

## LOW-POWER CAN TRANSCEIVER WITH BUS WAKE-UP

Check for Samples: [SN65HVD1040-HT](#)

### FEATURES

- Improved Drop-in Replacement for the TJA1040
- $\pm 12$  kV ESD Protection
- Low-Current Standby Mode with Bus Wake-up: 5  $\mu$ A Typical
- Bus-Fault Protection of  $-27$  V to 40 V
- Rugged Split-Pin Bus Stability
- Dominant Time-Out Function
- Thermal Shutdown Removed
- Power-Up/Down Glitch-Free Bus Inputs and Outputs
  - High Input Impedance with Low  $V_{CC}$
  - Monotonic Outputs During Power Cycling
- DeviceNet Vendor ID # 806

### APPLICATIONS

- Down-Hole Drilling
- High Temperature Environments
- Vibration/Modal Analysis
- Multi-Channel Data Acquisition
- Acoustics/Dynamic Strain Gauges
- Pressure Sensors

### SUPPORTS EXTREME TEMPERATURE APPLICATIONS

- Controlled Baseline
- One Assembly/Test Site
- One Fabrication Site
- Available in Extreme ( $-55^{\circ}\text{C}/210^{\circ}\text{C}$ ) Temperature Range <sup>(1)</sup>
- Extended Product Life Cycle
- Extended Product-Change Notification
- Product Traceability
- Texas Instruments high temperature products utilize highly optimized silicon (die) solutions with design and process enhancements to maximize performance over extended temperatures. All devices are characterized and qualified for 1000 hours continuous operating life at maximum rated temperature.

(1) Custom temperature ranges available

### DESCRIPTION

The SN65HVD1040 meets or exceeds the specifications of the ISO 11898 standard for use in applications employing a Controller Area Network (CAN). As CAN transceivers, these devices provide differential transmit and receive capability for a CAN controller at signaling rates of up to 1 megabit per second (Mbps). <sup>(2)</sup>

Designed for operation in especially harsh environments, the device features  $\pm 12$  kV ESD protection on the bus and split pins, cross-wire, overvoltage and loss of ground protection from  $-27$  to 40 V, a  $-12$  V to 12 V common-mode range, and will withstand voltage transients from  $-200$  V to 200 V according to ISO 7637.

The STB input (pin 8) selects between two different modes of operation; high-speed or low-power mode. The high-speed mode of operation is selected by connecting STB to ground.

If a high logic level is applied to the STB pin of the SN65HVD1040, the device enters a low-power bus-monitor standby mode. While the SN65HVD1040 is in the low-power bus-monitor standby mode, a dominant bit greater than 5  $\mu$ s on the bus is passed by the bus-monitor circuit to the receiver output. The local protocol controller may then reactivate the device when it needs to transmit to the bus.

A dominant-time-out circuit in the SN65HVD1040 prevents the driver from blocking network communication during a hardware or software failure. The time-out circuit is triggered by a falling edge on TXD (pin 1). If no rising edge is seen before the time-out constant of the circuit expires, the driver is disabled. The circuit is then reset by the next rising edge on TXD.

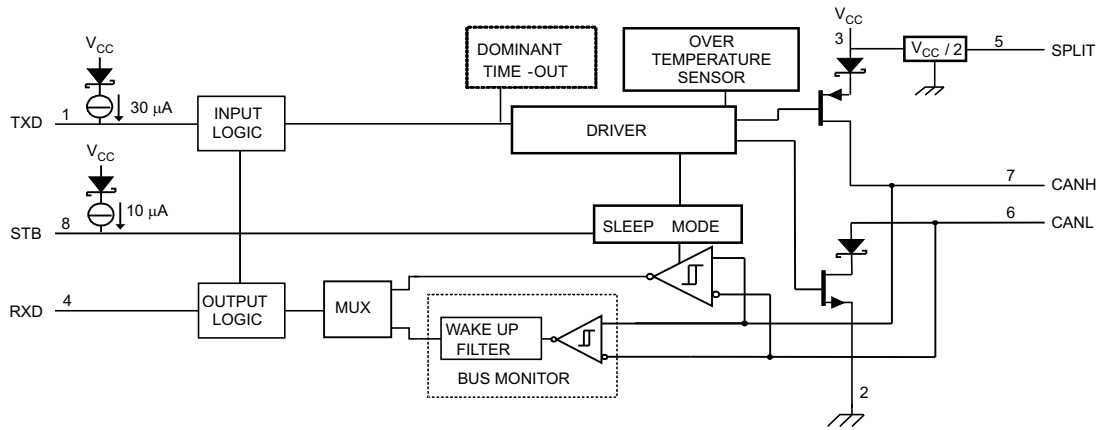
(2) The signaling rate of a line is the number of voltage transitions that are made per second expressed in the units bps (bits per second).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

The SPLIT output (pin 5) is available on the SN65HVD1040 as a  $V_{CC}/2$  common-mode bus voltage bias for a split-termination network.

The SN65HVD1040 is characterized for operation from  $-55^{\circ}\text{C}$  to  $210^{\circ}\text{C}$ .





This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

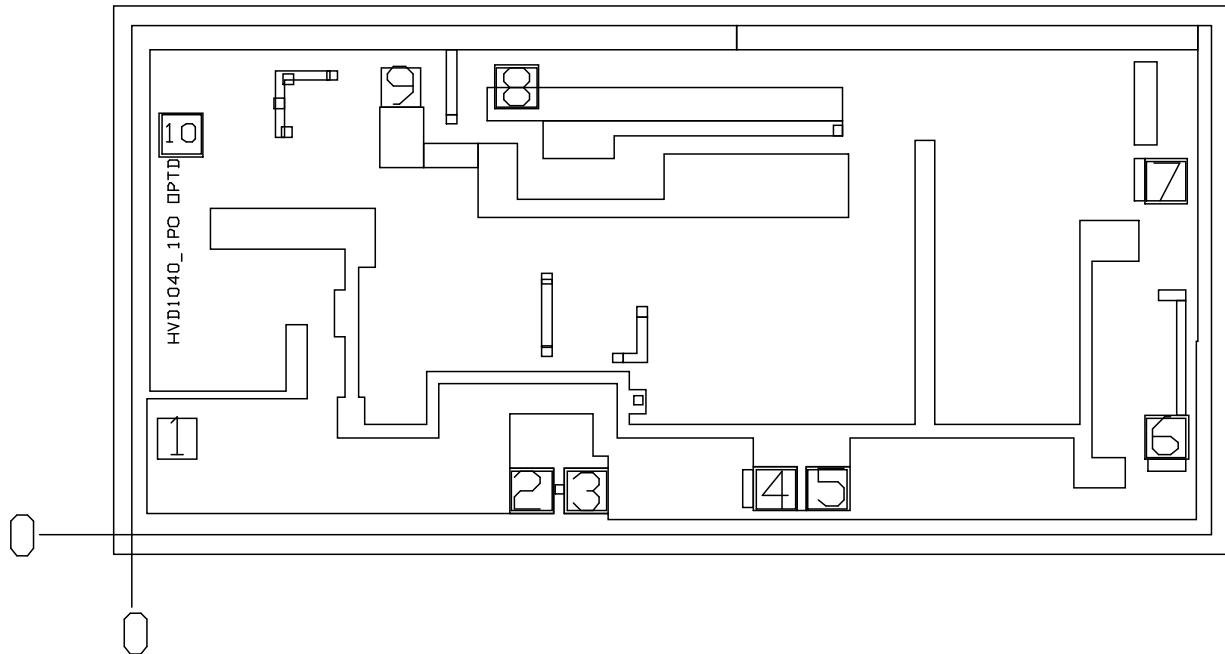
**Table 1. ORDERING INFORMATION<sup>(1)</sup>**

T <sub>J</sub>	PACKAGE	ORDERABLE PART NUMBER	TOP-SIDE MARKING
-55°C to 210°C	KGD (bare die)	SN65HVD1040SKGD3	NA
	HKQ	SN65HVD1040SHKQ	HVD1040SHKQ
-55°C to 175°C	D	SN65HVD1040HD	H1040

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI Web site at [www.ti.com](http://www.ti.com).

**BARE DIE INFORMATION**

DIE THICKNESS	BACKSIDE FINISH	BACKSIDE POTENTIAL	BOND PAD METALLIZATION COMPOSITION	BOND PAD THICKNESS
15 mils.	Silicon with backgrind	Floating	CuNiPd	15 microns



**Table 2. BOND PAD COORDINATES (μm)**

DESCRIPTION	PAD NUMBER	X MIN	Y MIN	X MAX	Y MAX	PAD SIZE X	PAD SIZE Y
TXD	1	53.64	162	137.7	246.06	84.06	84.06
GND	2	804.06	50.85	888.12	134.91	84.06	84.06
GND	3	920.07	50.85	1004.13	134.91	84.06	84.06
Vcc	4	1320.21	54.18	1404.27	138.24	84.06	84.06
Vcc	5	1431.09	54.18	1515.15	138.24	84.06	84.06
RXD	6	2148.75	164.34	2232.81	248.4	84.06	84.06
SPLIT	7	2147.4	707.49	2231.46	791.55	84.06	84.06
CANL	8	771.93	907.38	855.99	991.44	84.06	84.06
CANH	9	527.31	907.38	611.37	991.44	84.06	84.06
STB	10	62.28	806.13	146.34	890.19	84.06	84.06

**ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>**

		VALUE	
$V_{CC}$	Supply voltage <sup>(2)</sup>	–0.3 V to 7 V	
$V_{I(bus)}$	Voltage range at any bus terminal (CANH, CANL, SPLIT)	–27 V to 40 V	
$I_{O(OUT)}$	Receiver output current	–20 mA to 20 mA	
Voltage input, transient pulse <sup>(3)</sup> , (CANH, CANL, SPLIT)		–200 V to 200 V	
ESD	IEC Contact Discharge (IEC 61000-4-2)	Bus terminals vs GND ±6 kV	
	Human body model	JEDEC Standard 22, Test Method A114-C.01	Bus terminals vs GND ±12 kV All pins ±4 kV
	Field-Induced-Charged Device Model	JEDEC Standard 22, Test Method C101	All pins ±1 kV
	Machine model	ANSI/ESDS5.2-1996	±200 V
IEC		Bus terminals vs GND ±6 kV	
$V_I$	Voltage input range (TXD, STB)	–0.5 V to 6 V	
$T_J$	Junction temperature	–55°C to 210°C	

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) All voltage values, except differential I/O bus voltages, are with respect to network ground terminal.
- (3) Tested in accordance with ISO 7637, test pulses 1, 2, 3a, 3b, 5, 6 & 7.

**THERMAL CHARACTERISTICS FOR HKQ PACKAGE**

over operating free-air temperature range (unless otherwise noted)

PARAMETER		MIN	TYP	MAX	UNIT
$\theta_{JC}$	Junction-to-case thermal resistance	to ceramic side of case		5.7	°C/W
		to top of case lid (metal side of case)		13.7	

**THERMAL INFORMATION FOR D PACKAGE**

THERMAL METRIC <sup>(1)</sup>		SN65HVD1040	UNITS
		D	
		8 PINS	
$\theta_{JA}$	Junction-to-ambient thermal resistance <sup>(2)</sup>	91.9	°C/W
$\theta_{JCTop}$	Junction-to-case (top) thermal resistance <sup>(3)</sup>	39.9	
$\theta_{JB}$	Junction-to-board thermal resistance <sup>(4)</sup>	40.6	
$\psi_{JT}$	Junction-to-top characterization parameter <sup>(5)</sup>	3.9	
$\psi_{JB}$	Junction-to-board characterization parameter <sup>(6)</sup>	39.6	
$\theta_{JCbott}$	Junction-to-case (bottom) thermal resistance <sup>(7)</sup>	N/A	

- (1) For more information about traditional and new thermal metrics, see the *IC Package Thermal Metrics* application report, [SPRA953](#).
- (2) The junction-to-ambient thermal resistance under natural convection is obtained in a simulation on a JEDEC-standard, high-K board, as specified in JESD51-7, in an environment described in JESD51-2a.
- (3) The junction-to-case (top) thermal resistance is obtained by simulating a cold plate test on the package top. No specific JEDEC-standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.
- (4) The junction-to-board thermal resistance is obtained by simulating in an environment with a ring cold plate fixture to control the PCB temperature, as described in JESD51-8.
- (5) The junction-to-top characterization parameter,  $\psi_{JT}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $\theta_{JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).
- (6) The junction-to-board characterization parameter,  $\psi_{JB}$ , estimates the junction temperature of a device in a real system and is extracted from the simulation data for obtaining  $\theta_{JA}$ , using a procedure described in JESD51-2a (sections 6 and 7).
- (7) The junction-to-case (bottom) thermal resistance is obtained by simulating a cold plate test on the exposed (power) pad. No specific JEDEC standard test exists, but a close description can be found in the ANSI SEMI standard G30-88.

**RECOMMENDED OPERATING CONDITIONS**

		T <sub>J</sub> = -55°C to 125°C			T <sub>J</sub> = -55°C to 175°C			T <sub>J</sub> = -55°C to 210°C			UNIT
		MIN	NOM	MAX	MIN	NOM	MAX	MIN	NOM	MAX	
V <sub>CC</sub>	Supply voltage	4.75		5.25	4.75		5.25	4.75		5.25	V
V <sub>I</sub> or V <sub>IC</sub>	Voltage at any bus terminal (separately or common mode)	-12 <sup>(1)</sup>		12	-12 <sup>(1)</sup>		12	-12 <sup>(1)</sup>		12	V
V <sub>IH</sub>	High-level input voltage	2		5.25	2		5.25	2		5.25	V
V <sub>IL</sub>	Low-level input voltage	0		0.8	0		0.8	0		0.8	V
V <sub>ID</sub>	Differential input voltage	-6		6	-6		6	-6		6	V
I <sub>OH</sub>	High-level output current	Driver		-70			-70				mA
		Receiver		-2			-2				
I <sub>OL</sub>	Low-level output current	Driver		70			70			70	mA
		Receiver		2			2			2	
t <sub>SS</sub>	Maximum pulse width to remain in standby			0.7			0.7			0.7	μs
T <sub>J</sub>	Junction temperature	-55		125	-55		175	-55		210	°C

(1) The algebraic convention, in which the least positive (most negative) limit is designated as minimum is used in this data sheet.

**SUPPLY CURRENT**

over operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T <sub>J</sub> = -55°C to 125°C			T <sub>J</sub> = -55°C to 175°C			T <sub>J</sub> = -55°C to 210°C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
I <sub>CC</sub>	Dominant	V <sub>I</sub> = 0 V, 60 Ω Load, STB at 0 V		50	70		50	70		50	70	mA
	Recessive	V <sub>I</sub> = V <sub>CC</sub> , STB at 0 V		6	10		6	10		6	10	
	Standby	STB at V <sub>CC</sub> , V <sub>I</sub> = V <sub>CC</sub>		5	12		5	20		5	50	μA

**DEVICE SWITCHING CHARACTERISTICS**

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T <sub>J</sub> = -55°C to 125°C			T <sub>J</sub> = -55°C to 175°C			T <sub>J</sub> = -55°C to 210°C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t <sub>loop1</sub>	Total loop delay, driver input to receiver output, Recessive to Dominant	STB at 0 V, See <a href="#">Figure 10</a>	90		230	90		325	90		450	ns
t <sub>loop2</sub>	Total loop delay, driver input to receiver output, Dominant to Recessive		90		230	90		325	90		450	

## DRIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T <sub>J</sub> = -55°C to 125°C			T <sub>J</sub> = -55°C to 175°C			T <sub>J</sub> = -55°C to 210°C			UNIT	
			MIN	TYP <sup>(1)</sup>	MAX	MIN	TYP <sup>(1)</sup>	MAX	MIN	TYP <sup>(1)</sup>	MAX		
V <sub>O(D)</sub>	Bus output voltage (Dominant)	CAN H	V <sub>I</sub> = 0 V, STB at 0 V, R <sub>L</sub> = 60 Ω, See <a href="#">Figure 2</a> and <a href="#">Figure 3</a>	2.9	3.4	4.5	2.9	3.4	4.6	2.9	3.4	4.6	V
		CANL		0.8		1.75	0.8		1.75	0.8		1.75	
V <sub>O(R)</sub>	Bus output voltage (Recessive)	V <sub>I</sub> = 3 V, STB at 0 V, See <a href="#">Figure 2</a> and <a href="#">Figure 3</a>	2	2.5	3	2	2.5	3	2	2.5	3	V	
V <sub>O</sub>	Bus output voltage (Standby)	R <sub>L</sub> = 60 Ω, STB at V <sub>CC</sub> , See <a href="#">Figure 2</a> and <a href="#">Figure 3</a>	-0.1		0.1	-0.125		0.125	-0.15		0.15	V	
V <sub>OD(D)</sub>	Differential output voltage (Dominant)	V <sub>I</sub> = 0 V, R <sub>L</sub> = 60 Ω, STB at 0 V, See <a href="#">Figure 2</a> and <a href="#">Figure 3</a> , and <a href="#">Figure 4</a>	1.5		3	1.5		3	1.5		3	V	
		V <sub>I</sub> = 0 V, R <sub>L</sub> = 45 Ω, STB at 0 V, See <a href="#">Figure 2</a> and <a href="#">Figure 3</a>	1.4		3	1.4		3	1.4		3		
V <sub>SYM</sub>	Output symmetry (Dominant or Recessive) [ V <sub>O(CANH)</sub> + V <sub>O(CANL)</sub> ]	STB at 0 V, See <a href="#">Figure 3</a> and <a href="#">Figure 14</a>	0.9xV <sub>CC</sub>	V <sub>CC</sub>	1.1xV <sub>C</sub>	0.9xV <sub>CC</sub>	V <sub>CC</sub>	1.1xV <sub>C</sub>	0.9xV <sub>C</sub>	V <sub>CC</sub>	1.2xV <sub>CC</sub>	V	
V <sub>OD(R)</sub>	Differential output voltage (Recessive)	V <sub>I</sub> = 3 V, R <sub>L</sub> = 60 Ω, STB at 0 V, See <a href="#">Figure 2</a> and <a href="#">Figure 3</a>	-0.012		0.012	-0.014		0.017	-0.015		0.02	V	
		V <sub>I</sub> = 3 V, STB at 0 V, No Load	-0.5		0.05	-0.5		0.225	-0.75		0.8		
V <sub>OC(D)</sub>	Common-mode output voltage (Dominant)	STB at 0 V, See <a href="#">Figure 9</a>	2	2.3	3	2	2.3	3	2	2.3	3.1	V	
V <sub>OC(pp)</sub>	Peak-to-peak common-mode output voltage			0.3		0.3		0.3		0.3			
I <sub>IH</sub>	High-level input current, TXD input	V <sub>I</sub> at V <sub>CC</sub>	-2		2	-3		3	-3		3	μA	
I <sub>IL</sub>	Low-level input current, TXD input	V <sub>I</sub> at 0 V	-50		-10	-50		-10	-50		-10	μA	
I <sub>O(off)</sub>	Power-off TXD Leakage current	V <sub>CC</sub> at 0 V, TXD at 5 V			1			180			600	μA	
I <sub>OS(ss)</sub>	Short-circuit steady-state output current	V <sub>CANH</sub> = -12 V, CANL Open, See <a href="#">Figure 13</a>	-120	-72		-120	-72		-130	-72		mA	
		V <sub>CANH</sub> = 12 V, CANL Open, See <a href="#">Figure 13</a>		0.36	1		0.36	1		0.36	1.1		
		V <sub>CANL</sub> = -12 V, CANH Open, See <a href="#">Figure 13</a>	-1	-0.5		-1	-0.5		-1.1	-0.5			
		V <sub>CANL</sub> = 12 V, CANH Open, See <a href="#">Figure 13</a>		71	120		71	120		71	130		
C <sub>O</sub>	Output capacitance	See Input capacitance to ground in <a href="#">RECEIVER ELECTRICAL CHARACTERISTICS</a> .											

(1) All typical values are at 25°C with a 5-V supply.

## DRIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	$T_J = -55^\circ\text{C to } 125^\circ\text{C}$			$T_J = -55^\circ\text{C to } 175^\circ\text{C}$			$T_J = -55^\circ\text{C to } 210^\circ\text{C}$			UNIT			
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX				
$t_{PLH}$	Propagation delay time, low-to-high-level output	25	65	120	25	65	175	25	65	250	ns			
$t_{PHL}$	Propagation delay time, high-to-low-level output	25	45	120	25	45	175	25	45	250				
$t_{sk(p)}$	Pulse skew ( $t_{PHL} - t_{PLH}$ )	25			25			25						
$t_r$	Differential output signal rise time	25			25			25						
$t_f$	Differential output signal fall time	50			50			50						
$t_{en}$	Enable time from silent mode to dominant	See <a href="#">Figure 8</a>			11			14.5			18	$\mu\text{s}$		
$t_{dom}$	Dominant time-out	See <a href="#">Figure 11</a>			300	450	700	300	450	700	300	450	700	$\mu\text{s}$

## RECEIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T <sub>J</sub> = -55°C to 125°C			T <sub>J</sub> = -55°C to 175°C			T <sub>J</sub> = -55°C to 210°C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>IT+</sub>	Positive-going input threshold voltage	STB at 0 V, See <a href="#">Table 3</a>		800	900		800	900		800	900	mV
V <sub>IT-</sub>	Negative-going input threshold voltage		500	650		500	650		500	650		
V <sub>hys</sub>	Hysteresis voltage (V <sub>IT+</sub> – V <sub>IT-</sub> )		100	125		70	125		70	125		
V <sub>IT</sub>	Input threshold voltage	Standby mode	500		1150	500		1300	400		1350	
V <sub>OH</sub>	High-level output voltage	I <sub>O</sub> = -2 mA, See <a href="#">Figure 7</a>	4	4.6		4	4.6		4	4.6		V
V <sub>OL</sub>	Low-level output voltage	I <sub>O</sub> = 2 mA, See <a href="#">Figure 7</a>		0.2	0.4		0.2	0.5		0.2	0.55	V
I <sub>I(off)</sub>	Power-off bus input current	CANH or CANL = 5 V, V <sub>CC</sub> at 0 V, TXD at 0 V			5			15			30	μA
I <sub>O(off)</sub>	Power-off RXD leakage current	V <sub>CC</sub> at 0 V, RXD at 5 V			20			30			30	μA
C <sub>I</sub>	Input capacitance to ground, (CANH or CANL)	TXD at 3 V, V <sub>I</sub> = 0.4 sin(4E6πt) + 2.5 V		20			20			20		pF
C <sub>ID</sub>	Differential input capacitance	TXD at 3 V, V <sub>I</sub> = 0.4 sin(4E6πt)		10			10			10		pF
R <sub>ID</sub>	Differential input resistance	TXD at 3 V, STD at 0 V	30		80	30		80	30		80	kΩ
R <sub>IN</sub>	Input resistance, (CANH or CANL)	TXD at 3 V, STD at 0 V	15	30	40	15	30	40	15	30	40	
R <sub>I(m)</sub>	Input resistance matching [1 – (R <sub>IN(CANH)</sub> / R <sub>IN(CANL)</sub> )] x 100%	V <sub>CANH</sub> = V <sub>CANL</sub>	-3%	0%	3%	-5%	0%	5%	-12%	0%	12%	

## RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	T <sub>J</sub> = -55°C to 125°C			T <sub>J</sub> = -55°C to 175°C			T <sub>J</sub> = -55°C to 210°C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
t <sub>pLH</sub>	Propagation delay time, low-to-high-level output	STB at 0 V, TXD at 3 V, See <a href="#">Figure 7</a>	60	100	130	60	100	200	60	100	200	ns
t <sub>pHL</sub>	Propagation delay time, high-to-low-level output		45	70	130	45	70	200	45	70	200	
t <sub>r</sub>	Output signal rise time			8			8			8		
t <sub>f</sub>	Output signal fall time			8			8			8		
t <sub>BUS</sub>	Dominant time required on bus for wake-up from standby <sup>(1)</sup>	STB at V <sub>CC</sub> <a href="#">Figure 12</a>	0.7		5	1.0		5.1	1.45		5.25	μs

(1) The device under test shall not signal a wake-up condition with dominant pulses shorter than t<sub>BUS</sub> (min) and shall signal a wake-up condition with dominant pulses longer than t<sub>BUS</sub> (max). Dominant pulses with a length between t<sub>BUS</sub> (min) and t<sub>BUS</sub> (max) may lead to a wake-up.

## SPLIT-PIN CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

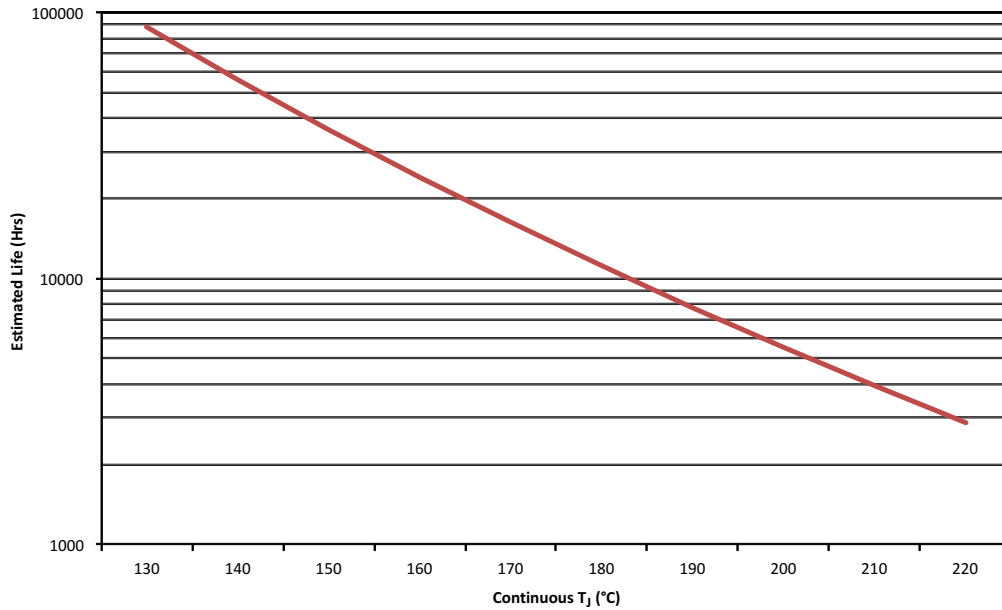
PARAMETER		TEST CONDITIONS	T <sub>J</sub> = -55°C to 125°C			T <sub>J</sub> = -55°C to 175°C			T <sub>J</sub> = -55°C to 210°C			UNIT
			MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX	
V <sub>O</sub>	Output voltage	-500 μA < I <sub>O</sub> < 500 μA	0.3xV <sub>CC</sub>	0.5xV <sub>CC</sub>	0.7xV <sub>CC</sub>	0.28xV <sub>CC</sub>	0.5xV <sub>CC</sub>	0.7xV <sub>CC</sub>	0.28xV <sub>C</sub>	0.5xV <sub>C</sub>	0.7xV <sub>CC</sub>	V
I <sub>O(st b)</sub>	Standby mode leakage current	STB at 2 V, -12 V ≤ V <sub>O</sub> ≤ 12 V	-5		5	-7		7	-15		15	μA



### STB-PIN CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER	TEST CONDITIONS	T <sub>J</sub> = -55°C to 125°C			T <sub>J</sub> = -55°C to 175°C			T <sub>J</sub> = -55°C to 210°C			UNIT	
		MIN	TYP	MAX	MIN	TYP	MAX	MIN	TYP	MAX		
I <sub>IH</sub>	High level input current	STB at 2 V	-10		0	-10		0	-10		0	μA
I <sub>IL</sub>	Low level input current	STB at 0 V	-10		0	-10		0	-10		0	μA



- A. See datasheet for absolute maximum and minimum recommended operating conditions.
- B. Silicon operating life design goal is 10 years at 105°C junction temperature (does not include package interconnect life).
- C. The predicted operating lifetime vs. junction temperature is based on reliability modeling using electromigration as the dominant failure mechanism affecting device wear out for the specific device process and design characteristics.

**Figure 1. SN65HVD1040-HT Operating Life Derating Chart**

PARAMETER MEASUREMENT INFORMATION

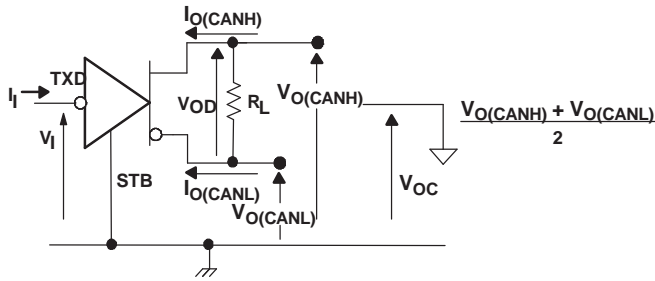


Figure 2. Driver Voltage, Current, and Test Definition

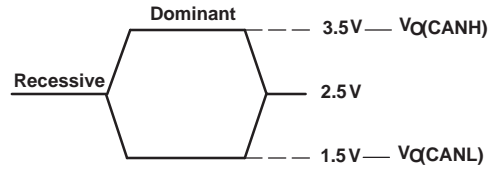


Figure 3. Bus Logic State Voltage Definitions

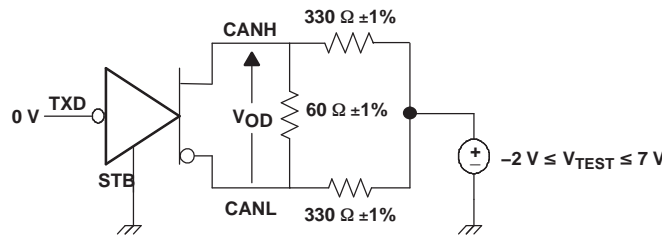


Figure 4. Driver V<sub>OD</sub> Test Circuit

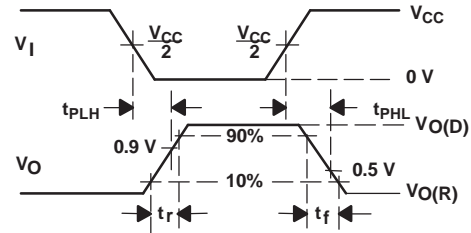
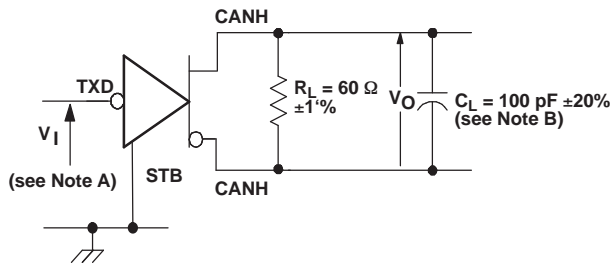


Figure 5. Driver Test Circuit and Voltage Waveforms

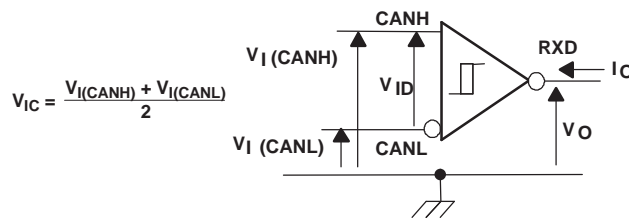
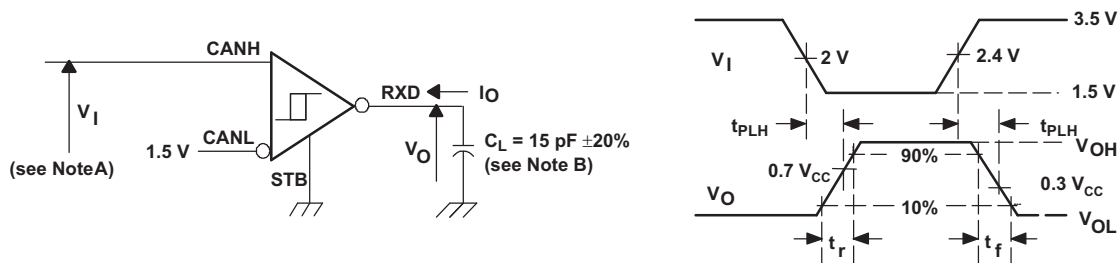


Figure 6. Receiver Voltage and Current Definitions

PARAMETER MEASUREMENT INFORMATION (continued)



- A. The input pulse is supplied by a generator having the following characteristics: PRR ≤ 125 kHz, 50% duty cycle, tr ≤ 6 ns, tf ≤ 6ns, ZO = 50 Ω.
- B. CL includes instrumentation and fixture capacitance within ±20%.

Figure 7. Receiver Test Circuit and Voltage Waveforms

Table 3. Differential Input Voltage Threshold Test

INPUT			OUTPUT	
V <sub>CANH</sub>	V <sub>CANL</sub>	V <sub>ID</sub>	R	
-11.1 V	-12 V	900 mV	L	V <sub>OL</sub>
12 V	11.1 V	900 mV	L	
-6 V	-12 V	6 V	L	
12 V	6 V	6 V	L	
-11.5 V	-12 V	500 mV	H	V <sub>OH</sub>
12 V	11.5 V	500 mV	H	
-12 V	-6 V	6 V	H	
6 V	12 V	6 V	H	
Open	Open	X	H	

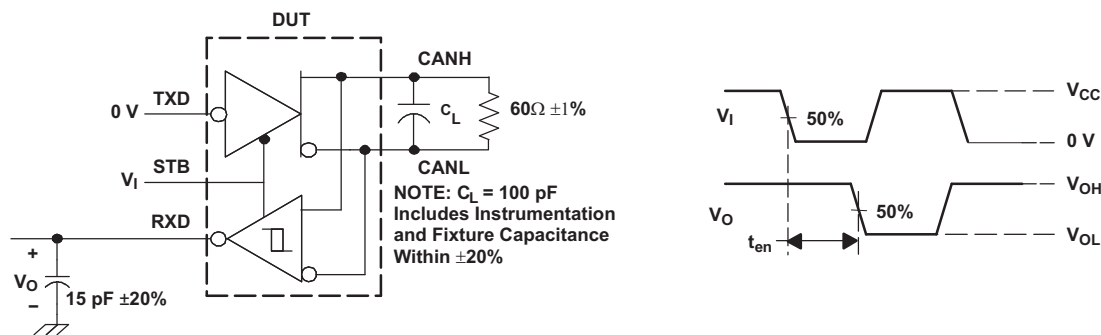
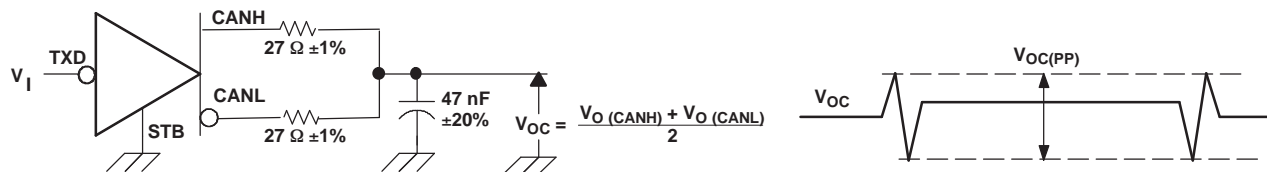
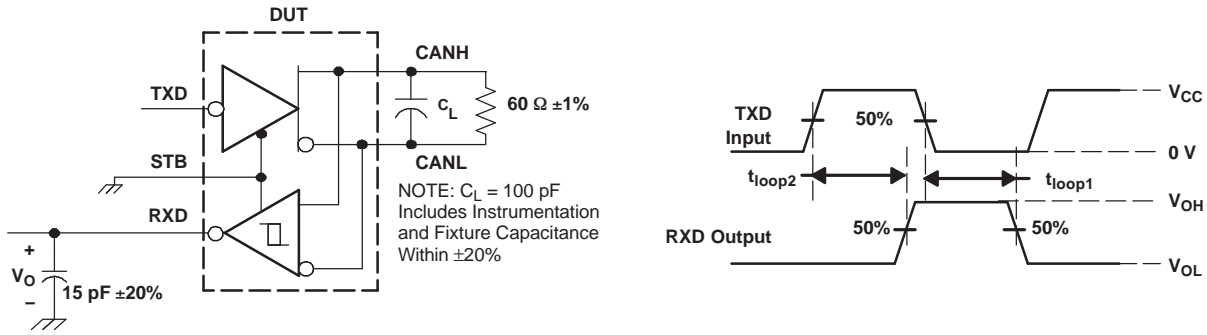


Figure 8. t<sub>en</sub> Test Circuit and Voltage Waveforms



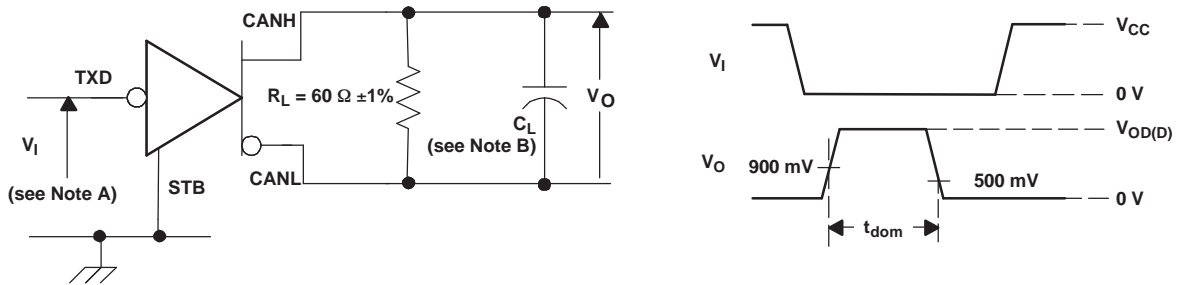
- A. All V<sub>I</sub> input pulses are from 0 V to V<sub>CC</sub> and supplied by a generator having the following characteristics: tr or tf ≤ 6 ns. Pulse Repetition Rate (PRR) = 125 kHz, 50% duty cycle.

Figure 9. Peak-to-Peak Common Mode Output Voltage Test and Waveform



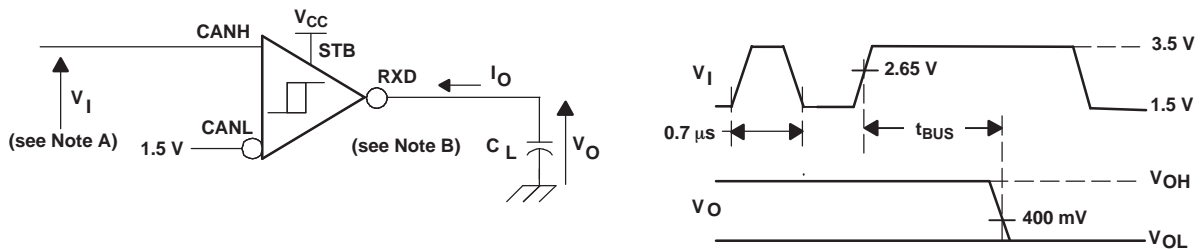
- A. All  $V_I$  input pulses are from 0 V to  $V_{CC}$  and supplied by a generator with the following characteristics:  $t_r$  or  $t_f \leq 6$  ns. Pulse Repetition Rate (PRR) = 125 kHz, 50% duty cycle.

Figure 10.  $t_{loop}$  Test Circuit and Voltage Waveforms



- A. All  $V_I$  input pulses are from 0 V to  $V_{CC}$  and supplied by a generator with the following characteristics:  $t_r$  or  $t_f \leq 6$  ns. Pulse Repetition Rate (PRR) = 500 Hz, 50% duty cycle.
- B.  $C_L = 100$  pF includes instrumentation and fixture capacitance within  $\pm 20\%$ .

Figure 11. Dominant Time-Out Test Circuit and Waveform



- A. For  $V_I$  bit width  $\leq 0.7 \mu s$ ,  $V_O = V_{OH}$ . For  $V_I$  bit width  $\geq 5 \mu s$ ,  $V_O = V_{OL}$ .  $V_I$  input pulses are supplied from a generator with the following characteristics;  $t_r$  or  $t_f \leq 6$  ns. Pulse Repetition Rate (PRR) = 50 Hz, 30% duty cycle.
- B.  $C_L = 15$  pF includes instrumentation and fixture capacitance within  $\pm 20\%$ .

Figure 12.  $t_{BUS}$  Test Circuit and Waveform

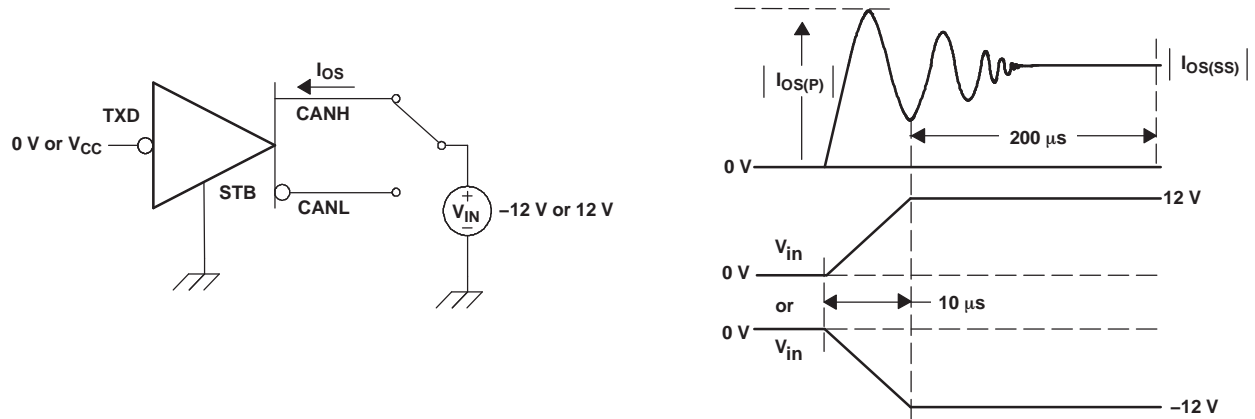


Figure 13. Driver Short-Circuit Current Test and Waveform

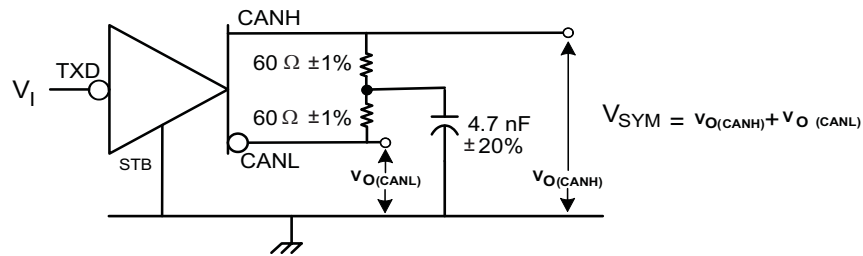


Figure 14. Driver Output Symmetry Test Circuit

## DEVICE INFORMATION

**Table 4. DRIVER FUNCTION TABLE<sup>(1)</sup>**

INPUTS		OUTPUTS		BUS STATE
TXD	STB	CANH	CANL	
L	L	H	L	DOMINANT
H	L	Z	Z	RECESSIVE
Open	X	Z	Z	RECESSIVE
X	H or Open	Z	Z	RECESSIVE

(1) H = high level; L = low level; X = irrelevant; Z = high impedance

**Table 5. RECEIVER FUNCTION TABLE<sup>(1)</sup>**

DIFFERENTIAL INPUTS $V_{ID} = \text{CANH} - \text{CANL}$	STB	OUTPUT RXD	BUS STATE
$V_{ID} \geq 0.9 \text{ V}$	L	L	DOMINANT
$V_{ID} \geq 1.15 \text{ V}$	H or Open	L	DOMINANT
$0.5 \text{ V} < V_{ID} < 0.9 \text{ V}$	X	?	?
$V_{ID} \leq 0.5 \text{ V}$	X	H	RECESSIVE
Open	X	H	RECESSIVE

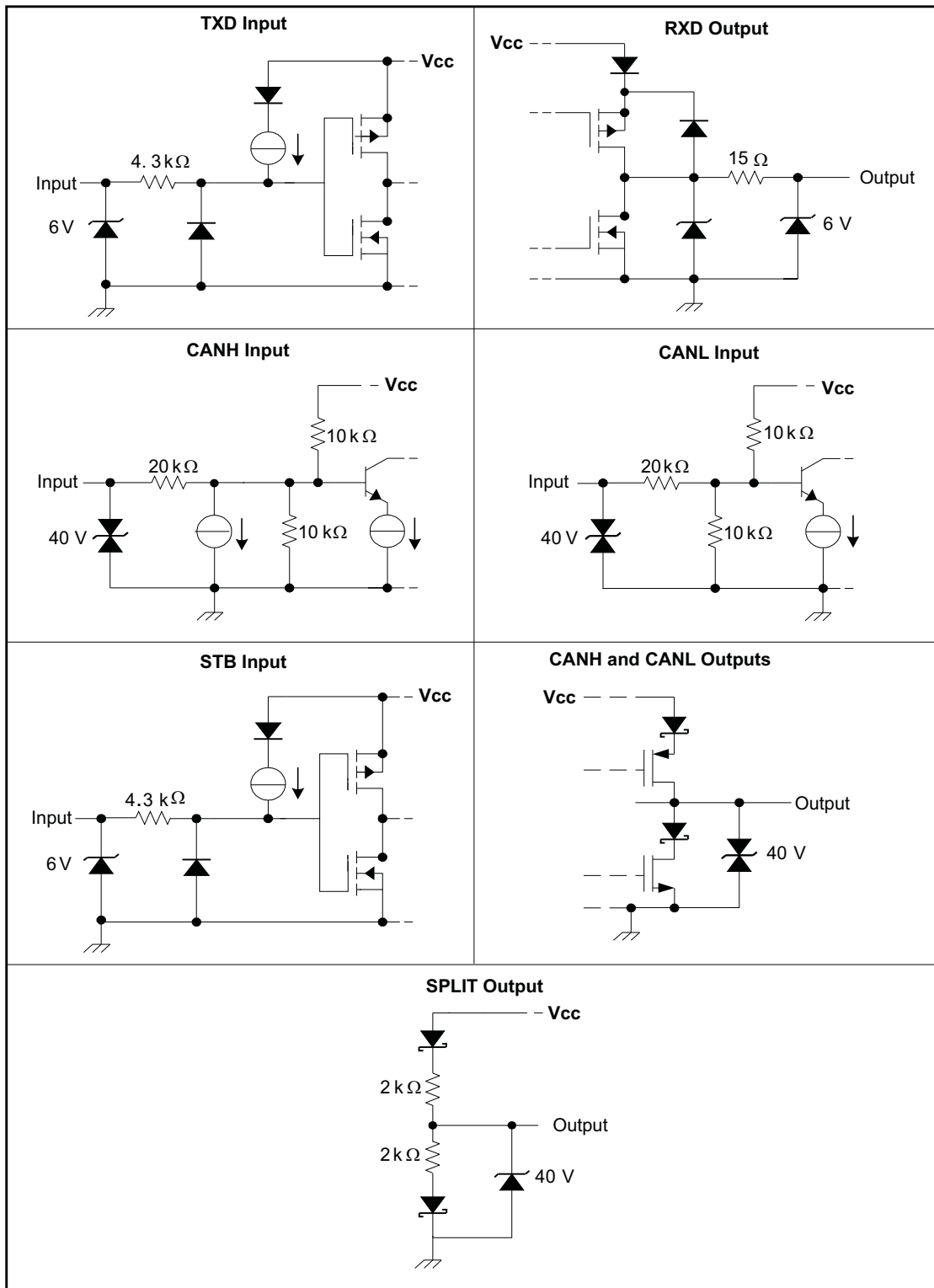
(1) H = high level; L = low level; X = irrelevant; ? = indeterminate; Z = high impedance

**DEVICE INFORMATION**
**Table 6. Parametric Cross Reference With the TJA1040**

TJA1040 <sup>(1)</sup>	PARAMETER	HVD10xx
<b>TJA1040 DRIVER SECTION</b>		
V <sub>IH</sub>	High-level input voltage	Recommended V <sub>IH</sub>
V <sub>IL</sub>	Low-level input voltage	Recommended V <sub>IL</sub>
I <sub>IH</sub>	High-level input current	Driver I <sub>IH</sub>
I <sub>IL</sub>	Low-level input current	Driver I <sub>IL</sub>
<b>TJA1040 BUS SECTION</b>		
V <sub>th(dif)</sub>	Differential input voltage	Receiver V <sub>IT</sub> and recommended V <sub>ID</sub>
V <sub>hys(dif)</sub>	Differential input hysteresis	Receiver V <sub>hys</sub>
V <sub>O(dom)</sub>	Dominant output voltage	Driver V <sub>O(D)</sub>
V <sub>O(reces)</sub>	Recessive output voltage	Driver V <sub>O(R)</sub>
V <sub>i(dif)(th)</sub>	Differential input voltage	Receiver V <sub>IT</sub> and recommended V <sub>ID</sub>
V <sub>O(dif0)(bus)</sub>	Differential bus voltage	Driver V <sub>OD(D)</sub> and V <sub>OD(R)</sub>
I <sub>LI</sub>	Power-off bus input current	Receiver I <sub>I(off)</sub>
I <sub>O(SC)</sub>	Short-circuit output current	Driver I <sub>OS(SS)</sub>
R <sub>i(cm)</sub>	CANH, CANL input resistance	Receiver R <sub>IN</sub>
R <sub>i(def)</sub>	Differential input resistance	Receiver R <sub>ID</sub>
R <sub>i(cm) (m)</sub>	Input resistance matching	Receiver R <sub>I (m)</sub>
C <sub>i(cm)</sub>	Input capacitance to ground	Receiver C <sub>I</sub>
C <sub>i(dif)</sub>	Differential input capacitance	Receiver C <sub>ID</sub>
<b>TJA1040 RECEIVER SECTION</b>		
I <sub>OH</sub>	High-level output current	Recommended I <sub>OH</sub>
I <sub>OL</sub>	Low-level output current	Recommended I <sub>OL</sub>
<b>TJA1040 SPLIT PIN SECTION</b>		
V <sub>O</sub>	Reference output voltage	V <sub>O</sub>
<b>TJA1040 TIMING SECTION</b>		
t <sub>d(TXD-BUSon)</sub>	Delay TXD to bus active	Driver t <sub>PLH</sub>
t <sub>d(TXD-BUSoff)</sub>	Delay TXD to bus inactive	Driver t <sub>PHL</sub>
t <sub>d(BUSon-RXD)</sub>	Delay bus active to RXD	Receiver t <sub>PHL</sub>
t <sub>d(BUSoff-RXD)</sub>	Delay bus inactive to RXD	Receiver t <sub>PLH</sub>
t <sub>PD(TXD-RXD)</sub>	Prop delay TXD to RXD	Device t <sub>LOOP1</sub> and t <sub>LOOP2</sub>
t <sub>d(stb-norm)</sub>	Enable time from standby to dominant	Driver t <sub>en</sub>
<b>TJA1040 STB PIN SECTION</b>		
V <sub>IH</sub>	High-level input voltage	Recommended V <sub>IH</sub>
V <sub>IL</sub>	Low-level input voltage	Recommended V <sub>IL</sub>
I <sub>IH</sub>	High-level input current	I <sub>IH</sub>
I <sub>IL</sub>	Low-level input current	I <sub>IL</sub>

(1) From TJA1040 Product Specification, Philips Semiconductors, 2003 February 19.

Equivalent Input and Output Schematic Diagrams





TYPICAL CHARACTERISTICS

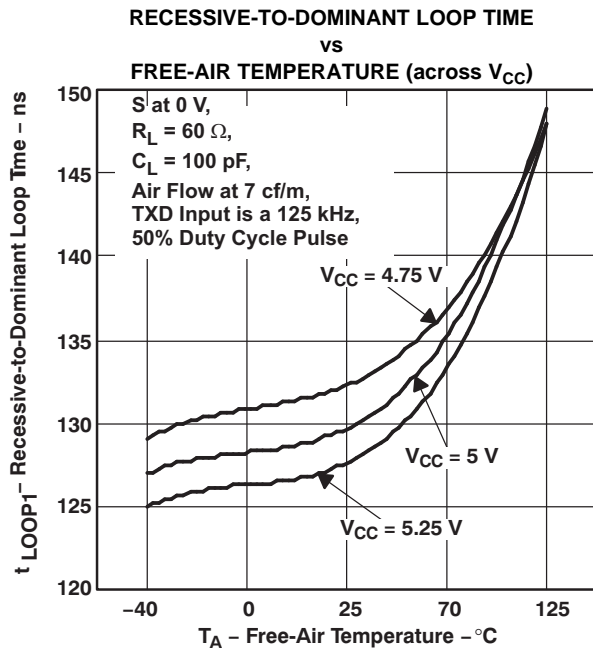


Figure 15.

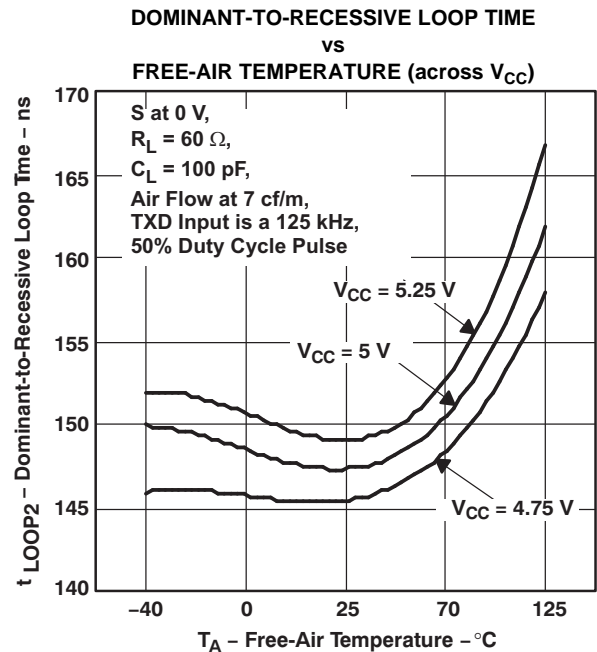


Figure 16.

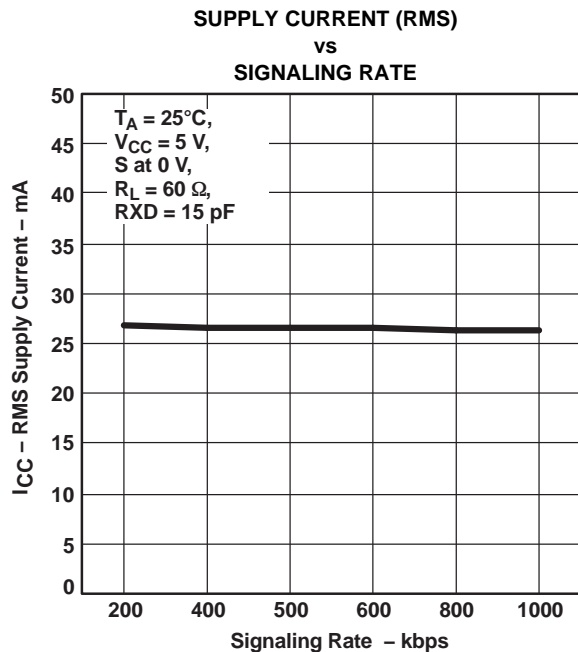


Figure 17.

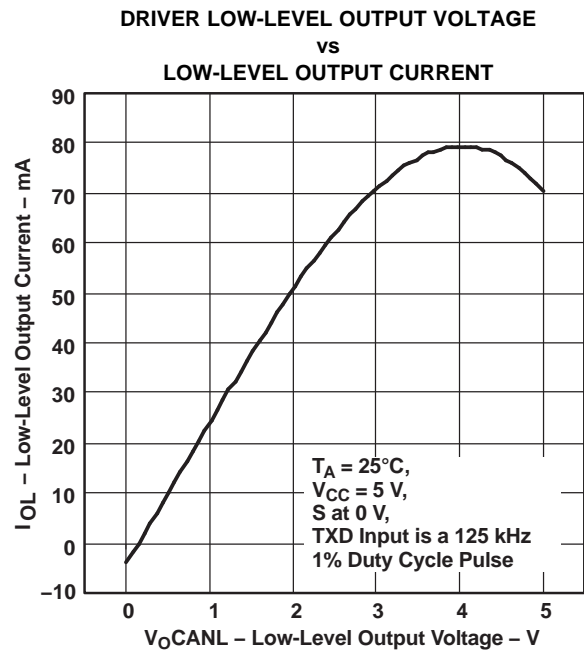


Figure 18.

**TYPICAL CHARACTERISTICS (continued)**

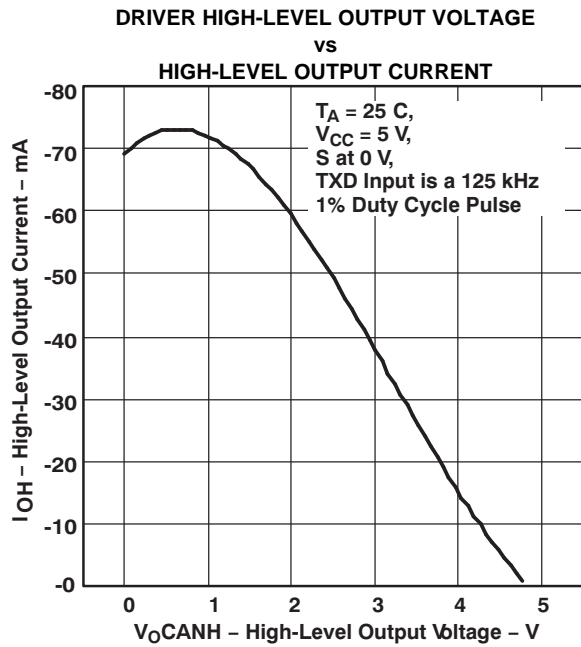


Figure 19.

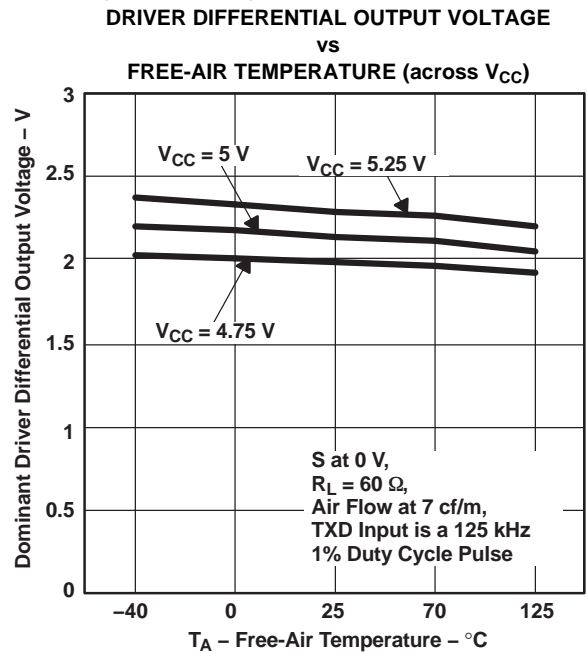


Figure 20.

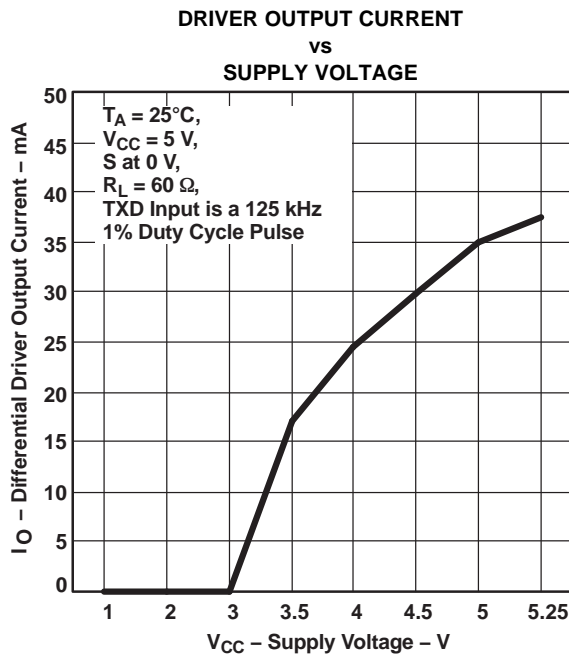


Figure 21.

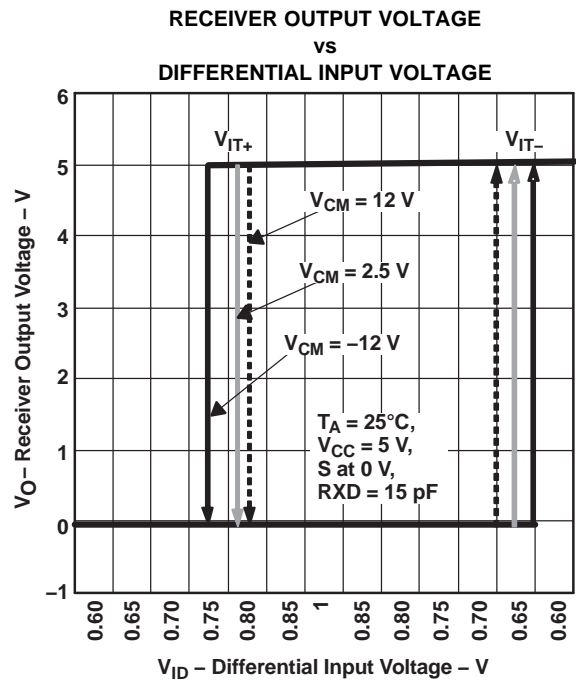


Figure 22.

TYPICAL CHARACTERISTICS (continued)

TYPICAL ELECTROMAGNETIC EMISSIONS  
UP TO 50 MHz (Peak Amplitude)

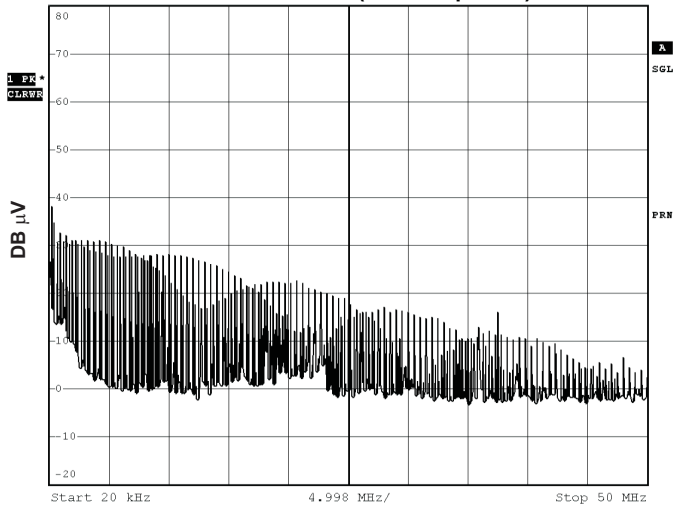


Figure 23. Frequency Spectrum of Common-Mode Emissions

TYPICAL ELECTROMAGNETIC  
IMMUNITY PERFORMANCE

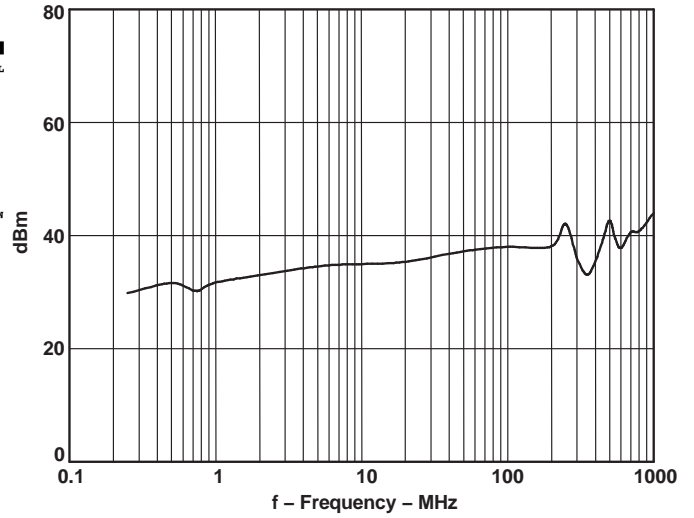


Figure 24. Direct Power Injection (DPI) Response vs Frequency

## APPLICATION INFORMATION

### CAN Basics

The basics of arbitration require that the receiver at the sending node designate the first bit as dominant or recessive after the initial wave of the first bit of a message travels to the most remote node on a network and back again. Typically, this “sample” is made at 75% of the bit width, and within this limitation, the maximum allowable signal distortion in a CAN network is determined by network electrical parameters.

Factors to be considered in network design include the approximately 5 ns/m propagation delay of typical twisted-pair bus cable; signal amplitude loss due to the loss mechanisms of the cable; and the number, length, and spacing of drop-lines (stubs) on a network. Under strict analysis, variations among the different oscillators in a system also need to be accounted for with adjustments in signaling rate and stub and bus length. [Table 7](#) lists the maximum signaling rates achieved with the SN65HVD1040 with several bus lengths of category 5, shielded twisted pair (CAT 5 STP) cable.

**Table 7. Maximum Signaling Rates for Various Cable Lengths**

Bus Length (m)	Signaling Rate (kbps)
30	1000
100	500
250	250
500	125
1000	62.5

The ISO 11898 Standard specifies a maximum bus length of 40 m and maximum stub length of 0.3 m with a maximum of 30 nodes. However, with careful design, users can have longer cables, longer stub lengths, and many more nodes to a bus. (Note: Non-standard application may come with a trade-off in signaling rate.) A large number of nodes requires a transceiver with high input impedance such as the HVD1040.

The Standard specifies the interconnect to be a single twisted-pair cable (shielded or unshielded) with 120  $\Omega$  characteristic impedance ( $Z_0$ ). Resistors equal to the characteristic impedance of the line terminate both ends of the cable to prevent signal reflections. Unterminated drop-lines connect nodes to the bus and should be kept as short as possible to minimize signal reflections.

Connectors, while not specified by the standard should have as little effect as possible on standard operating parameters such as capacitive loading. Although unshielded cable is used in many applications, data transmission circuits employing CAN transceivers are usually used in applications requiring a rugged interconnection with a wide common-mode voltage range. Therefore, shielded cable is recommended in these electronically harsh environments, and when coupled with the Standard's  $-2$ -V to 7-V common-mode range of tolerable ground noise, helps to ensure data integrity. The HVD1040 enhances the Standard's insurance of data integrity with an extended  $-12$  V to 12 V range of common-mode operation.

**PACKAGING INFORMATION**

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
SN65HVD1040HD	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-4-260C-72 HR	-55 to 175	H1040	<a href="#">Samples</a>
SN65HVD1040SHKQ	ACTIVE	CFP	HKQ	8	25	TBD	AU	N / A for Pkg Type	-55 to 210	HVD1040S HKQ	<a href="#">Samples</a>
SN65HVD1040SKGD3	ACTIVE	XCEPT	KGD	0	210	TBD	Call TI	N / A for Pkg Type	-55 to 210		<a href="#">Samples</a>

(1) The marketing status values are defined as follows:

**ACTIVE:** Product device recommended for new designs.

**LIFEBUY:** TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

**NRND:** Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

**PREVIEW:** Device has been announced but is not in production. Samples may or may not be available.

**OBSELETE:** TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

**TBD:** The Pb-Free/Green conversion plan has not been defined.

**Pb-Free (RoHS):** TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

**Pb-Free (RoHS Exempt):** This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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**OTHER QUALIFIED VERSIONS OF SN65HVD1040-HT :**

- Catalog: [SN65HVD1040](#)
- Automotive: [SN65HVD1040-Q1](#)

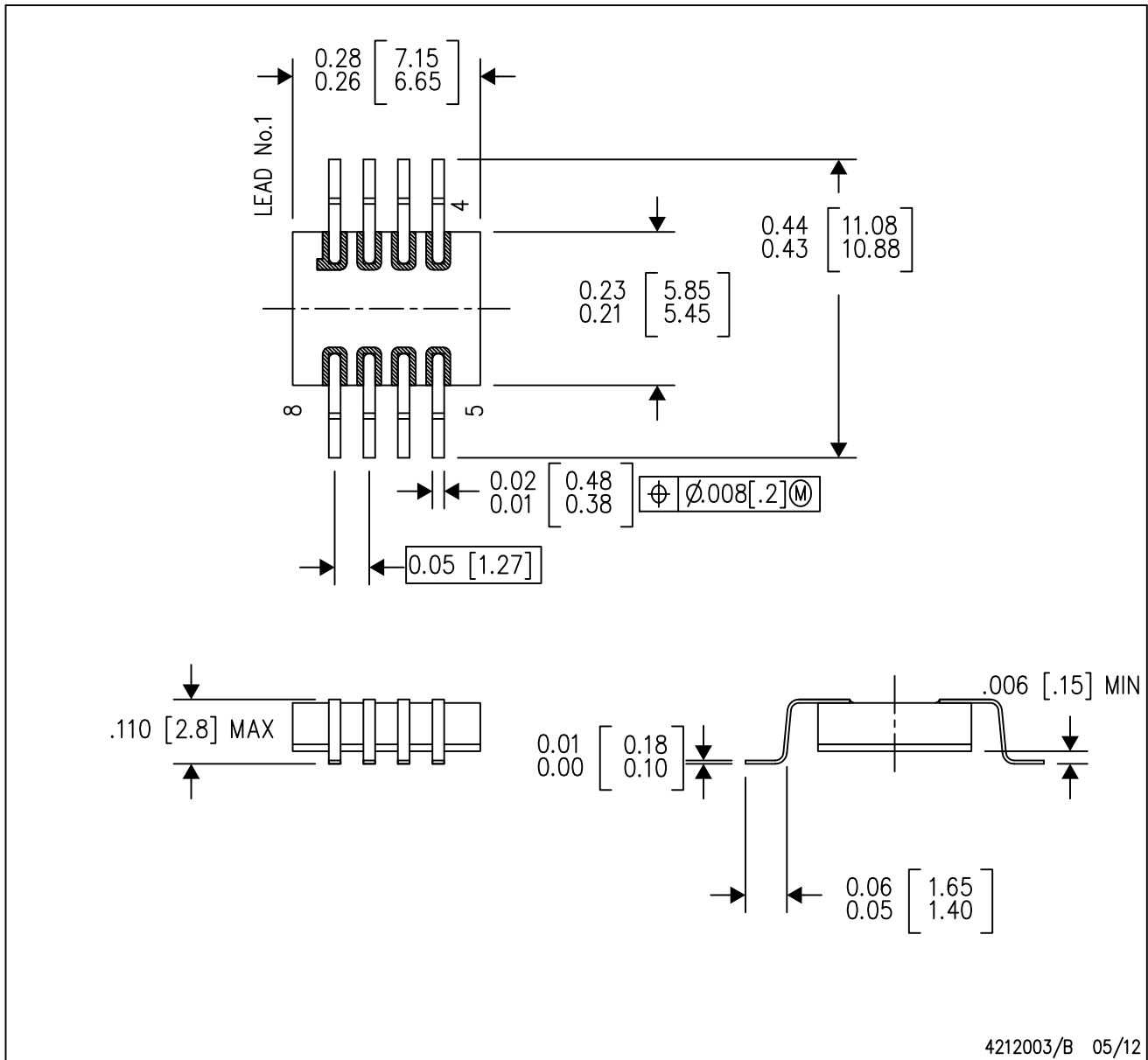
## NOTE: Qualified Version Definitions:

- Catalog - TI's standard catalog product
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

# MECHANICAL DATA

HKQ (R-CDFP-G8)

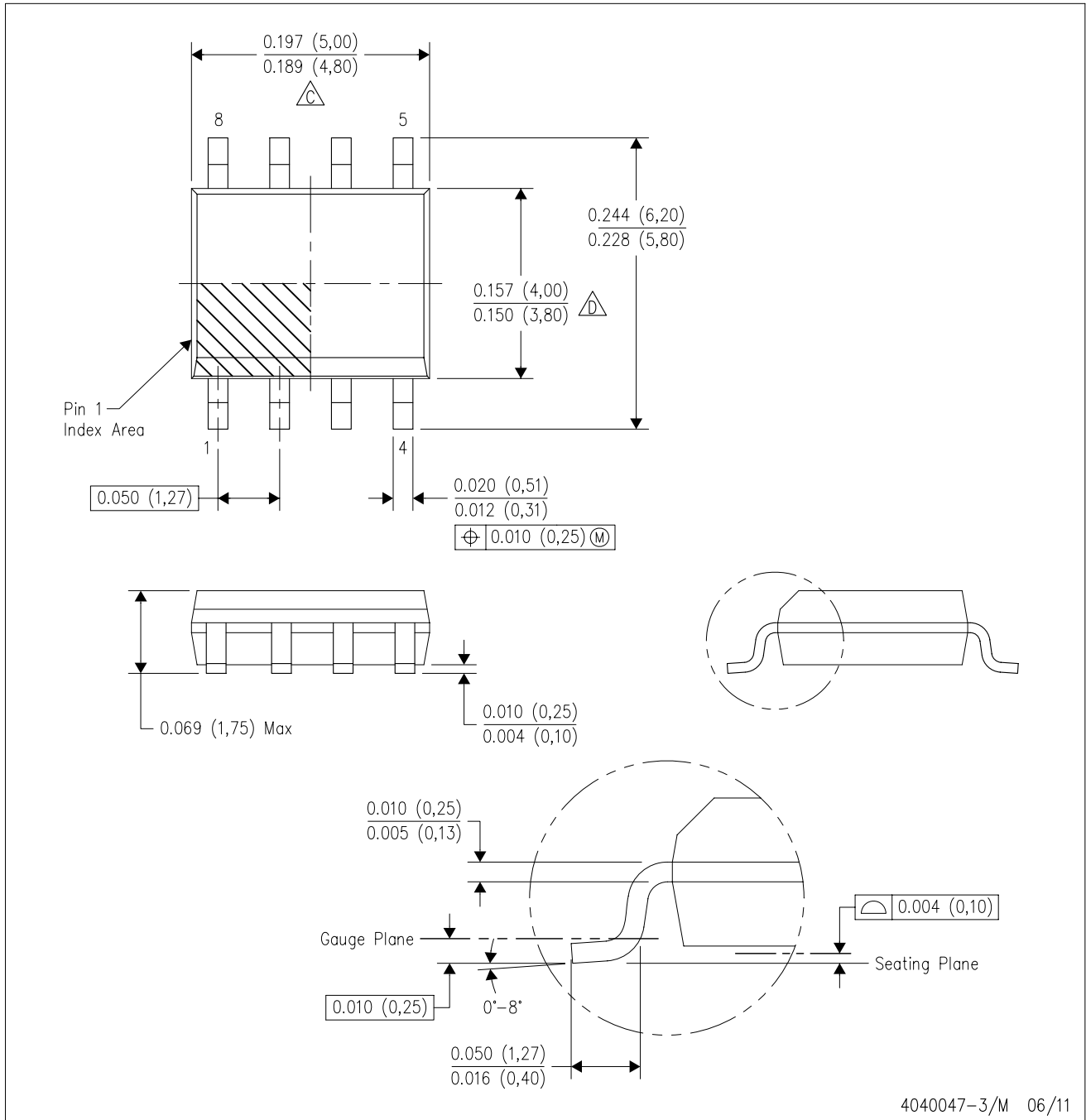
CERAMIC GULL WING





- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  - C. This package can be hermetically sealed with a metal lid.
  - D. The terminals will be gold plated.
  - E. Lid is not connected to any lead.

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in inches (millimeters).
  - B. This drawing is subject to change without notice.
  -  Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
  -  Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
  - E. Reference JEDEC MS-012 variation AA.



D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



- NOTES:
- A. All linear dimensions are in millimeters.
  - B. This drawing is subject to change without notice.
  - C. Publication IPC-7351 is recommended for alternate designs.
  - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
  - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

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