EMC OPTIMIZED CAN TRANSCEIVER

FEATURES

- **Improved Replacement for the TJA1050**
- **High Electromagnetic Immunity (EMI)**
- **Very Low Electromagnetic Emissions (EME)**
- **Meets or Exceeds the Requirements of ISO 11898-2**
- **Bus-Fault Protection of –27 V to 40 V**
- **Dominant Time-Out Function**
- **Thermal Shutdown Protection**
- **Power-Up/Down Glitch-Free Bus Inputs and Outputs**
  - **– High Input Impedance with Low V_{CC}**
  - **– Monotonic Outputs During Power Cycling**

APPLICATIONS

- **Industrial Automation**
  - **– DeviceNET™ Data Buses (Vendor ID #806)**
- **SAE J2284 High Speed CAN for Automotive Applications**
- **SAE J1939 Standard Data Bus Interface**
- **ISO 11783 Standard Data Bus Interface**
- **NMEA 2000 Standard Data Bus Interface**

DESCRIPTION

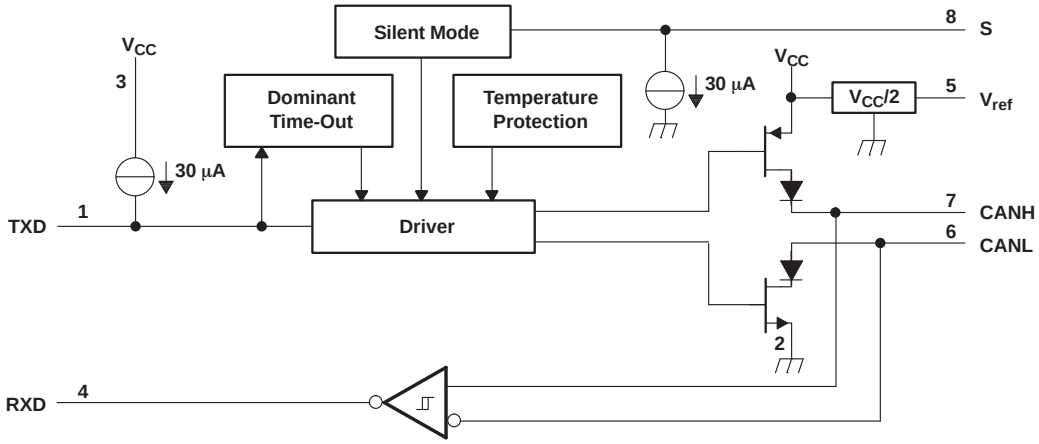
The SN65HVD1050 meets or exceeds the specifications of the ISO 11898 standard for use in applications employing a Controller Area Network (CAN). The device is also qualified for use in automotive applications in accordance with AEC-Q100.(1)

As a CAN transceiver, this device provides differential transmit capability to the bus and differential receive capability to a CAN controller at signaling rates up to 1 megabit per second (Mbps)(2).

Designed for operation is especially harsh environments, the HVD1050 features cross-wire, over-voltage and loss of ground protection from -27 V to 40V, over-temperature protection, a -12 V to 12 V common-mode range, and will withstand voltage transients from -200 V to 200 V according to ISO 7637.

(1) The device is available with Q100 qualification as the SN65HVD1050Q (PRODUCT PREVIEW).
(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).

FUNCTION BLOCK DIAGRAM



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the MOS gates.

DESCRIPTION (CONTINUED)

Pin 8 provides for two different modes of operation: high-speed or silent mode. The high-speed mode of operation is selected by connecting S (pin 8) to ground.

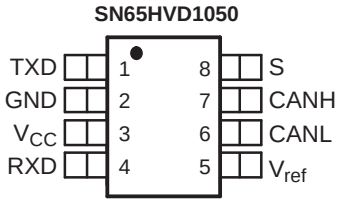
If a high logic level is applied to the S pin of the SN65HVD1050, the device enters a listen-only silent mode during which the driver is switched off while the receiver remains fully functional.

In silent mode, all bus activity is passed by the receiver output to the local protocol controller. When data transmission is required, the local protocol controller reverses this low-current silent mode by placing a logic-low on the S pin to resume full operation.

A dominant-time-out circuit in the SN65HVD1050 prevents the driver from blocking network communication with 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.

V_{ref} (pin 5) is available as a $V_{CC}/2$ voltage reference.

The SN65HVD1050 is characterized for operation from –40°C to 125°C.



ORDERING INFORMATION

PART NUMBER	PACKAGE	MARKED AS	ORDERING NUMBER
SN65HVD1050	SOIC-8	VP1050	SN65HVD1050D (rail)
			SN65HVD1050DR (reel)

ABSOLUTE MAXIMUM RATINGS(1)

		UNIT
V_{CC}	Supply voltage(2)	–0.3 V to 7 V
	Voltage range at any bus terminal (CANH, CANL, V_{ref})	–27 V to 40 V
I_O	Receiver output current	20 mA
V_I	Voltage input, transient pulse(3) (CANH, CANL)	-200 V to 200 V
V_I	Voltage input range (TXD, S)	-0.5 V to 6 V
T_J	Junction temperature	–40ºC to 170ºC

(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, and 7.

ELECTROSTATIC DISCHARGE PROTECTION

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

PARAMETER	TEST CONDITIONS		UNIT
Electrostatic discharge (1)	Human Body Model(2)	Bus terminals and GND	±8 kV
		All pins	±4 kV
	Charged Device Model(3)	All pins	±1.5 kV
	Machine Model		±0.2 V

(1) All typical values at 25°C.
(2) Tested in accordance JEDEC Standard 22, Test Method A114-A.
(3) Tested in accordance JEDEC Standard 22, Test Method C101.

RECOMMENDED OPERATING CONDITIONS

			MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		4.75		5.25	V
V_I or V_{IC}	Voltage at any bus terminal (separately or common mode)		–12		12	V
V_{IH}	High-level input voltage	TXD, S	2		5.25	V
V_{IL}	Low-level input voltage		0		0.8	V
V_{ID}	Differential input voltage		–7		7	V
I_{OH}	High-level output current	Driver	–70			mA
		Receiver	–2			
I_{OL}	Low-level output current	Driver			70	mA
		Receiver			2	
T_J	Junction temperature	See *Thermal Characteristics* table, 1 Mbps minimum signaling rate with R_L = 54Ω			150	°C

SUPPLY CURRENT

over recommended operating conditions (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{CC}	5-V Supply current	Silent mode	S at V_{CC}, V_I = V_{CC}		6	10	mA
		Dominant	V_I = 0 V, 60 Ω Load, S at 0 V		50	70	
		Recessive	V_I = V_{CC}, No Load, S at 0 V		6	10	

DEVICE SWITCHING CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
$t_{d(LOOP1)}$	Total loop delay, driver input to receiver output, recessive to dominant	Figure 9, S at 0V	90		190	ns
$t_{d(LOOP2)}$	Total loop delay, driver input to receiver output, dominant to recessive		90		190	

DRIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditiions (unless otherwise noted)

PARAMETER			TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
$V_{O(D)}$	Bus output voltage (Dominant)	CANH	V_I = 0 V, S at 0 V, R_L = 60 Ω, See Figure 1 and Figure 2	2.9	3.4	4.5	V
		CANL		0.8		1.5	
$V_{O(R)}$	Bus output voltage (Recessive)		V_I = 3 V, S at 0 V, R_L = 60 Ω, See Figure 1 and Figure 2	2	2.3	3	V

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

DRIVER ELECTRICAL CHARACTERISTICS (continued)

over recommended operating conditiions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
$V_{OD(D)}$	Differential output voltage (Dominant)	V_I = 0 V, R_L = 60 Ω, S at 0 V, See Figure 1, Figure 2, and Figure 3	1.5		3	V
		V_I = 0 V, R_L = 45 Ω, S at 0 V, See Figure 1, Figure 2, and Figure 3	1.4		3	V
$V_{OD(R)}$	Differential output voltage (Recessive)	V_I = 3 V, S at 0 V, See Figure 1 and Figure 2	–0.012		0.012	V
		V_I = 3 V, S at 0 V, No Load	–0.5		0.05	
$V_{OC(ss)}$	Steady state common-mode output voltage	S at 0 V, Figure 8	2	2.3	3	V
$\Delta V_{OC(ss)}$	Change in steady-state common-mode output voltage			30		mV
I_{IH}	High-level input current, TXD input	V_I at V_{CC}	–2		2	µA
I_{IL}	Low-level input current, TXD input	V_I at 0 V	–50		–10	
$I_{O(off)}$	Power-off TXD output current	V_{CC} at 0 V, TXD at 5 V			1	
$I_{OS(ss)}$	Short-circuit steady-state output current	V_{CANH} = -12 V, CANL Open, See Figure 11	–105	–72		mA
		V_{CANH} = 12 V, CANL Open, SeeFigure 11		0.36	1	
		V_{CANL} = -12 V, CANH Open, See Figure 11	–1	–0.5		
		V_{CANL} = 12 V, CANH Open, See Figure 11		71	105	
C_O	Output capacitance	See receiver input capacitance				

DRIVER SWITCHING CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	Propagation delay time, low-to-high-level output	S at 0 V, See Figure 4	25	65	120	ns
t_{PHL}	Propagation delay time, high-to-low-level output		25	45	90	
t_r	Differential output signal rise time			25		
t_f	Differential output signal fall time			50		
t_{en}	Enable time from silent mode to dominant	See Figure 7			1	µs
$t_{(dom)}$	Dominant time-out	↓V_I, See Figure 10	300	450	700	µs

RECEIVER ELECTRICAL CHARACTERISTICS

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
V_{IT+}	Positive-going input threshold voltage	S at 0 V, See Table 1		800	900	mV
$V_{IT–}$	Negative-going input threshold voltage		500	650		
V_{hys}	Hysteresis voltage (V_{IT+}– $V_{IT–}$)		100	125		
V_{OH}	High-level output voltage	I_O = –2 mA, See Figure 6	4	4.6		V
V_{OL}	Low-level output voltage	I_O = 2 mA, See Figure 6		0.2	0.4	V
$I_{I(off)}$	Power-off bus input current	CANH or CANL = 5 V, Other pin at 0 V, V_{CC} at 0 V, TXD at 0 V		165	250	µA
$I_{O(off)}$	Power-off RXD leakage current	V_{CC} at 0 V, RXD at 5 V			20	µA
C_I	Input capacitance to ground, (CANH or CANL)	TXD at 3 V, V_I = 0.4 sin (4E6πt) + 2.5 V		13		pF
C_{ID}	Differential input capacitance	TXD at 3 V, V_I = 0.4 sin (4E6πt)		5		
R_{ID}	Differential input resistance	TXD at 3 V, S at 0 V	30		80	kΩ
R_{IN}	Input resistance, (CANH or CANL)		15	30	40	

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

RECEIVER ELECTRICAL CHARACTERISTICS (continued)

over recommended operating conditions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP(1)	MAX	UNIT
$R_{I(m)}$	Input resistance matching $[1 – (R_{IN\ (CANH)} / R_{IN\ (CANL)})] \times 100\%$	$V_{(CANH)} = V_{(CANL)}$	–3%	0%	3%	

RECEIVER SWITCHING CHARACTERISTICS

over recommended operating conditiions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
t_{PLH}	Propagation delay time, low-to-high-level output	S at 0 V or V_{CC}, See Figure 6	60	100	130	ns
t_{PHL}	Propagation delay time, high-to-low-level output		45	70	90	ns
t_r	Output signal rise time			8		ns
t_f	Output signal fall time			8		ns

S-PIN CHARACTERISTICS

over recommended operating conditiions (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
I_{IH}	High level input current	S at 2 V	20	40	70	µA
I_{IL}	Low level input current	S at 0.8 V	5	20	30	

VREF-PIN CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
V_O	Reference output voltage	$–50\ \mu A < I_O < 50\ \mu A$	0.4 V_{CC}	0.5 V_{CC}	0.6 V_{CC}	V

THERMAL CHARACTERISTICS

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
θ_{JA}	Junction-to-Air	Low-K thermal resistance(1)		211		°C/W
		High-K thermal resistance		131		
θ_{JB}	Junction-to-Board Thermal Resistance			53		
θ_{JC}	Junction-to-Case Thermal Resistance			79		
P_D	Average power dissipation	V_{CC} = 5.0 V, T_j = 27°C, R_L = 60 Ω, S at 0 V, Input to TXD a 500 kHz, 50% duty cycle square wave. CL at RXD = 15 pF		112		mW
		V_{CC} = 5.5 V, T_j = 130°C, R_L = 45 Ω, S at 0 V, Input to TXD a 500 kHz, 50% duty cycle square wave. CL at RXD = 15 pF			170	
	Thermal shutdown temperature			190		°C

(1) Tested in accordance with the Low-K or High-K thermal metric definitions of EIA/JESD51-3 for leaded surface-mount packages.

FUNCTION TABLES

DRIVER

INPUTS		OUTPUTS		BUS STATE
TXD(1)	S(1)	CANH(1)	CANL(1)	
L	L or Open	H	L	DOMINANT
H	X	Z	Z	RECESSIVE
Open	X	Z	Z	RECESSIVE
X	H	Z	Z	RECESSIVE

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

RECEIVER

DIFFERENTIAL INPUTS V_{ID} = V(CANH) – V(CANL)	OUTPUT RXD(1)	BUS STATE
$V_{ID} \geq$ 0.9 V	L	DOMINANT
0.5 V < V_{ID} < 0.9 V	?	?
$V_{ID} \leq$ 0.5 V	H	RECESSIVE
Open	H	RECESSIVE

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

PARAMETER MEASUREMENT INFORMATION

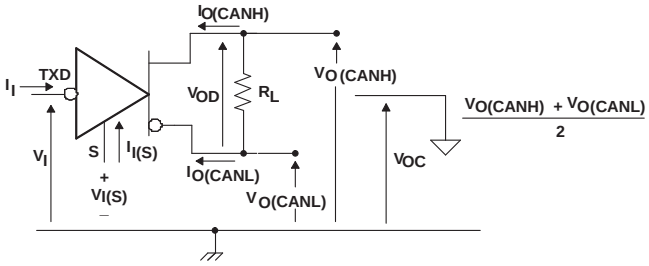


Figure 1. Driver Voltage, Current, and Test Definition

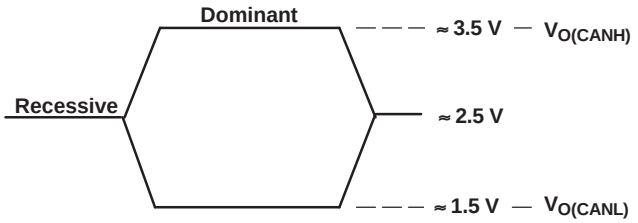


Figure 2. Bus Logic State Voltage Definitions

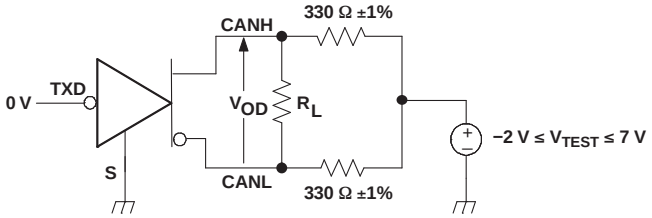


Figure 3. Driver V_{OD} Test Circuit

PARAMETER MEASUREMENT INFORMATION (continued)

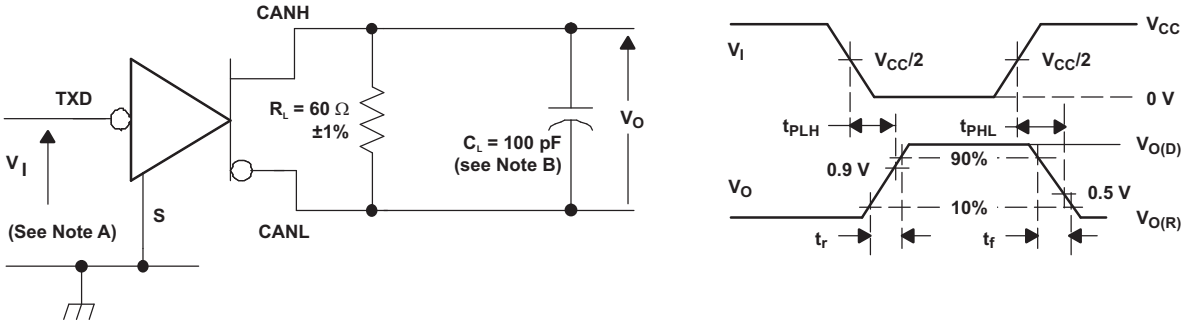


Figure 4. Driver Test Circuit and Voltage Waveforms

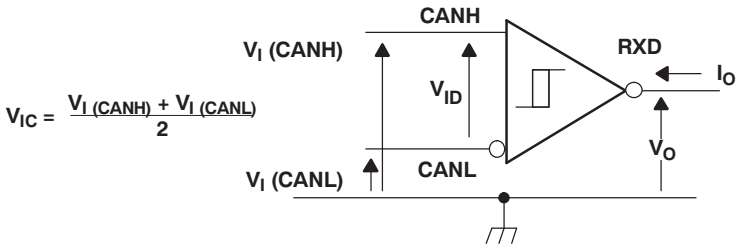
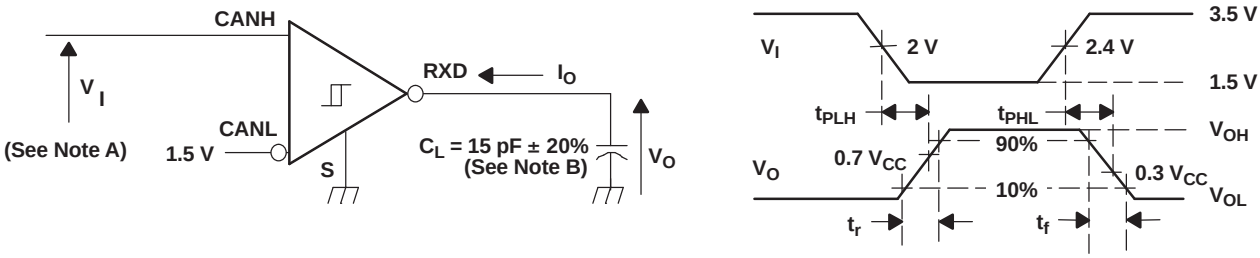


Figure 5. Receiver Voltage and Current Definitions



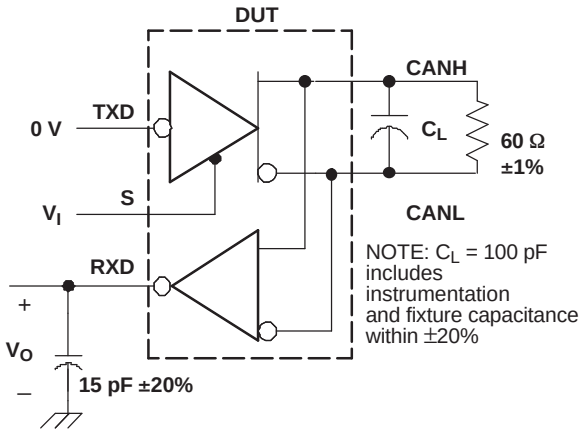
A. The input pulse is supplied by a generator having the following characteristics: PRR ≤ 125 kHz, 50% duty cycle, t_r≤ 6 ns, t_f≤ 6ns, Z_O = 50 Ω.

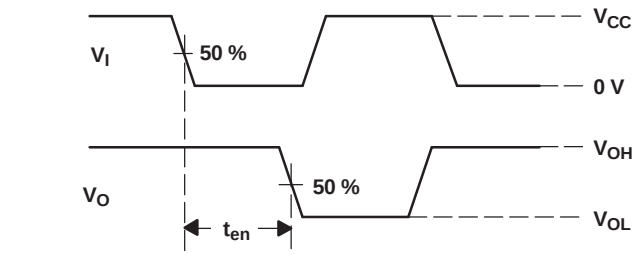
B. C_L includes instrumentation and fixture capacitance within ±20%.

Figure 6. Receiver Test Circuit and Voltage Waveforms

Table 1. Differential Input Voltage Threshold Test

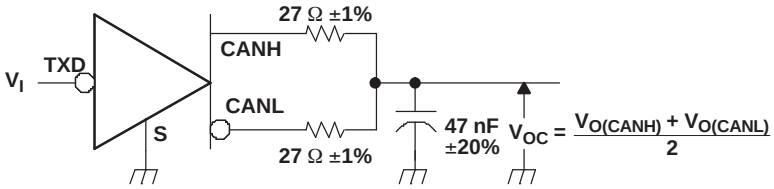
INPUT			OUTPUT	
V_{CANH}	V_{CANL}	$\lvert V_{ID}\rvert$	R	
–11.1 V	–12 V	900 mV	L	V_{OL}
12 V	11.1 V	900 mV	L	
–6 V	–12 V	6 V	L	
12 V	6 V	6 V	L	
–11.5 V	–12 V	500 mV	H	V_{OH}
12 V	11.5 V	500 mV	H	
–12 V	–6 V	6 V	H	
6 V	12 V	6 V	H	
Open	Open	X	H	





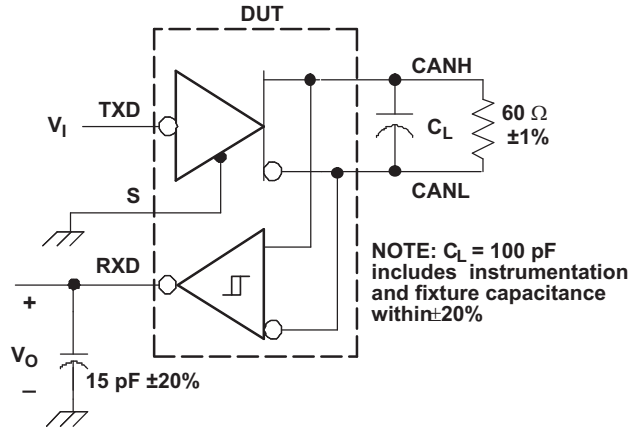
NOTE: All V_I input pulses are supplied by a generator having the following characteristics: t_r or $t_f \le 6$ ns, Pulse Repetition Rate (PRR) = 25 kHz, 50% duty cycle

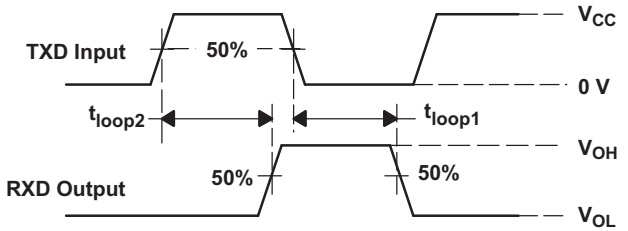
Figure 7. t_{en} Test Circuit and Waveform



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

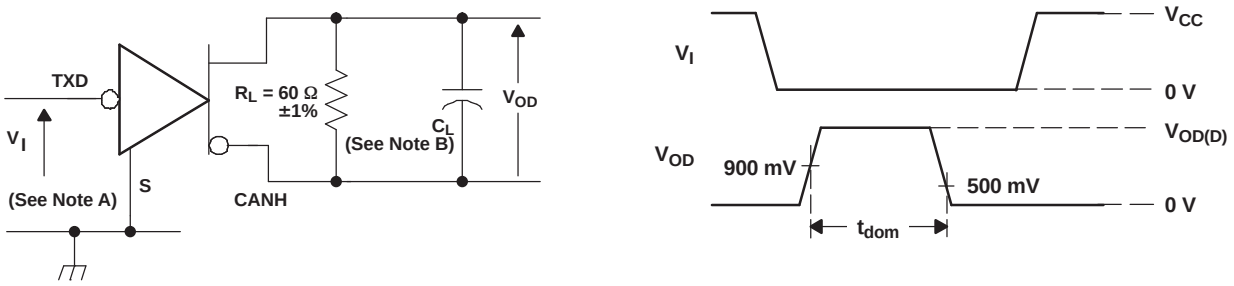
Figure 8. Common Mode Output Voltage Test and Waveforms





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

Figure 9. $t_{(LOOP)}$ Test Circuit and Waveform



A. All V_I input pulses are from 0 V to V_{CC} and supplied by a generator having 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 ±20%.

Figure 10. Dominant Time-Out Test Circuit and Waveforms

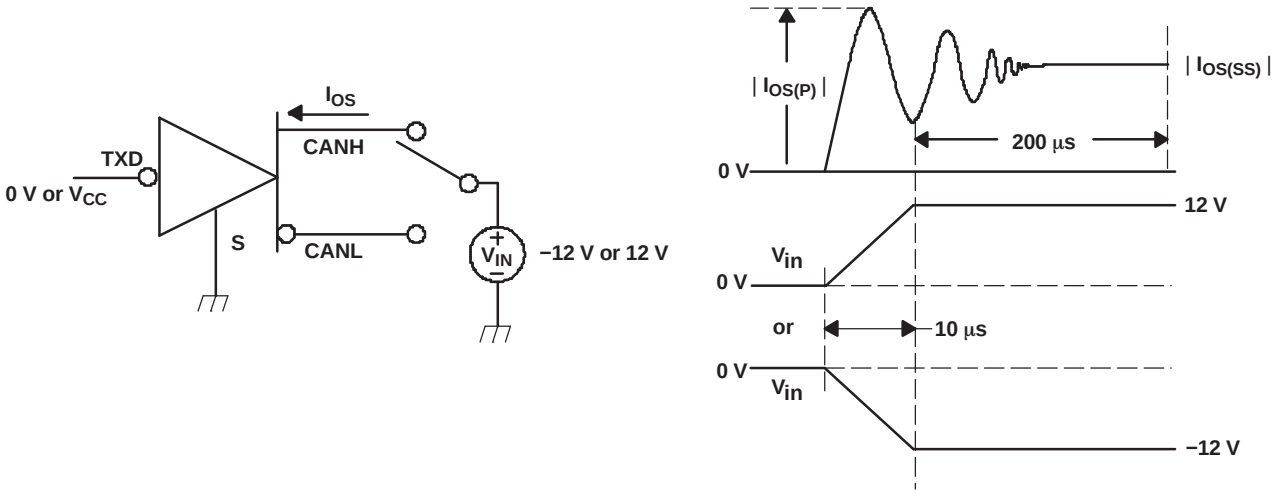


Figure 11. Driver Short-Circuit Current Test and Waveform

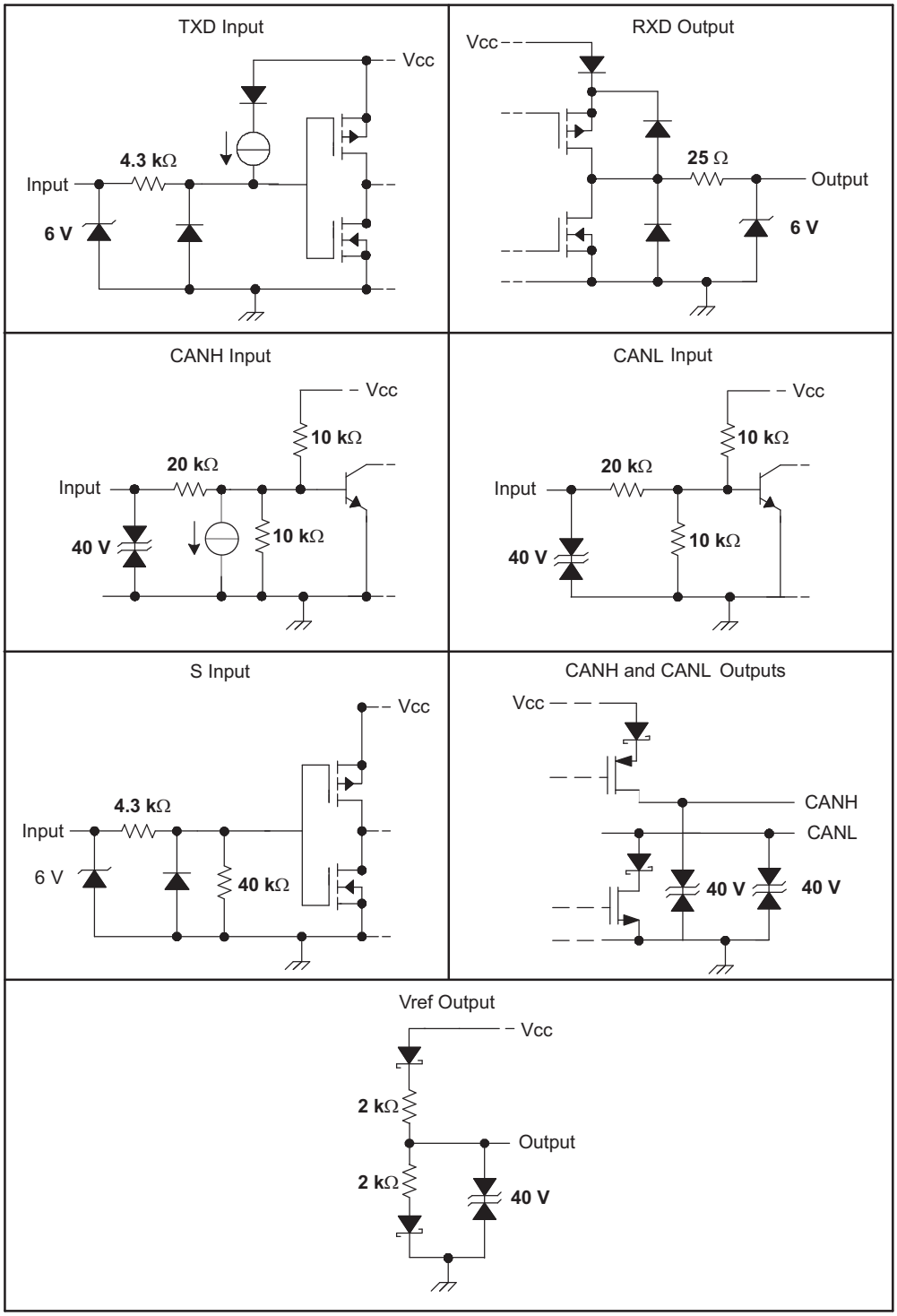
DEVICE INFORMATION

Table 2. Parametric Cross Reference With the TJA1050

TJA1050 (1)	PARAMETER	HVD1050
TRANSMITTER SECTION		
V_{IH}	High-level input voltage	Recommended V_{IH}
V_{IL}	Low-level input voltage	Recommended V_{IL}
I_{IH}	High-level input current	Driver I_{IH}
I_{IL}	Low-level input current	Driver I_{IL}
BUS SECTION		
I_{LI}	Power-off bus input current	Receiver $I_{I(off)}$
$I_{O(SC)}$	Short-circuit output current	Driver $I_{OS(SS)}$
$V_{O(dom)}$	Dominant output voltage	Driver $V_{O(D)}$
$V_{i(dif)(th)}$	Differential input voltage	Receiver V_{IT} and recommended V_{ID}
$V_{i(dif)(hys)}$	Diffrential input hysteresis	Receiver V_{hys}
$V_{O(reces)}$	Recessive output voltage	Driver $V_{O(R)}$
$V_{O(dif)(bus)}$	Differential bus voltage	Driver $V_{OD(D)}$ and $V_{OD(R)}$
$R_{i(cm)}$	CANH, CANL input resistance	Receiver R_{IN}
$R_{i(dif)}$	Differential input resistance	Receiver R_{ID}
$R_{i(cm)(m)}$	Input resistance matching	Receiver $R_{I\ (m)}$
C_i	Input capacitance to ground	Receiver C_I
$C_{i(dif)}$	Differential input capacitance	Receiver C_{ID}
RECEIVER SECTION		
I_{OH}	High-level output current	Recommended I_{OH}
I_{OL}	Low-level output current	Recommended I_{OL}
Vref PIN SECTION		
V_{ref}	Reference output voltage	V_O
TIMING SECTION		
$t_{d(TXD-BUSon)}$	Delay TXD to bus active	Driver t_{PLH}
$t_{d(TXD-BUSoff)}$	Delay TXD to bus inactive	Driver t_{PHL}
$t_{d(BUSon-RXD)}$	Delay bus active to RXD	Receiver t_{PHL}
$t_{d(BUSoff-RXD)}$	Delay bus inactive to RXD	Receiver t_{PLH}
	$t_{d(TXD-BUSon)} + t_{d(BUSon-RXD)}$	Device t_{LOOP1}
	$t_{d(TXD-BUSoff)} + t_{d(BUSoff-RXD)}$	Device t_{LOOP2}
$t_{dom(TXD)}$	Dominant time out	Driver $t_{(dom)}$
S PIN SECTION		
V_{IH}	High-level input voltage	Recommended V_{IH}
V_{IL}	Low-level input voltage	Recommended V_{IL}
I_{IH}	High-level input current	I_{IH}
I_{IL}	Low-level input current	I_{IL}

(1) From TJA1050 Product Specification, Philips Semiconductors, 2002 May 16.

Equivalent Input and Output Schematic Diagrams



TYPICAL CHARACTERISTICS

RECESSIVE-TO-DOMINANT LOOP TIME
vs
FREE-AIR TEMPERATURE (across V_{CC})

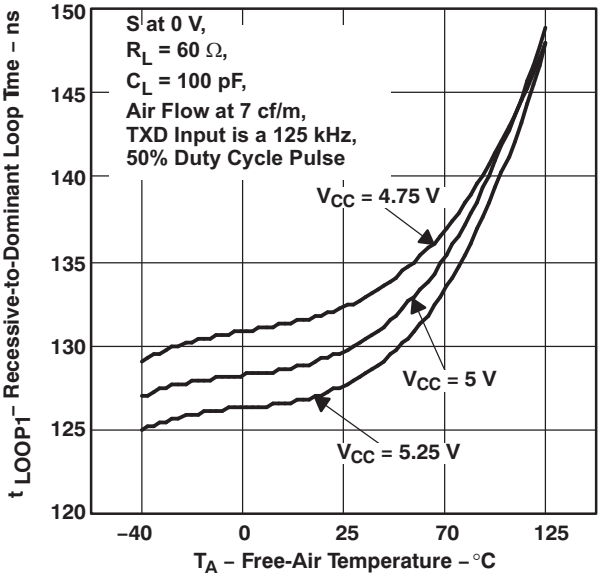


Figure 12.

DOMINANT-TO-RECESSIVE LOOP TIME
vs
FREE-AIR TEMPERATURE (across V_{CC})

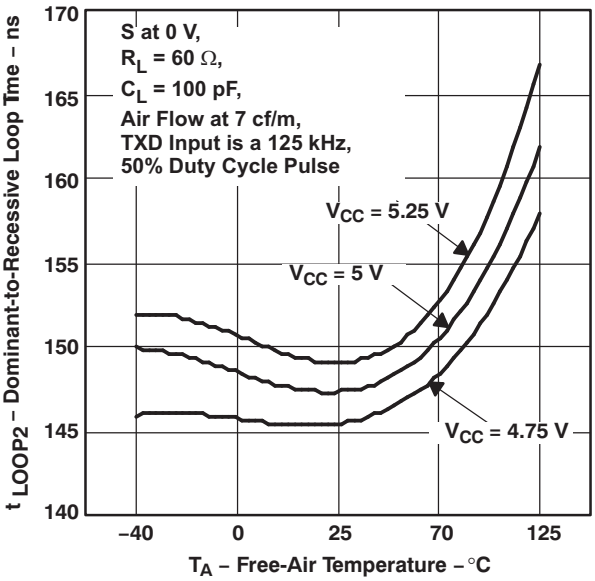


Figure 13.

SUPPLY CURRENT (RMS)
vs
SIGNALING RATE

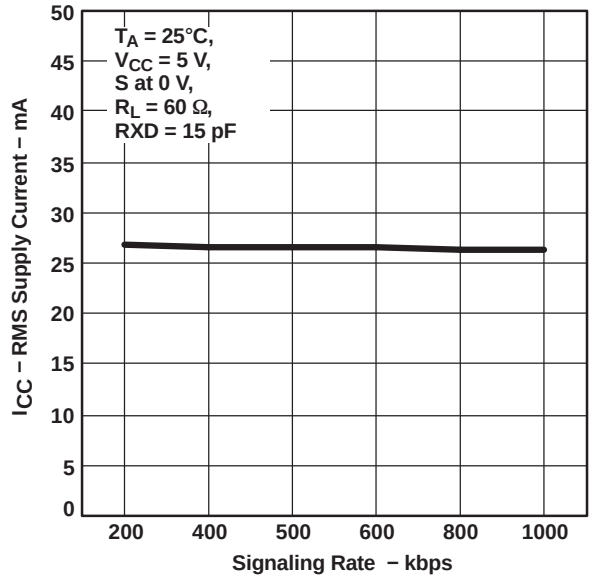


Figure 14.

DRIVER LOW-LEVEL OUTPUT VOLTAGE
vs
LOW-LEVEL OUTPUT CURRENT

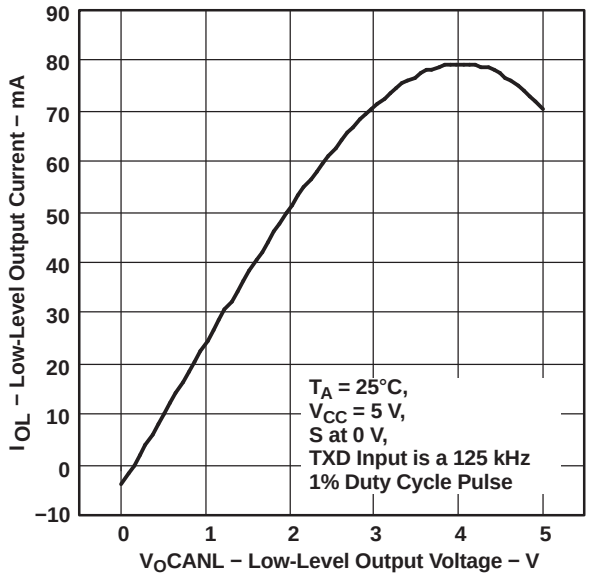


Figure 15.

TYPICAL CHARACTERISTICS (continued)

DRIVER HIGH-LEVEL OUTPUT VOLTAGE
vs
HIGH-LEVEL OUTPUT CURRENT

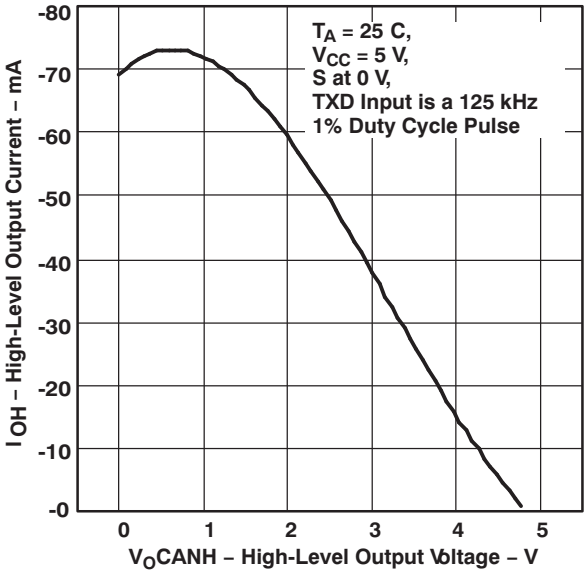


Figure 16.

DRIVER DIFFERENTIAL OUTPUT VOLTAGE
vs
FREE-AIR TEMPERATURE (across V_{CC})

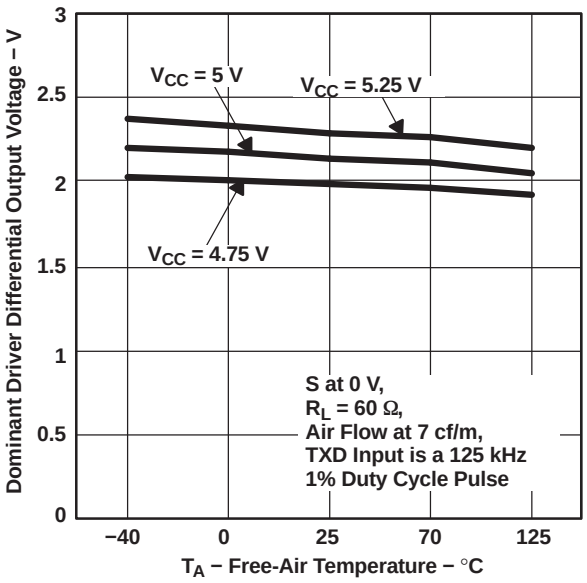


Figure 17.

DRIVER OUTPUT CURRENT
vs
SUPPLY VOLTAGE

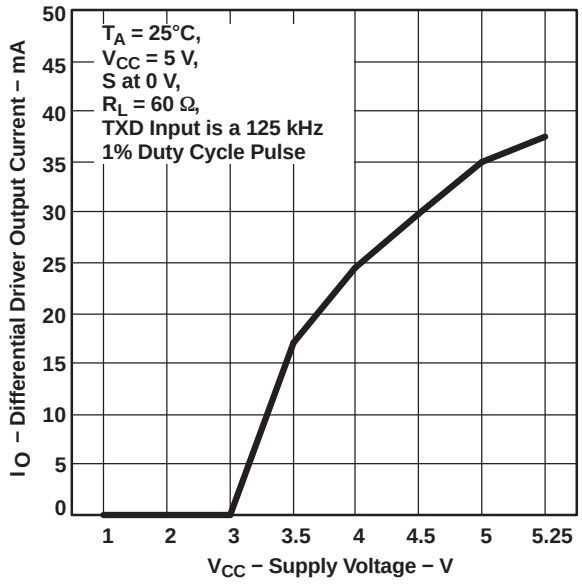


Figure 18.

RECEIVER OUTPUT VOLTAGE
vs
DIFFERENTIAL INPUT VOLTAGE

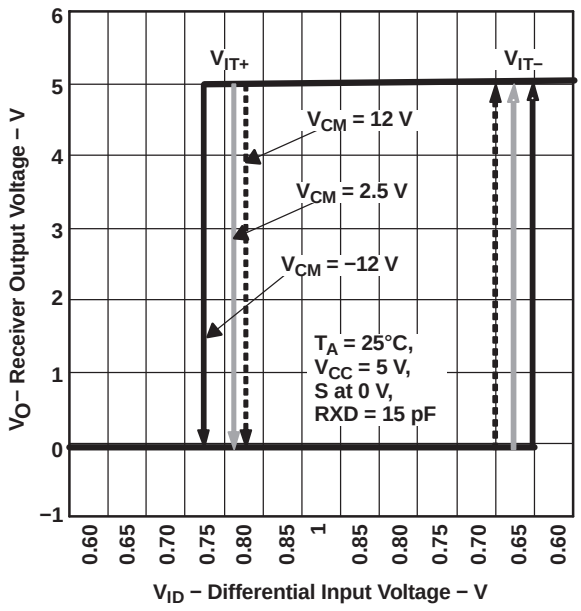


Figure 19.

TYPICAL CHARACTERISTICS (continued)

TYPICAL ELECTROMAGNETIC EMISSIONS UP TO 50 MHZ (Peak Amplitude)

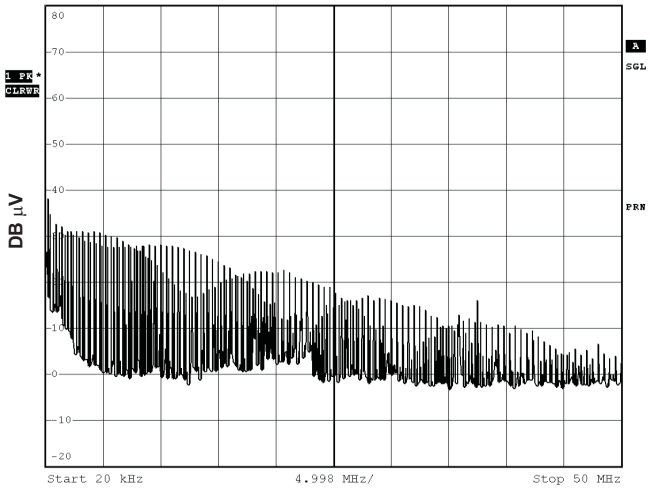


Figure 20.

TYPICAL ELECTROMAGNETIC IMMUNITY PERFORMANCE

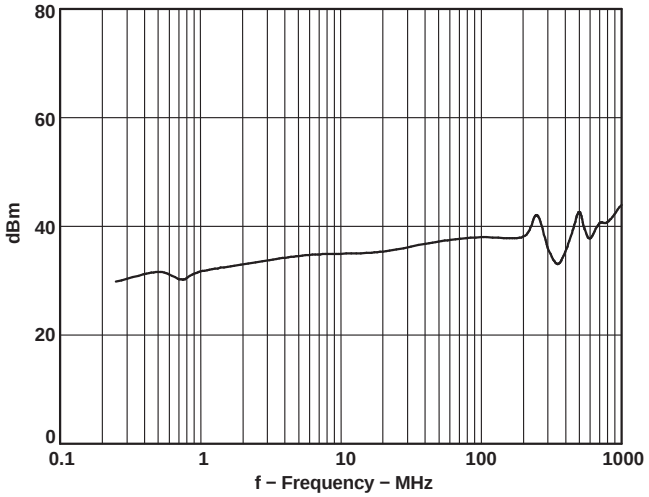


Figure 21.

PACKAGING INFORMATION

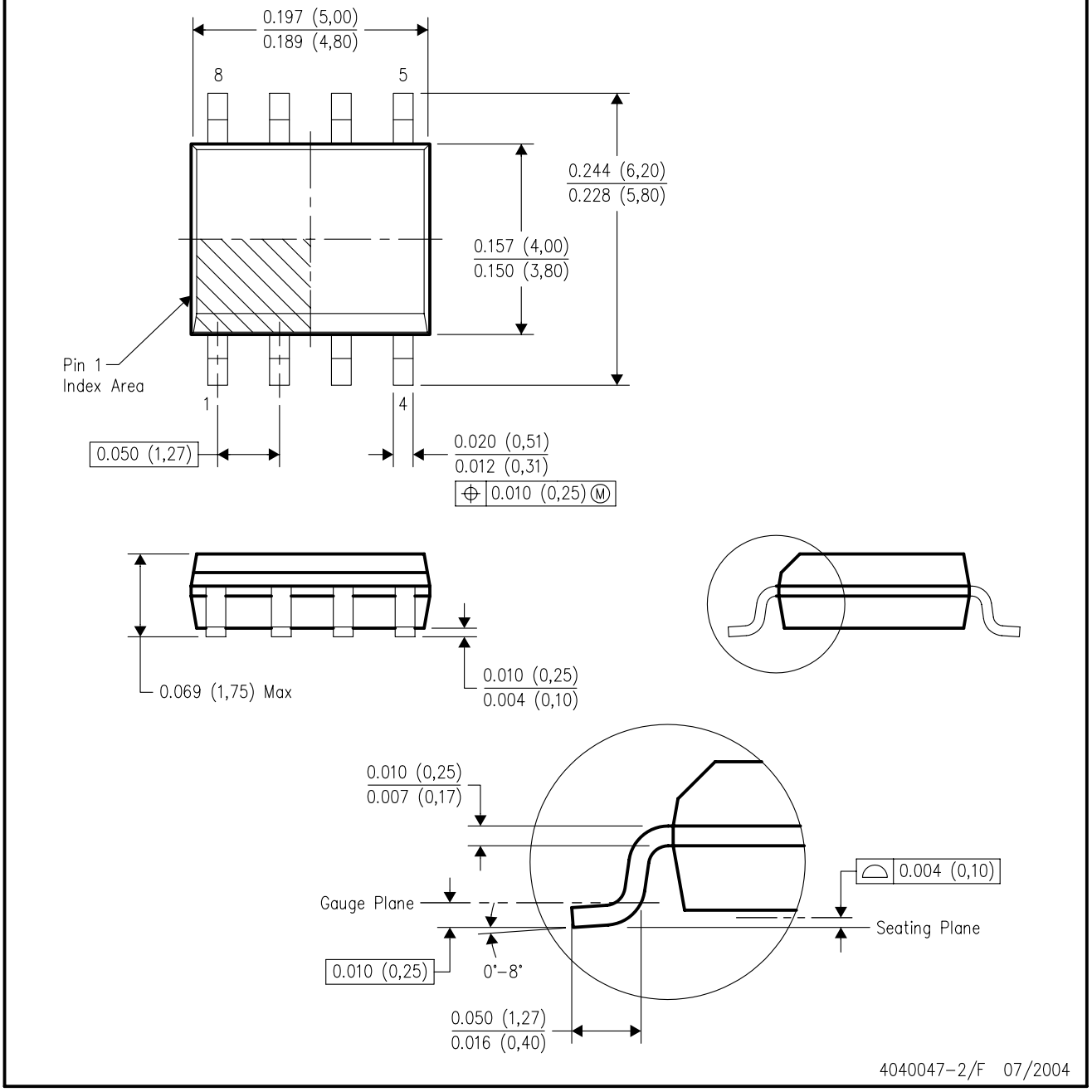
Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
SN65HVD1050D	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1050DG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1050DR	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN65HVD1050DRG4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM

(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.
OBSOLETE: 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.

D (R–PDSO–G8) PLASTIC SMALL–OUTLINE PACKAGE



NOTES:
A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed 0.006 (0,15).
D. Falls within JEDEC MS–012 variation AA.

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