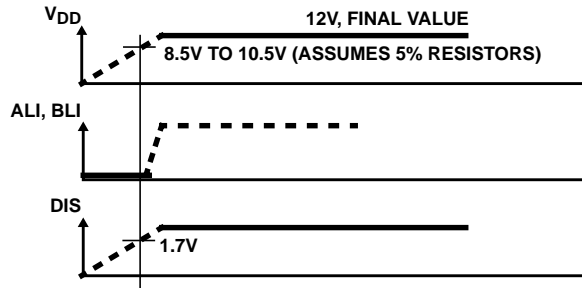


FIGURE 37.



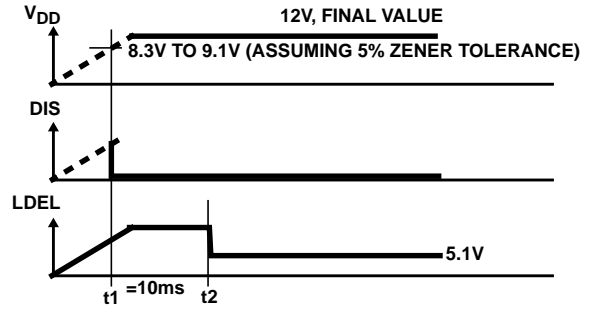
Timing Diagrams



NOTE:

7. ALI and/or BLI may be high after  $t_1$ , whereupon the ENABLE pin may also be brought high.

FIGURE 38.

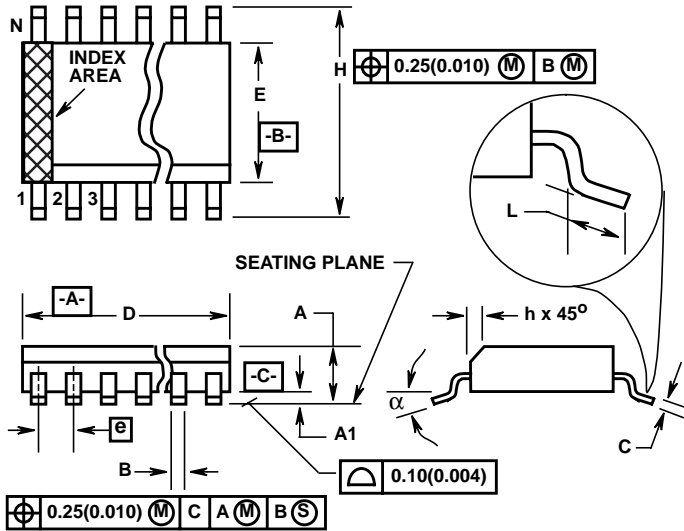


NOTE:

8. Between  $t_1$  and  $t_2$  the  $IN+$  and  $IN-$  inputs must cause the  $OUT$  pin to go through one complete cycle (transition order is not important). If the ENABLE pin is low after the undervoltage circuit is satisfied, the ENABLE pin will initiate the 10ms time delay during which the  $IN+$  and  $IN-$  pins must cycle at least once.

FIGURE 39.

**Small Outline Plastic Packages (SOIC)**



**M20.3 (JEDEC MS-013-AC ISSUE C)  
20 LEAD WIDE BODY SMALL OUTLINE PLASTIC PACKAGE**

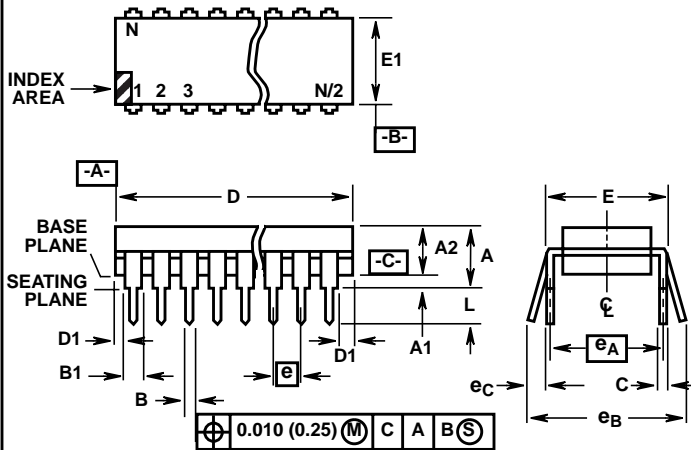
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0926	0.1043	2.35	2.65	-
A1	0.0040	0.0118	0.10	0.30	-
B	0.013	0.0200	0.33	0.51	9
C	0.0091	0.0125	0.23	0.32	-
D	0.4961	0.5118	12.60	13.00	3
E	0.2914	0.2992	7.40	7.60	4
e	0.050 BSC		1.27 BSC		-
H	0.394	0.419	10.00	10.65	-
h	0.010	0.029	0.25	0.75	5
L	0.016	0.050	0.40	1.27	6
N	20		20		7
$\alpha$	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.

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Dual-In-Line Plastic Packages (PDIP)



NOTES:

- Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
- Dimensioning and tolerancing per ANSI Y14.5M-1982.
- Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication No. 95.
- Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
- D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
- E and  $e_A$  are measured with the leads constrained to be perpendicular to datum  $-C-$ .
- $e_B$  and  $e_C$  are measured at the lead tips with the leads unconstrained.  $e_C$  must be zero or greater.
- B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
- N is the maximum number of terminal positions.
- 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).

E20.3 (JEDEC MS-001-AD ISSUE D)  
20 LEAD 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	1.55	1.77	8
C	0.008	0.014	0.204	0.355	-
D	0.980	1.060	24.89	26.9	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	20		20		9

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