

24-BIT FET BUS-EXCHANGE SWITCH, 2.5-V/3.3-V LOW-VOLTAGE BUS SWITCH WITH 5-V-TOLERANT LEVEL SHIFTER

SCDS157A—OCTOBER 2003—REVISED FEBRUARY 2005

FEATURES

- Member of the Texas Instruments Widebus™ Family
- Output Voltage Translation Tracks V_{CC}
- Supports Mixed-Mode Signal Operation on All Data I/O Ports
 - 5-V Input Down to 3.3-V Output Level Shift With 3.3-V V_{CC}
 - 5-V/3.3-V Input Down to 2.5-V Output Level Shift With 2.5-V V_{CC}
- 5-V-Tolerant I/Os With Device Powered Up or Powered Down
- Bidirectional Data Flow, With Near-Zero Propagation Delay
- Low ON-State Resistance (r_{on}) Characteristics ($r_{on} = 5\ \Omega$ Typ)
- Low Input/Output Capacitance Minimizes Loading ($C_{iO(OFF)} = 9\text{ pF}$ Typ)
- Data and Control Inputs Provide Undershoot Clamp Diodes
- Low Power Consumption ($I_{CC} = 70\ \mu\text{A}$ Max)
- V_{CC} Operating Range From 2.3 V to 3.6 V
- Data I/Os Support 0-V to 5-V Signaling Levels (0.8 V, 1.2 V, 1.5 V, 1.8 V, 2.5 V, 3.3 V, 5 V)
- Control Inputs Can Be Driven by TTL or 5-V/3.3-V CMOS Outputs
- I_{off} Supports Partial-Power-Down Mode Operation
- Latch-Up Performance Exceeds 250 mA Per JESD 17
- ESD Performance Tested Per JESD 22
 - 2000-V Human-Body Model (A114-B, Class II)
 - 1000-V Charged-Device Model (C101)
- Supports Digital Applications: Level Translation, PCI Interface, USB Interface, Memory Interleaving, and Bus Isolation
- Ideal for Low-Power Portable Equipment

DGG OR DGV PACKAGE
(TOP VIEW)

S0	1	56	S1
1A1	2	55	S2
1A2	3	54	1B1
2A1	4	53	1B2
2A2	5	52	2B1
3A1	6	51	2B2
3A2	7	50	3B1
GND	8	49	GND
4A1	9	48	3B2
4A2	10	47	4B1
5A1	11	46	4B2
5A2	12	45	5B1
6A1	13	44	5B2
6A2	14	43	6B1
7A1	15	42	6B2
7A2	16	41	7B1
V_{CC}	17	40	7B2
8A1	18	39	8B1
GND	19	38	GND
8A2	20	37	8B2
9A1	21	36	9B1
9A2	22	35	9B2
10A1	23	34	10B1
10A2	24	33	10B2
11A1	25	32	11B1
11A2	26	31	11B2
12A1	27	30	12B1
12A2	28	29	12B2

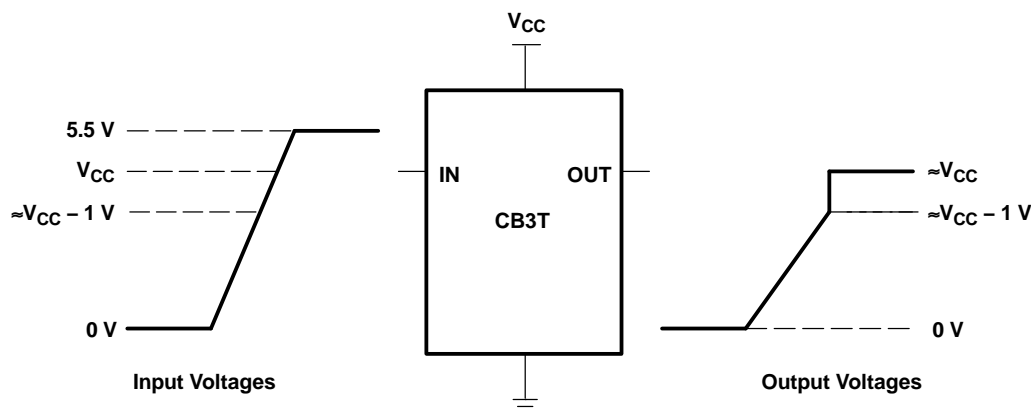
DESCRIPTION/ORDERING INFORMATION

The SN74CB3T16212 is a high-speed TTL-compatible FET bus-exchange switch, with low ON-state resistance (r_{on}), allowing for minimal propagation delay. The device fully supports mixed-mode signal operation on all data I/O ports by providing voltage translation that tracks V_{CC} . The SN74CB3T16212 supports systems using 5-V TTL, 3.3-V LVTTTL, and 2.5-V CMOS switching standards, as well as user-defined switching levels (see Figure 1).

SN74CB3T16212

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NOTE: If the input high-voltage (V_{IH}) level is greater than or equal to $V_{CC} - 1$ V and less than or equal to 5.5 V, the output high-voltage (V_{OH}) level is equal to approximately the V_{CC} voltage level.

Figure 1. Typical DC Voltage Translation Characteristics

The SN74CB3T16212 operates as a 24-bit bus switch or as a 12-bit bus exchange that provides data exchanging between four signal ports. The select (S0, S1, S2) inputs control the data path of the bus-exchange switch. When the bus-exchange switch is ON, the A port is connected to the B port, allowing bidirectional data flow between ports. When the bus-exchange switch is OFF, a high-impedance state exists between the A and B ports.

This device is fully specified for partial-power-down applications using I_{off} . The I_{off} feature ensures that damaging current will not backflow through the device when it is powered down. The device has isolation during power off.

To ensure the high-impedance state during power up or power down, each select input should be tied to GND through a pulldown resistor; the minimum value of the resistor is determined by the current-sourcing capability of the driver.

ORDERING INFORMATION

T_A	PACKAGE ⁽¹⁾		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	TSSOP – DGG	Tape and reel	SN74CB3T16212DGGR	CB3T16212
	TVSOP – DGV	Tape and reel	SN74CB3T16212DGVR	KR212
	VFBGA – GQL	Tape and reel	SN74CB3T16212GQLR	KR212
	VFBGA – ZQL (Pb-free)	Tape and reel	SN74CB3T16212ZQLR	

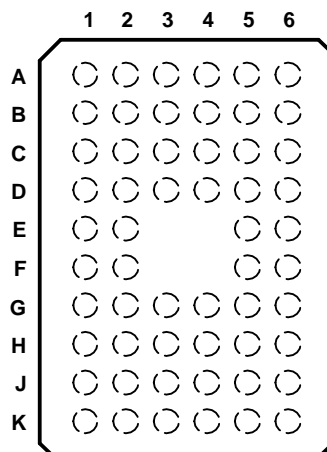
(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

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**GQL OR ZQL PACKAGE
(TOP VIEW)**



TERMINAL ASSIGNMENTS

	1	2	3	4	5	6
A	1A2	1A1	S0	S1	S2	1B1
B	3A1	2A2	2A1	1B2	2B1	2B2
C	4A1	GND	3A2	3B1	GND	3B2
D	5A2	4A2	5A1	4B2	4B1	5B1
E	6A2	6A1			5B2	6B1
F	7A1	7A2			7B1	6B2
G	V _{CC}	GND	8A1	8B1	GND	7B2
H	8A2	9A1	9A2	9B2	9B1	8B2
J	10A1	10A2	11A1	11B1	10B2	10B1
K	11A2	12A1	12A2	12B2	12B1	11B2

FUNCTION TABLE

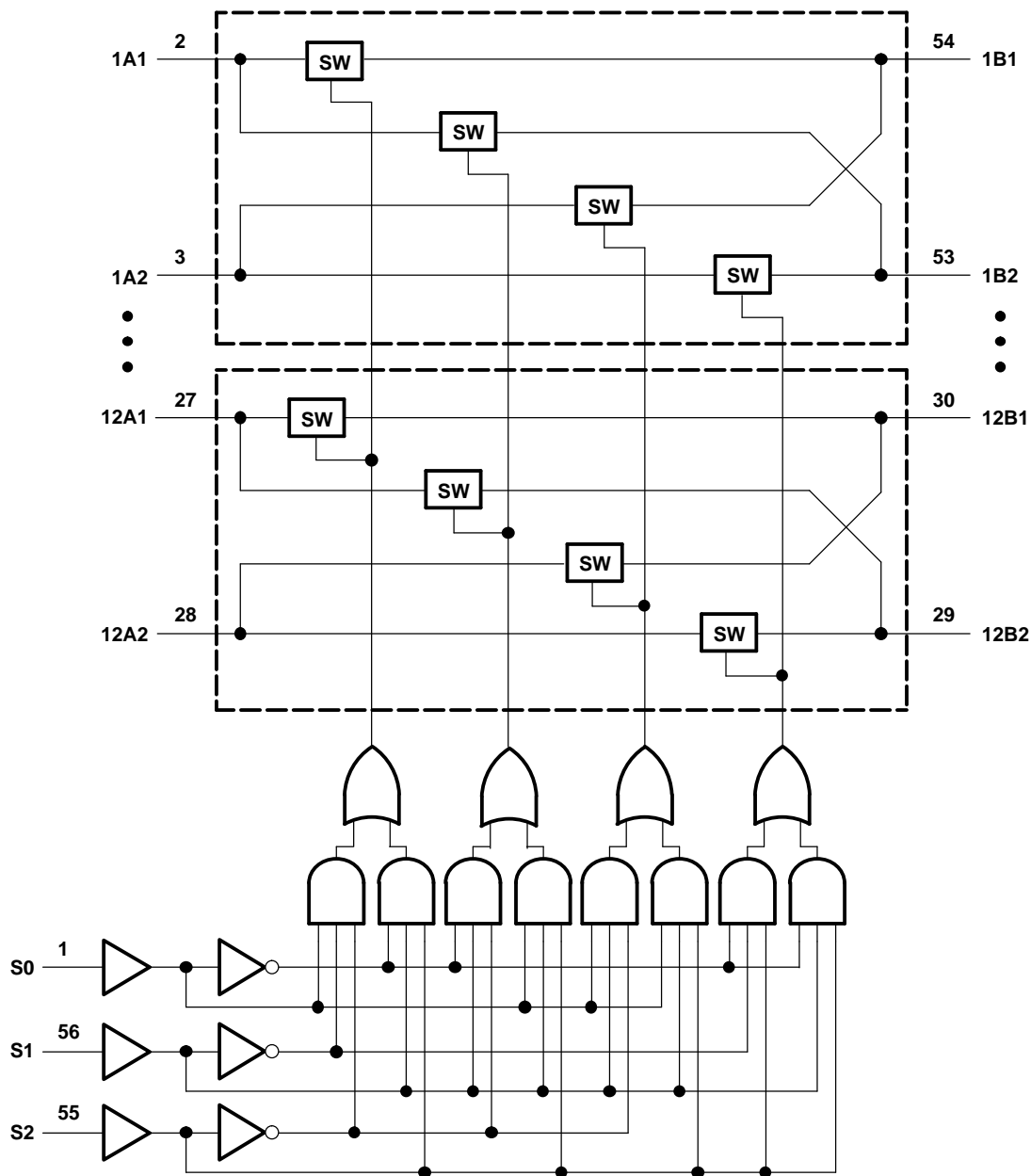
INPUTS			INPUTS/OUTPUTS		FUNCTION
S2	S1	S0	A1	A2	
L	L	L	Z	Z	Disconnect
L	L	H	B1 port	Z	A1 port = B1 port
L	H	L	B2 port	Z	A1 port = B2 port
L	H	H	Z	B1 port	A2 port = B1 port
H	L	L	Z	B2 port	A2 port = B2 port
H	L	H	Z	Z	Disconnect
H	H	L	B1 port	B2 port	A1 port = B1 port A2 port = B2 port
H	H	H	B2 port	B1 port	A1 port = B2 port A2 port = B1 port

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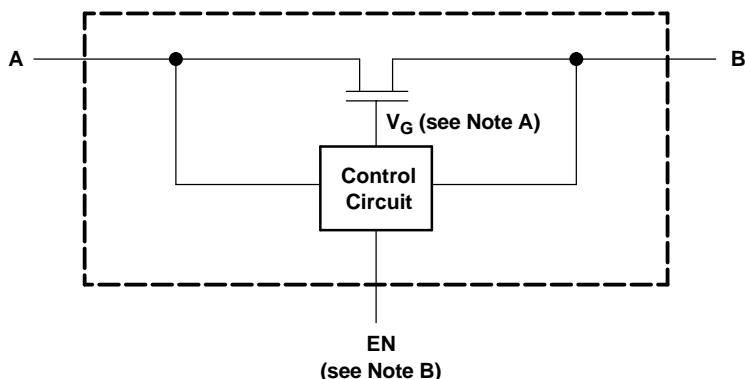
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LOGIC DIAGRAM (POSITIVE LOGIC)



SIMPLIFIED SCHEMATIC, EACH FET SWITCH (SW)



- A. Gate voltage (V_G) is equal to approximately $V_{CC} + V_T$ when the switch is ON and $V_I > V_{CC} + V_T$.
B. EN is the internal enable signal applied to the switch.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

over free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V_{CC}	Supply voltage range ⁽²⁾		−0.5	7	V
V_{IN}	Control input voltage range ⁽²⁾⁽³⁾		−0.5	7	V
$V_{I/O}$	Switch I/O voltage range ⁽²⁾⁽³⁾⁽⁴⁾		−0.5	7	V
I_{IK}	Control input clamp current	$V_{IN} < 0$		−50	mA
$I_{I/OK}$	I/O port clamp current	$V_{I/O} < 0$		−50	mA
$I_{I/O}$	ON-state switch current ⁽⁵⁾			±128	mA
	Continuous current through V_{CC} or GND			±100	mA
θ_{JA}	Package thermal impedance ⁽⁶⁾	DGG package		64	°C/W
		DGV package		48	
		GQL/ZQL package		42	
T_{stg}	Storage temperature range		−65	150	°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 voltages are with respect to ground, unless otherwise specified.
(3) The input and output voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
(4) V_I and V_O are used to denote specific conditions for $V_{I/O}$.
(5) I_I and I_O are used to denote specific conditions for $I_{I/O}$.
(6) The package thermal impedance is calculated in accordance with JESD 51-7.

RECOMMENDED OPERATING CONDITIONS⁽¹⁾

			MIN	MAX	UNIT
V_{CC}	Supply voltage		2.3	3.6	V
V_{IH}	High-level control input voltage	$V_{CC} = 2.3 \text{ V to } 2.7 \text{ V}$	1.7	5.5	V
		$V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$	2	5.5	
V_{IL}	Low-level control input voltage	$V_{CC} = 2.3 \text{ V to } 2.7 \text{ V}$	0	0.7	V
		$V_{CC} = 2.7 \text{ V to } 3.6 \text{ V}$	0	0.8	
$V_{I/O}$	Data input/output voltage		0	5.5	V
T_A	Operating free-air temperature		−40	85	°C

- (1) All unused control inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

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ELECTRICAL CHARACTERISTICS⁽¹⁾

PARAMETER		TEST CONDITIONS	MIN	TYP ⁽²⁾	MAX	UNIT
V_{IK}		$V_{CC} = 3\text{ V}$, $I_I = -18\text{ mA}$			-1.2	V
V_{OH}		See Figures 3 and 4				
I_{IN}	Control inputs	$V_{CC} = 3.6\text{ V}$, $V_{IN} = 3.6\text{ V}$ to 5.5 V or GND			± 10	μA
I_I		$V_{CC} = 3.6\text{ V}$, $V_{IN} = V_{CC}$ or GND, Switch ON	$V_I = V_{CC} - 0.7\text{ V}$ to 5.5 V		± 20	μA
			$V_I = 0.7\text{ V}$ to $V_{CC} - 0.7\text{ V}$		-40	
			$V_I = 0$ to 0.7 V		± 5	
$I_{OZ}^{(3)}$		$V_{CC} = 3.6\text{ V}$, $V_I = 0$, $V_{IN} = V_{CC}$ or GND, $V_O = 0$ to 5.5 V , Switch OFF			± 10	μA
I_{off}		$V_{CC} = 0$, $V_I = 0$, $V_O = 0$ to 5.5 V			10	μA
I_{CC}		$V_{CC} = 3.6\text{ V}$, $V_{IN} = V_{CC}$ or GND, $I_{I/O} = 0$, Switch ON or OFF	$V_I = V_{CC}$ or GND		70	μA
			$V_I = 5.5\text{ V}$		70	
$\Delta I_{CC}^{(4)}$	Control inputs	$V_{CC} = 3\text{ V}$ to 3.6 V , One input at $V_{CC} - 0.6\text{ V}$, Other inputs at V_{CC} or GND			300	μA
C_{in}	Control inputs	$V_{CC} = 3.3\text{ V}$, $V_{IN} = V_{CC}$ or GND		4		pF
$C_{iO(OFF)}$		$V_{CC} = 3.3\text{ V}$, $V_{IN} = V_{CC}$ or GND, $V_{I/O} = 5.5\text{ V}$, 3.3 V , or GND, Switch OFF		9		pF
$C_{iO(ON)}$		$V_{CC} = 3.3\text{ V}$, $V_{IN} = V_{CC}$ or GND, Switch ON	$V_{I/O} = 5.5\text{ V}$ or 3.3 V		8	pF
			$V_{I/O} = \text{GND}$		23	
$r_{ON}^{(5)}$		$V_{CC} = 2.3\text{ V}$, TYP at $V_{CC} = 2.5\text{ V}$, $V_I = 0$	$I_O = 24\text{ mA}$		5	Ω
			$I_O = 16\text{ mA}$		5	
		$V_{CC} = 3\text{ V}$, $V_I = 0$	$I_O = 64\text{ mA}$		5	
			$I_O = 32\text{ mA}$		5	

(1) V_{IN} and I_{IN} refer to control inputs. V_I , V_O , I_I , and I_O refer to data pins.

(2) All typical values are at $V_{CC} = 3.3\text{ V}$ (unless otherwise noted), $T_A = 25^\circ\text{C}$.

(3) For I/O ports, the parameter I_{OZ} includes the input leakage current.

(4) This is the increase in supply current for each input that is at the specified TTL voltage level, rather than V_{CC} or GND.

(5) Measured by the voltage drop between A and B terminals at the indicated current through the switch. ON-state resistance is determined by the lower of the voltages of the two (A or B) terminals.

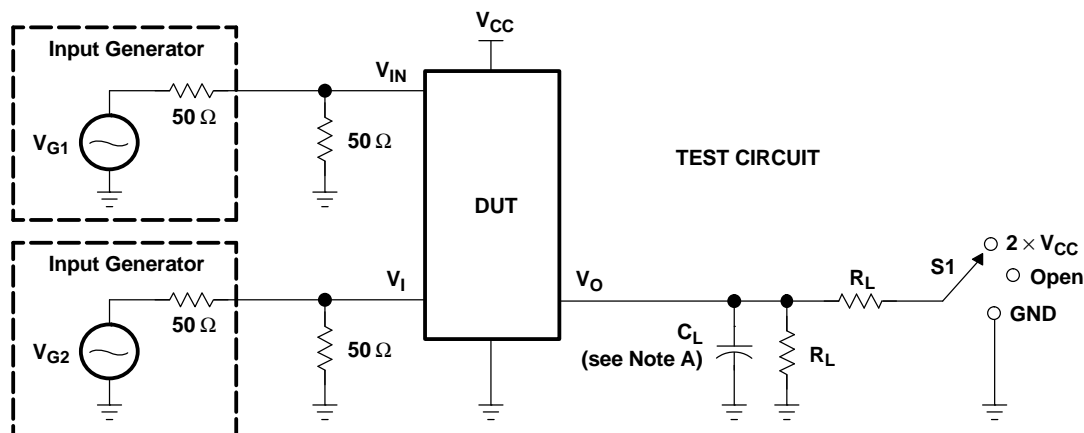
SWITCHING CHARACTERISTICS

over operating free-air temperature range (unless otherwise noted) (see Figure 2)

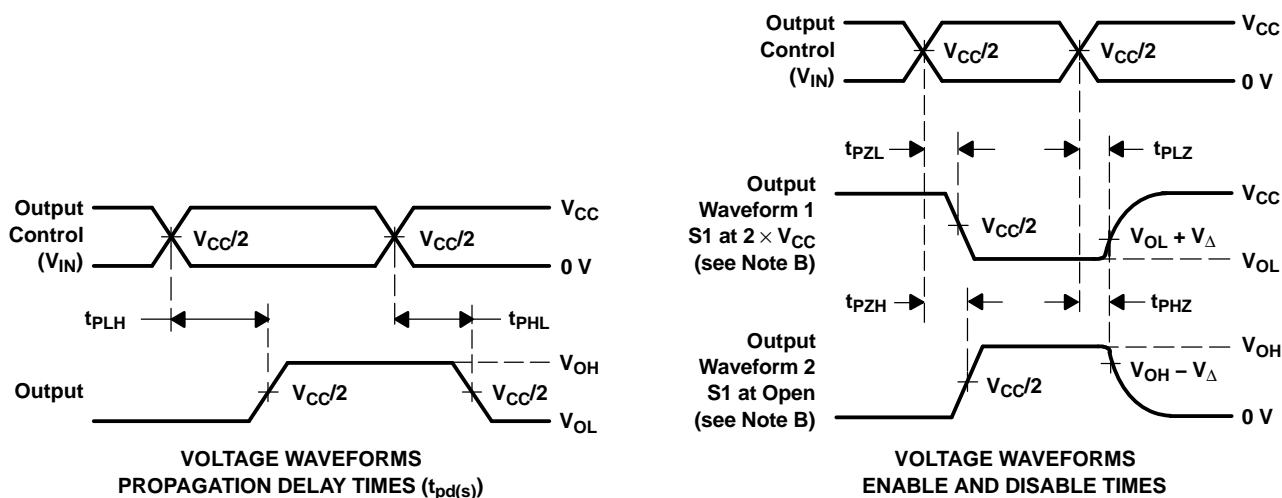
PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 2.5\text{ V} \pm 0.2\text{ V}$		$V_{CC} = 3.3\text{ V} \pm 0.3\text{ V}$		UNIT
			MIN	MAX	MIN	MAX	
$t_{pd}^{(1)}$	A or B	B or A		0.15		0.25	ns
$t_{pd(s)}$	S	A	1	15.5	1	11.5	ns
t_{en}	S	B	1	15	1	12	ns
t_{dis}	S	B	1	12	1	10.5	ns

(1) The propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).

PARAMETER MEASUREMENT INFORMATION



TEST	V_{CC}	$S1$	R_L	V_I	C_L	V_{Δ}
$t_{pd(s)}$	$2.5 \text{ V} \pm 0.2 \text{ V}$	Open	500 Ω	3.6 V or GND	30 pF	
	$3.3 \text{ V} \pm 0.3 \text{ V}$	Open	500 Ω	5.5 V or GND	50 pF	
t_{PLZ}/t_{PZL}	$2.5 \text{ V} \pm 0.2 \text{ V}$	$2 \times V_{CC}$	500 Ω	GND	30 pF	0.15 V
	$3.3 \text{ V} \pm 0.3 \text{ V}$	$2 \times V_{CC}$	500 Ω	GND	50 pF	0.3 V
t_{PHZ}/t_{PZH}	$2.5 \text{ V} \pm 0.2 \text{ V}$	Open	500 Ω	3.6 V	30 pF	0.15 V
	$3.3 \text{ V} \pm 0.3 \text{ V}$	Open	500 Ω	5.5 V	50 pF	0.3 V



- NOTES: A. C_L includes probe and jig capacitance.
 B. Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
 C. All input pulses are supplied by generators having the following characteristics: $PRR \leq 10 \text{ MHz}$, $Z_O = 50 \Omega$, $t_r \leq 2.5 \text{ ns}$, $t_f \leq 2.5 \text{ ns}$.
 D. The outputs are measured one at a time, with one transition per measurement.
 E. t_{PLZ} and t_{PHZ} are the same as t_{dis} .
 F. t_{PZL} and t_{PZH} are the same as t_{en} .
 G. t_{PLH} and t_{PHL} are the same as $t_{pd(s)}$. The t_{pd} propagation delay is the calculated RC time constant of the typical ON-state resistance of the switch and the specified load capacitance, when driven by an ideal voltage source (zero output impedance).
 H. All parameters and waveforms are not applicable to all devices.

Figure 2. Test Circuit and Voltage Waveforms

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WITH 5-V-TOLERANT LEVEL SHIFTER

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TYPICAL CHARACTERISTICS

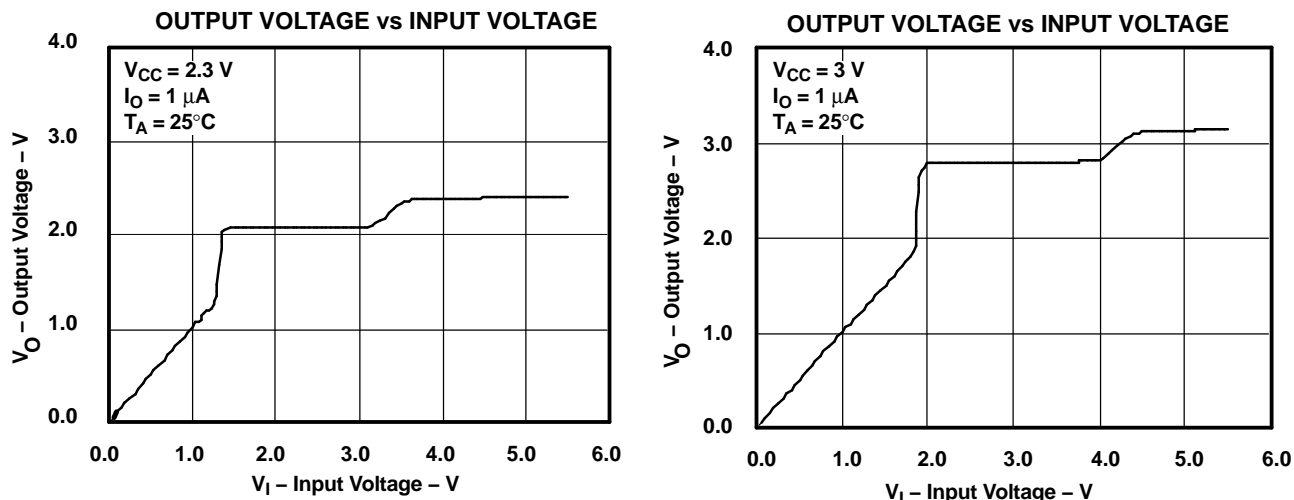


Figure 3. Data Output Voltage vs Data Input Voltage

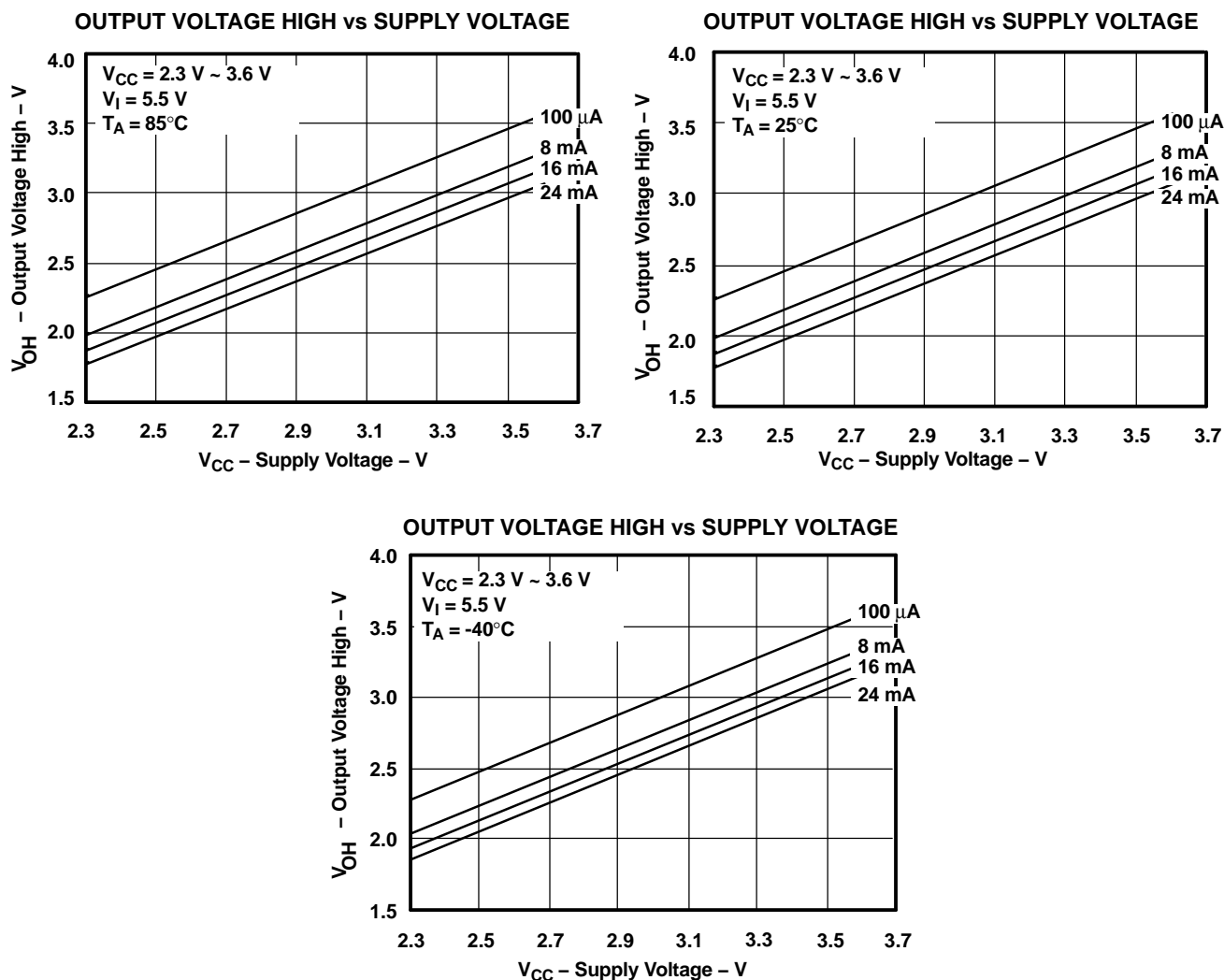


Figure 4. V_{OH} Values

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
74CB3T16212DGGRE4	ACTIVE	TSSOP	DGG	56	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
74CB3T16212DGVRE4	ACTIVE	TVSOP	DGV	56	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
SN74CB3T16212DGGR	ACTIVE	TSSOP	DGG	56	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
SN74CB3T16212DGVR	ACTIVE	TVSOP	DGV	56	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
SN74CB3T16212ZQLR	ACTIVE	VFBGA	ZQL	56	1000	Pb-Free (RoHS)	SNAGCU	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) 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.

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.

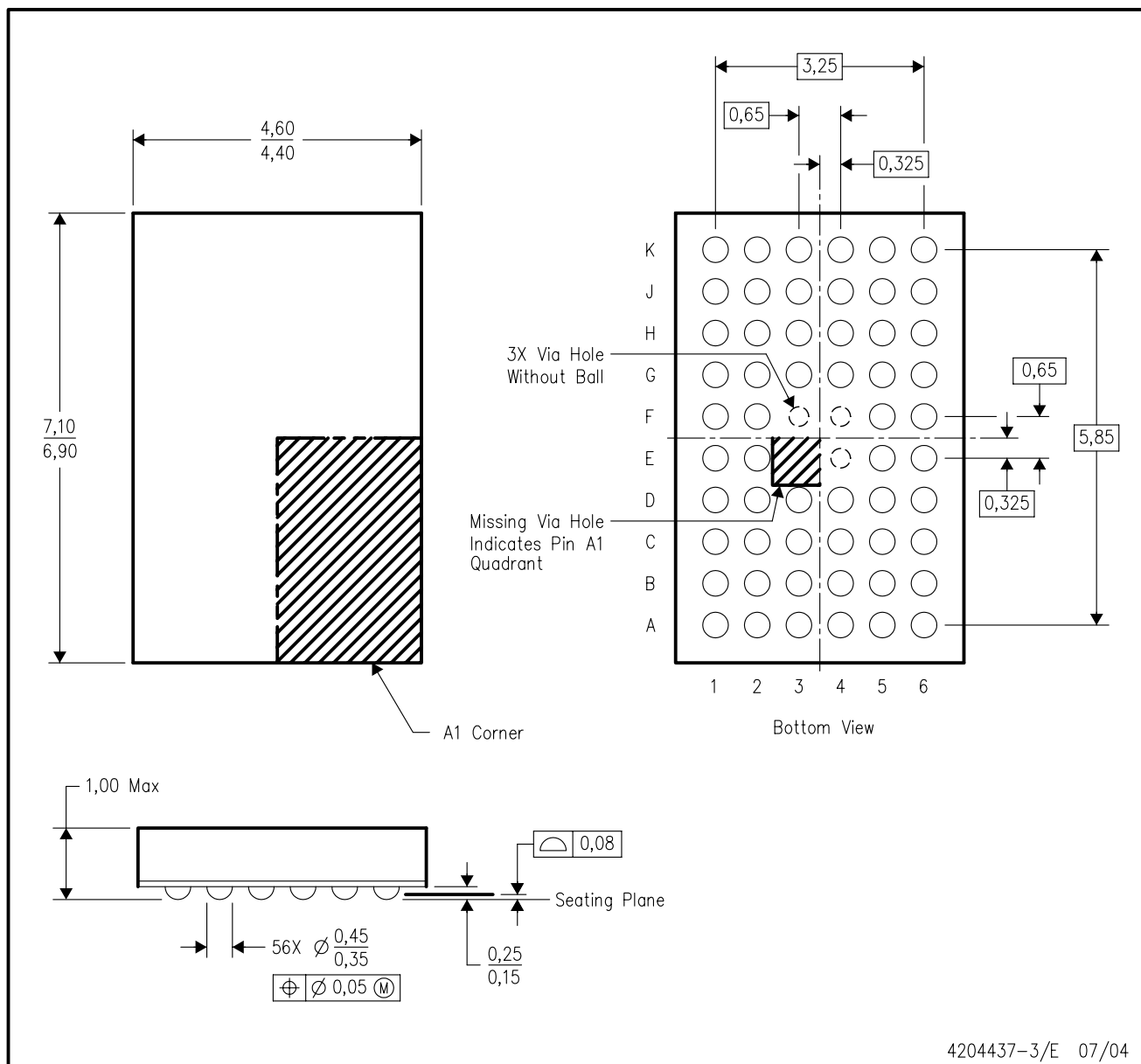
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MECHANICAL DATA

ZQL (R-PBGA-N56)

PLASTIC BALL GRID ARRAY



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Falls within JEDEC MO-225 variation BA.
 - D. This package is lead-free. Refer to the 56 GQL package (drawing 4200583) for tin-lead (SnPb).

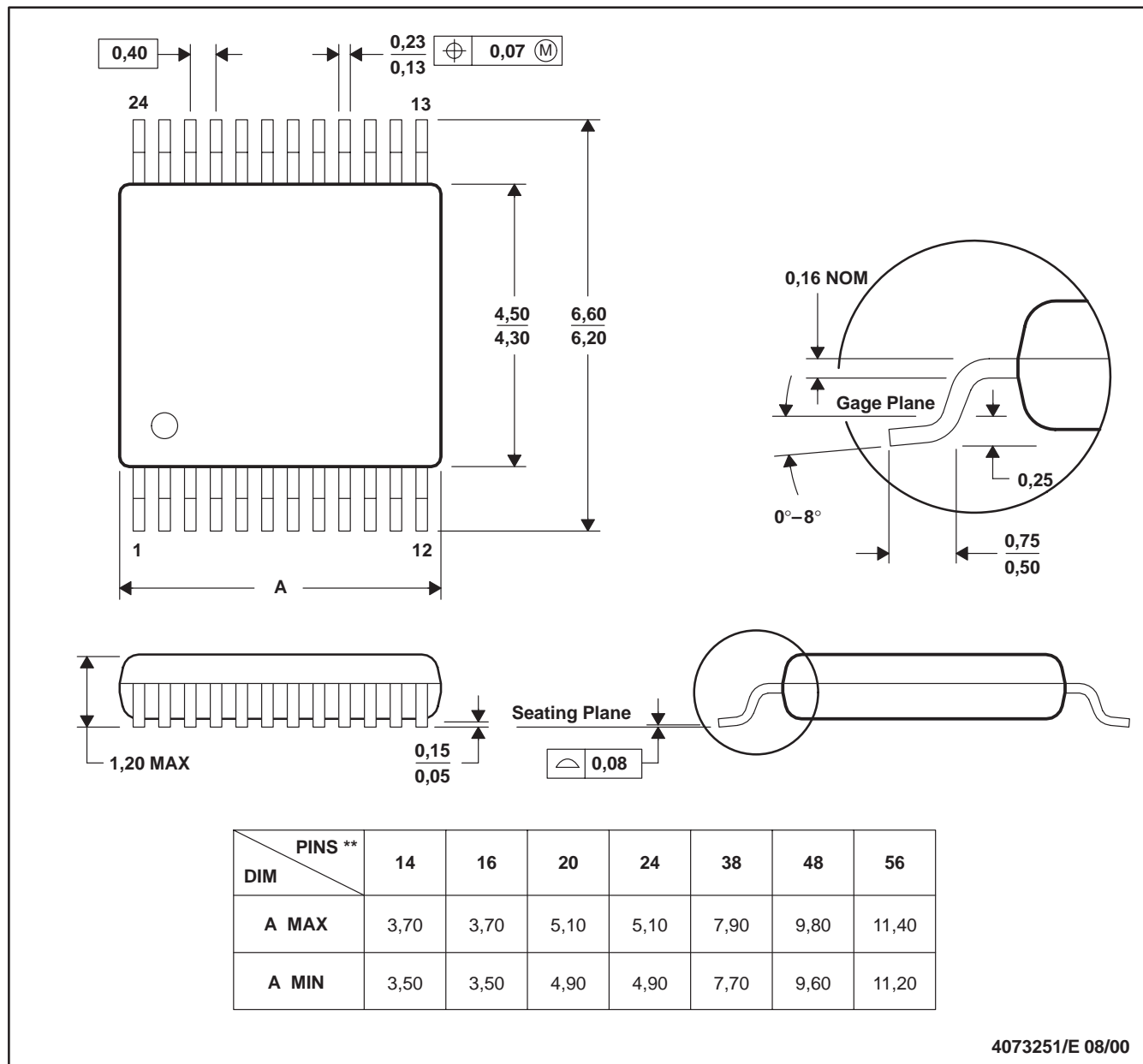
MECHANICAL DATA

MPDS006C – FEBRUARY 1996 – REVISED AUGUST 2000

DGV (R-PDSO-G**)

PLASTIC SMALL-OUTLINE

24 PINS SHOWN



- NOTES: A. All linear dimensions are in millimeters.
 B. This drawing is subject to change without notice.
 C. Body dimensions do not include mold flash or protrusion, not to exceed 0,15 per side.
 D. Falls within JEDEC: 24/48 Pins – MO-153
 14/16/20/56 Pins – MO-194

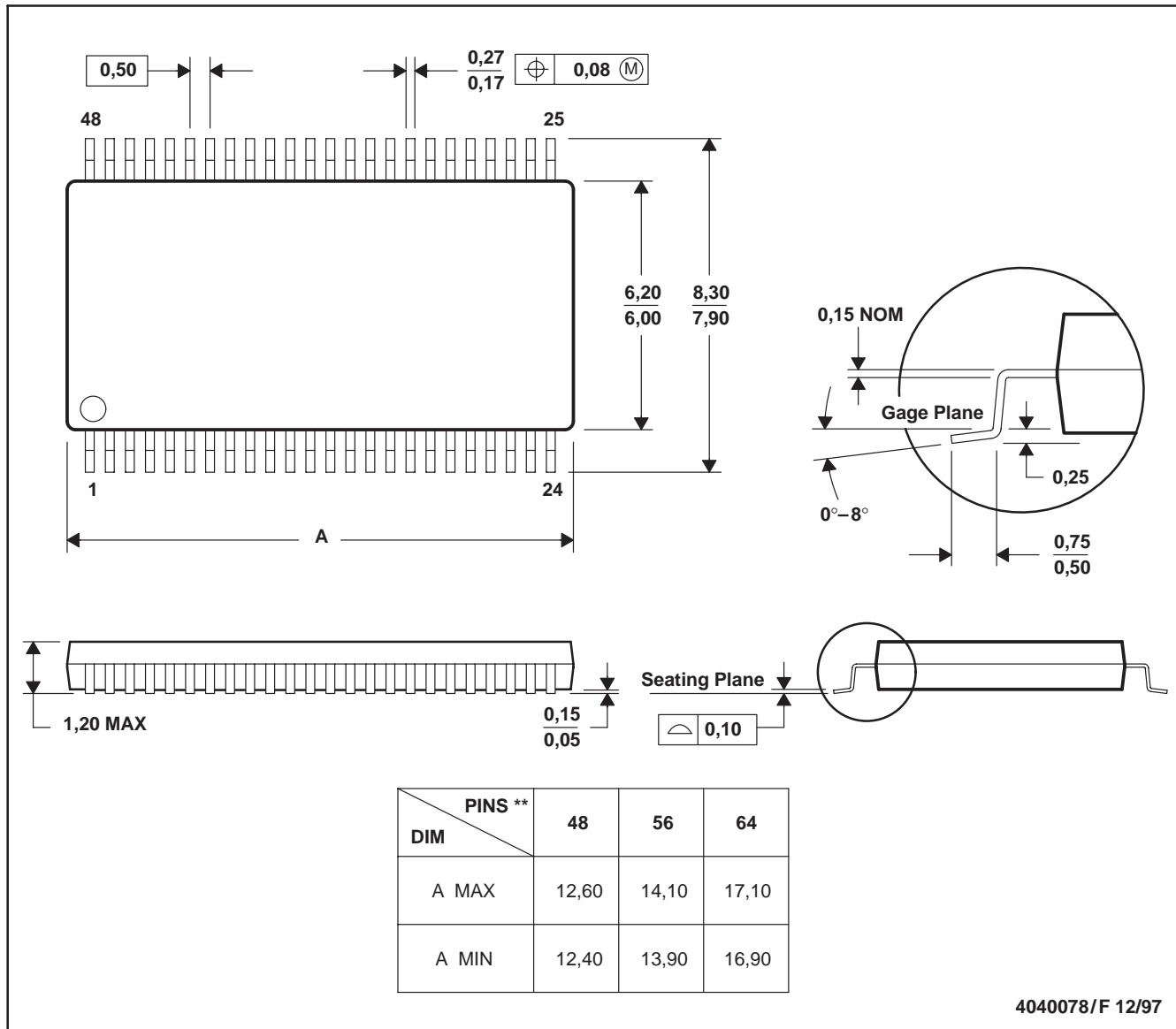
MECHANICAL DATA

MTSS003D – JANUARY 1995 – REVISED JANUARY 1998

DGG (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

48 PINS SHOWN



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Body dimensions do not include mold protrusion not to exceed 0,15.
 - D. Falls within JEDEC MO-153

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