

SN54LVTH162374, SN74LVTH162374 3.3-V ABT 16-BIT EDGE-TRIGGERED D-TYPE FLIP-FLOPS WITH 3-STATE OUTPUTS

SCBS262K – JULY 1993 – REVISED SEPTEMBER 2003

- Members of the Texas Instruments Widebus™ Family
- Output Ports Have Equivalent 22-Ω Series Resistors, So No External Resistors Are Required
- Support Mixed-Mode Signal Operation (5-V Input and Output Voltages With 3.3-V V_{CC})
- Support Unregulated Battery Operation Down to 2.7 V
- Typical V_{OLP} (Output Ground Bounce) <0.8 V at V_{CC} = 3.3 V, T_A = 25°C
- I_{off} and Power-Up 3-State Support Hot Insertion
- Bus Hold on Data Inputs Eliminates the Need for External Pullup/Pulldown Resistors
- Distributed V_{CC} and GND Pins Minimize High-Speed Switching Noise
- Flow-Through Architecture Optimizes PCB Layout
- Latch-Up Performance Exceeds 500 mA Per JESD 17
- ESD Protection Exceeds JESD 22
 - 2000-V Human-Body Model (A114-A)
 - 200-V Machine Model (A115-A)

SN54LVTH162374 . . . WD PACKAGE
SN74LVTH162374 . . . DGG OR DL PACKAGE
(TOP VIEW)

1OE	1	48	1CLK
1Q1	2	47	1D1
1Q2	3	46	1D2
GND	4	45	GND
1Q3	5	44	1D3
1Q4	6	43	1D4
V _{CC}	7	42	V _{CC}
1Q5	8	41	1D5
1Q6	9	40	1D6
GND	10	39	GND
1Q7	11	38	1D7
1Q8	12	37	1D8
2Q1	13	36	2D1
2Q2	14	35	2D2
GND	15	34	GND
2Q3	16	33	2D3
2Q4	17	32	2D4
V _{CC}	18	31	V _{CC}
2Q5	19	30	2D5
2Q6	20	29	2D6
GND	21	28	GND
2Q7	22	27	2D7
2Q8	23	26	2D8
2OE	24	25	2CLK

description/ordering information

The 'LVTH162374 devices are 16-bit edge-triggered D-type flip-flops with 3-state outputs designed for low-voltage (3.3-V) V_{CC} operation, but with the capability to provide a TTL interface to a 5-V system environment. They are particularly suitable for implementing buffer registers, I/O ports, bidirectional bus drivers, and working registers.

ORDERING INFORMATION

T _A	PACKAGE†		ORDERABLE PART NUMBER	TOP-SIDE MARKING
–40°C to 85°C	SSOP – DL	Tube	SN74LVTH162374DL	LVTH162374
		Tape and reel	SN74LVTH162374DLR	
	TSSOP – DGG	Tape and reel	SN74LVTH162374DGGR	LVTH162374
	VFBGA – GQL	Tape and reel	SN74LVTH162374KR	LL2374
	VFBGA – ZQL (Pb-free)		74LVTH162374ZQLR	
–55°C to 125°C	CFP – WD	Tube	SNJ54LVTH162374WD	SNJ54LVTH162374WD

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



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description/ordering information (continued)

These devices can be used as two 8-bit flip-flops or one 16-bit flip-flop. On the positive transition of the clock (CLK), the Q outputs of the flip-flop take on the logic levels set up at the D inputs.

A buffered output-enable ($\overline{OE}$) input can be used to place the eight outputs in either a normal logic state (high or low logic levels) or a high-impedance state. In the high-impedance state, the outputs neither load nor drive the bus lines significantly. The high-impedance state and the increased drive provide the capability to drive bus lines without need for interface or pullup components.

$\overline{OE}$ does not affect internal operations of the flip-flop. Old data can be retained or new data can be entered while the outputs are in the high-impedance state.

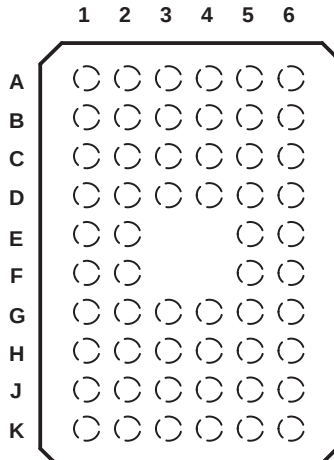
The outputs, which are designed to source or sink up to 12 mA, include equivalent 22- Ω series resistors to reduce overshoot and undershoot.

Active bus-hold circuitry holds unused or undriven inputs at a valid logic state. Use of pullup or pulldown resistors with the bus-hold circuitry is not recommended.

When V_{CC} is between 0 and 1.5 V, the devices are in the high-impedance state during power up or power down. However, to ensure the high-impedance state above 1.5 V, $\overline{OE}$ should be tied to V_{CC} through a pullup resistor; the minimum value of the resistor is determined by the current-sinking capability of the driver.

These devices are fully specified for hot-insertion applications using I_{off} and power-up 3-state. The I_{off} circuitry disables the outputs, preventing damaging current backflow through the devices when they are powered down. The power-up 3-state circuitry places the outputs in the high-impedance state during power up and power down, which prevents driver conflict.

GQL OR ZQL PACKAGE (TOP VIEW)



terminal assignments

	1	2	3	4	5	6
A	$1\overline{OE}$	NC	NC	NC	NC	1CLK
B	1Q2	1Q1	GND	GND	1D1	1D2
C	1Q4	1Q3	V_{CC}	V_{CC}	1D3	1D4
D	1Q6	1Q5	GND	GND	1D5	1D6
E	1Q8	1Q7			1D7	1D8
F	2Q1	2Q2			2D2	2D1
G	2Q3	2Q4	GND	GND	2D4	2D3
H	2Q5	2Q6	V_{CC}	V_{CC}	2D6	2D5
J	2Q7	2Q8	GND	GND	2D8	2D7
K	2 $\overline{OE}$	NC	NC	NC	NC	2CLK

NC – No internal connection

FUNCTION TABLE (each flip-flop)

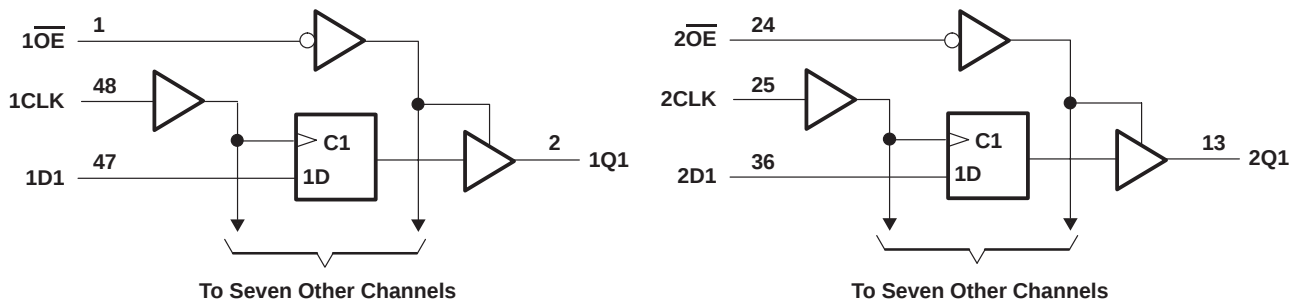
INPUTS			OUTPUT Q
$\overline{OE}$	CLK	D	
L	$\uparrow$	H	H
L	$\uparrow$	L	L
L	H or L	X	Q_0
H	X	X	Z

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logic diagram (positive logic)



Pin numbers shown are for the DGG, DL, and WD packages.

absolute maximum ratings over operating free-air temperature range (unless otherwise noted)[†]

Supply voltage range, V_{CC}	–0.5 V to 4.6 V
Input voltage range, V_I (see Note 1)	–0.5 V to 7 V
Voltage range applied to any output in the high-impedance or power-off state, V_O (see Note 1)	–0.5 V to 7 V
Voltage range applied to any output in the high state, V_O (see Note 1)	–0.5 V to $V_{CC} + 0.5$ V
Current into any output in the low state, I_O	30 mA
Current into any output in the high state, I_O (see Note 2)	30 mA
Input clamp current, I_{IK} ($V_I < 0$)	–50 mA
Output clamp current, I_{OK} ($V_O < 0$)	–50 mA
Package thermal impedance, θ_{JA} (see Note 3): DGG package	70°C/W
DL package	63°C/W
GQL/ZQL package	42°C/W
Storage temperature range, T_{Stg}	–65°C to 150°C

[†] 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.

- NOTES: 1. The input and output negative-voltage ratings may be exceeded if the input and output clamp-current ratings are observed.
 2. This current flows only when the output is in the high state and $V_O > V_{CC}$.
 3. The package thermal impedance is calculated in accordance with JESD 51-7.

recommended operating conditions (see Note 4)

		SN54LVTH162374		SN74LVTH162374		UNIT
		MIN	MAX	MIN	MAX	
V_{CC}	Supply voltage	2.7	3.6	2.7	3.6	V
V_{IH}	High-level input voltage	2		2		V
V_{IL}	Low-level input voltage		0.8		0.8	V
V_I	Input voltage		5.5		5.5	V
I_{OH}	High-level output current		–12		–12	mA
I_{OL}	Low-level output current		12		12	mA
$\Delta t/\Delta v$	Input transition rise or fall rate	Outputs enabled			10	ns/V
$\Delta t/\Delta V_{CC}$	Power-up ramp rate	200		200		μs/V
T_A	Operating free-air temperature	–55	125	–40	85	°C

NOTE 4: 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 over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER		TEST CONDITIONS	SN54LVTH162374			SN74LVTH162374			UNIT
			MIN	TYP†	MAX	MIN	TYP†	MAX	
V_{IK}		$V_{CC} = 2.7\text{ V}$, $I_I = -18\text{ mA}$			-1.2			-1.2	V
V_{OH}		$V_{CC} = 3\text{ V}$, $I_{OH} = -12\text{ mA}$	2			2			V
V_{OL}		$V_{CC} = 3\text{ V}$, $I_{OL} = 12\text{ mA}$			0.8			0.8	V
I_I		$V_{CC} = 0\text{ or }3.6\text{ V}$, $V_I = 5.5\text{ V}$			10			10	μA
	Control inputs	$V_{CC} = 3.6\text{ V}$, $V_I = V_{CC}\text{ or GND}$			± 1			± 1	
	Data inputs	$V_{CC} = 3.6\text{ V}$, $V_I = V_{CC}$ $V_I = 0$			1 -5			1 -5	
I_{off}		$V_{CC} = 0$, $V_I\text{ or }V_O = 0\text{ to }4.5\text{ V}$						± 100	μA
$I_{I(hold)}$	Data inputs	$V_{CC} = 3\text{ V}$, $V_I = 0.8\text{ V}$	75			75			μA
		$V_{CC} = 3\text{ V}$, $V_I = 2\text{ V}$	-75			-75			
		$V_{CC} = 3.6\text{ V}^\ddagger$, $V_I = 0\text{ to }3.6\text{ V}$						500 -750	
I_{OZH}		$V_{CC} = 3.6\text{ V}$, $V_O = 3\text{ V}$			5			5	μA
I_{OZL}		$V_{CC} = 3.6\text{ V}$, $V_O = 0.5\text{ V}$			-5			-5	μA
I_{OZPU}		$V_{CC} = 0\text{ to }1.5\text{ V}$, $V_O = 0.5\text{ V to }3\text{ V}$, $OE = \text{don't care}$			$\pm 100^*$			± 100	μA
I_{OZPD}		$V_{CC} = 1.5\text{ V to }0$, $V_O = 0.5\text{ V to }3\text{ V}$, $OE = \text{don't care}$			$\pm 100^*$			± 100	μA
I_{CC}		$V_{CC} = 3.6\text{ V}$, $I_O = 0$, $V_I = V_{CC}\text{ or GND}$							mA
		Outputs high			0.19			0.19	
		Outputs low			5			5	
		Outputs disabled			0.19			0.19	
$\Delta I_{CC}^\S$		$V_{CC} = 3\text{ V to }3.6\text{ V}$, One input at $V_{CC} - 0.6\text{ V}$, Other inputs at $V_{CC}\text{ or GND}$			0.2			0.2	mA
C_i		$V_I = 3\text{ V or }0$			3			3	pF
C_o		$V_O = 3\text{ V or }0$			9			9	pF

* On products compliant to MIL-PRF-38535, this parameter is not production tested.

† All typical values are at $V_{CC} = 3.3\text{ V}$, $T_A = 25^\circ\text{C}$.

‡ This is the bus-hold maximum dynamic current. It is the minimum overdrive current required to switch the input from one state to another.

§ This is the increase in supply current for each input that is at the specified TTL voltage level, rather than $V_{CC}\text{ or GND}$.

timing requirements over recommended operating free-air temperature range (unless otherwise noted) (see Figure 1)

			SN54LVTH162374				SN74LVTH162374				UNIT
			V _{CC} = 3.3 V ± 0.3 V		V _{CC} = 2.7 V		V _{CC} = 3.3 V ± 0.3 V		V _{CC} = 2.7 V		
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
f _{clock}	Clock frequency		160		160		160		160		MHz
t _w	Pulse duration, CLK high or low		3		3.3		3		3		ns
t _{su}	Setup time, data before CLK↑	High or low	2.8		3.2		1.8		2		ns
t _h	Hold time, data after CLK↑	High or low	1.2		0.5		0.8		0.1		ns



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switching characteristics over recommended operating free-air temperature range, $C_L = 50$ pF (unless otherwise noted) (see Figure 1)

PARAMETER	FROM (INPUT)	TO (OUTPUT)	SN54LVTH162374				SN74LVTH162374				UNIT	
			V _{CC} = 3.3 V ± 0.3 V		V _{CC} = 2.7 V		V _{CC} = 3.3 V ± 0.3 V			V _{CC} = 2.7 V		
			MIN	MAX	MIN	MAX	MIN	TYP†	MAX	MIN		MAX
f _{max}			160		160		160		160		MHz	
t _{PLH}	CLK	Q	1.4	6.6	7.4	2	3.4	5.3	6.2	ns		
t _{PHL}			1.4	5.8	6	2.2	3.3	4.9	5.1			
t _{PZH}	$\overline{OE}$	Q	1	6.6	7.4	1.8	3.5	5.6	6.9	ns		
t _{PZL}			1.4	6	6.8	1.8	3.5	4.9	6			
t _{PHZ}	$\overline{OE}$	Q	1	6.6	7.4	2.4	4.2	5.4	5.7	ns		
t _{PLZ}			1.4	6	6	2	3.8	5	5.1			
t _{sk(o)}							0.5			ns		

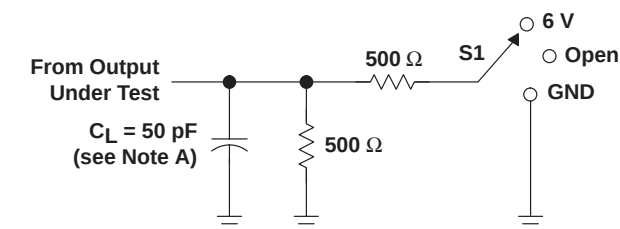
[†] All typical values are at $V_{CC} = 3.3\text{ V}$, $T_A = 25^\circ\text{C}$.

SN54LVTH162374, SN74LVTH162374

3.3-V ABT 16-BIT EDGE-TRIGGERED D-TYPE FLIP-FLOPS WITH 3-STATE OUTPUTS

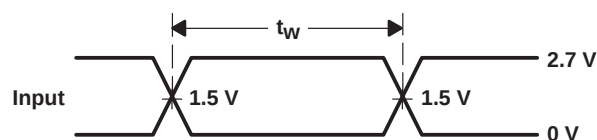
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PARAMETER MEASUREMENT INFORMATION

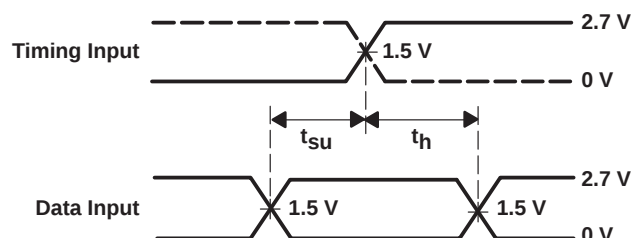


LOAD CIRCUIT

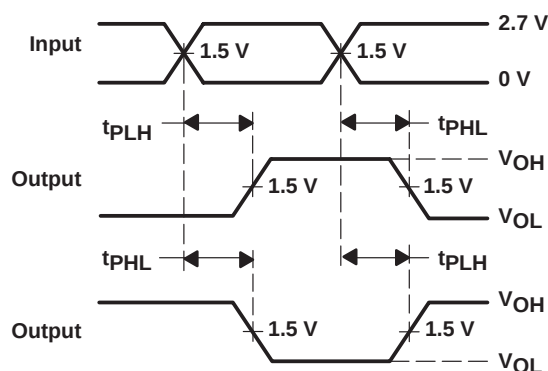
TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	6 V
t_{PHZ}/t_{PZH}	GND



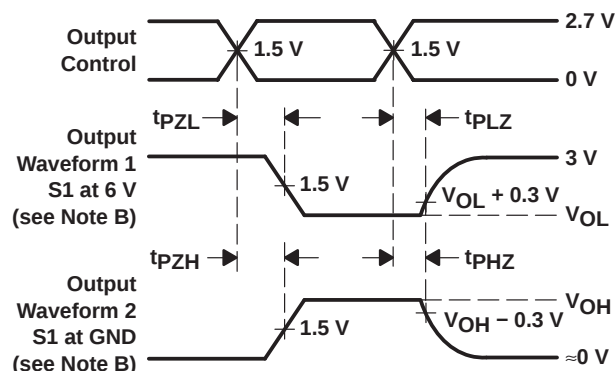
VOLTAGE WAVEFORMS
PULSE DURATION



VOLTAGE WAVEFORMS
SETUP AND HOLD TIMES



VOLTAGE WAVEFORMS
PROPAGATION DELAY TIMES
INVERTING AND NONINVERTING OUTPUTS



VOLTAGE WAVEFORMS
ENABLE AND DISABLE TIMES
LOW- AND HIGH-LEVEL ENABLING

- 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.

Figure 1. Load Circuit and Voltage Waveforms

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
5962-9854201QXA	ACTIVE	CFP	WD	48	1	None	Call TI	Level-NC-NC-NC
5962-9854201VXA	ACTIVE	CFP	WD	48	1	None	Call TI	Level-NC-NC-NC
74LVTH162374ZQLR	ACTIVE	VFBGA	ZQL	56	1000	Pb-Free (RoHS)	SNAGCU	Level-1-260C-UNLIM
SN74LVTH162374DGGR	ACTIVE	TSSOP	DGG	48	2000	Pb-Free (RoHS)	CU NIPDAU	Level-1-250C-UNLIM
SN74LVTH162374DL	ACTIVE	SSOP	DL	48	25	None	CU NIPDAU	Level-1-235C-UNLIM
SN74LVTH162374DLR	ACTIVE	SSOP	DL	48	1000	None	CU NIPDAU	Level-1-235C-UNLIM
SN74LVTH162374KR	ACTIVE	VFBGA	GQL	56	1000	None	SNPB	Level-1-240C-UNLIM
SNJ54LVTH162374WD	ACTIVE	CFP	WD	48	1	None	Call TI	Level-NC-NC-NC

⁽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 - May not be currently available - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

None: Not yet available Lead (Pb-Free).

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" and in addition, uses package materials that do not contain halogens, including bromine (Br) or antimony (Sb) above 0.1% of total product weight.

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

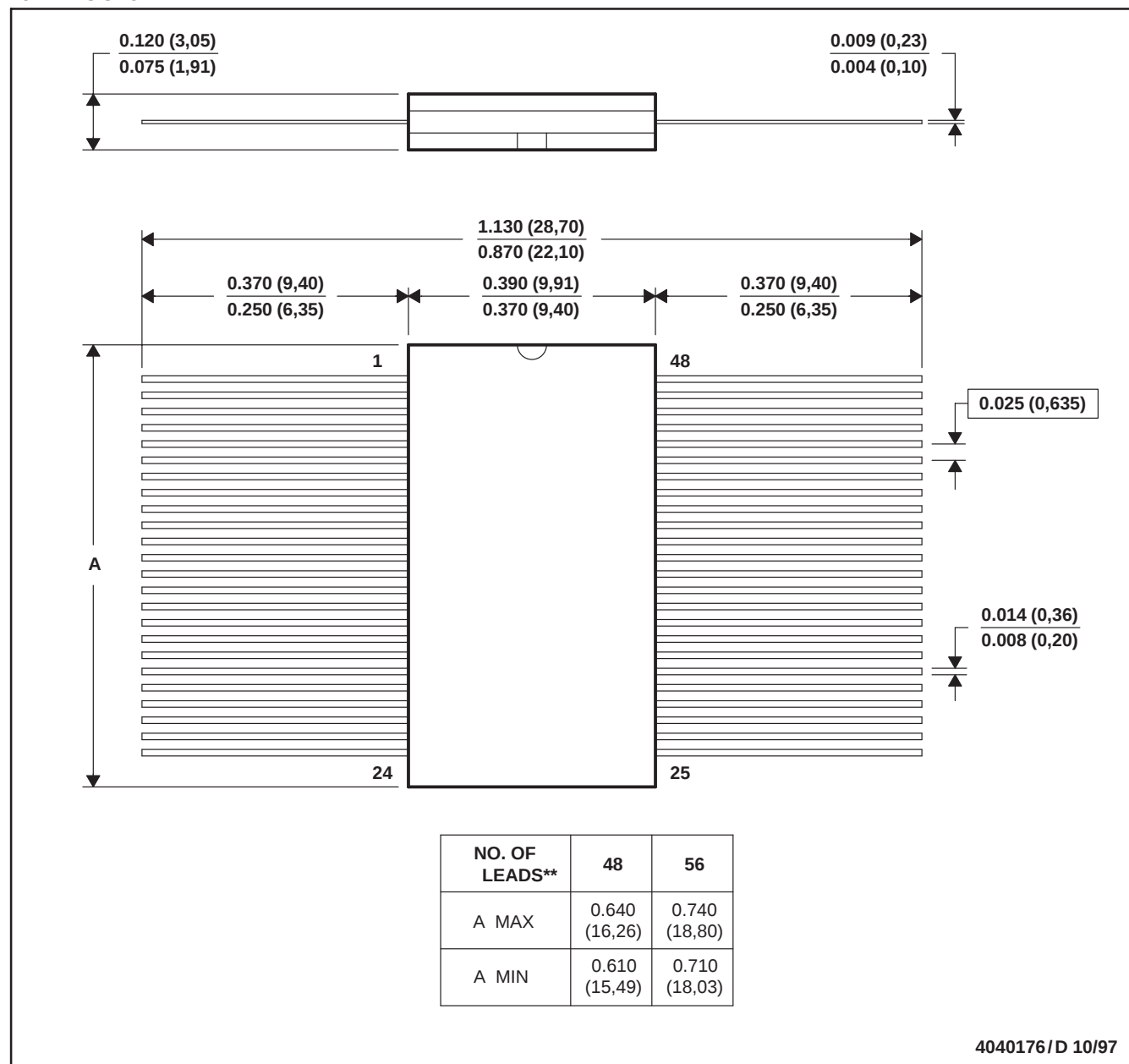
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WD (R-GDFP-F**)

CERAMIC DUAL FLATPACK

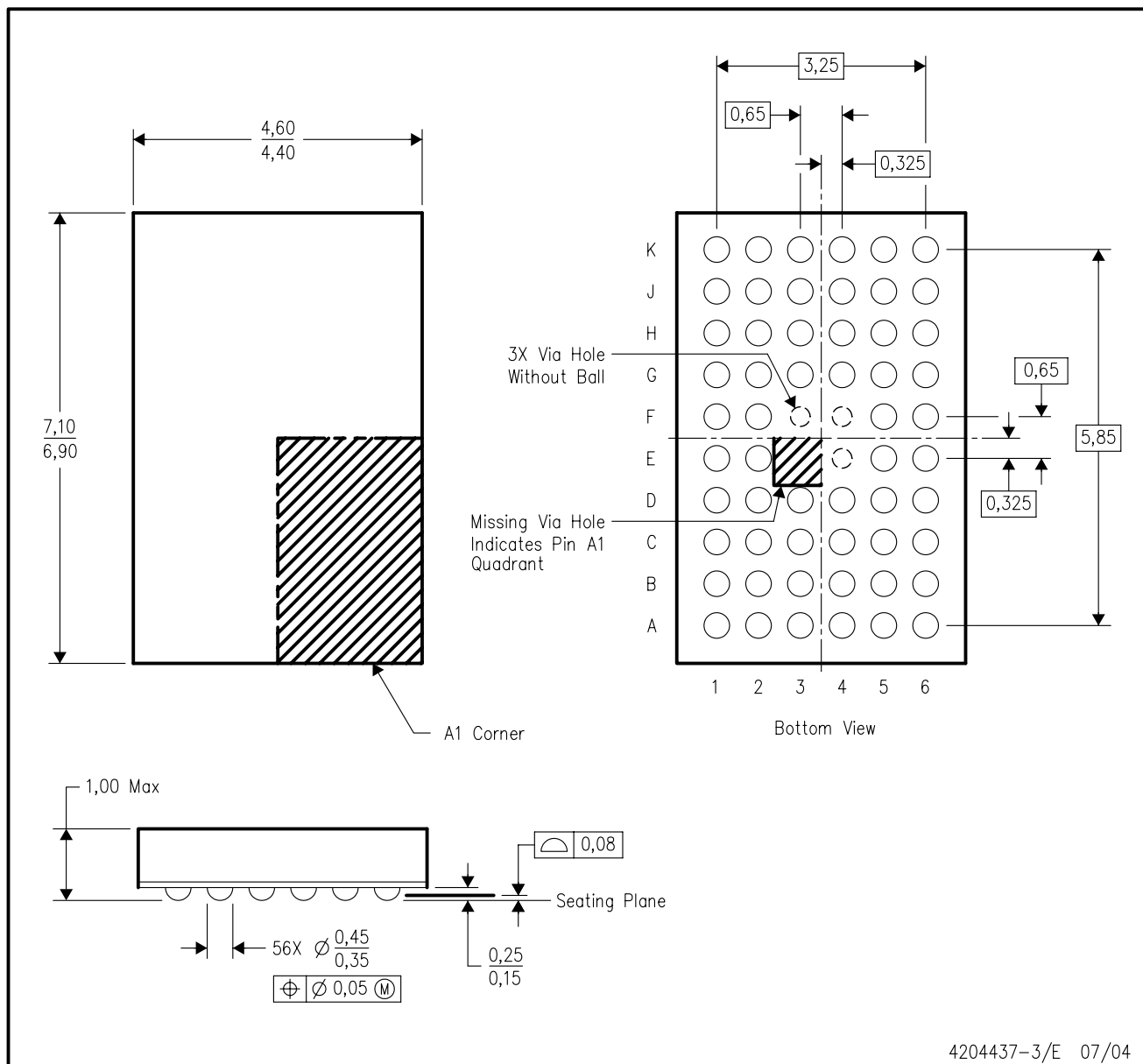
48 LEADS SHOWN



- NOTES:
- All linear dimensions are in inches (millimeters).
 - This drawing is subject to change without notice.
 - This package can be hermetically sealed with a ceramic lid using glass frit.
 - Index point is provided on cap for terminal identification only
 - Falls within MIL STD 1835: GDFP1-F48 and JEDEC MO-146AA
GDFP1-F56 and JEDEC MO-146AB

ZQL (R-PBGA-N56)

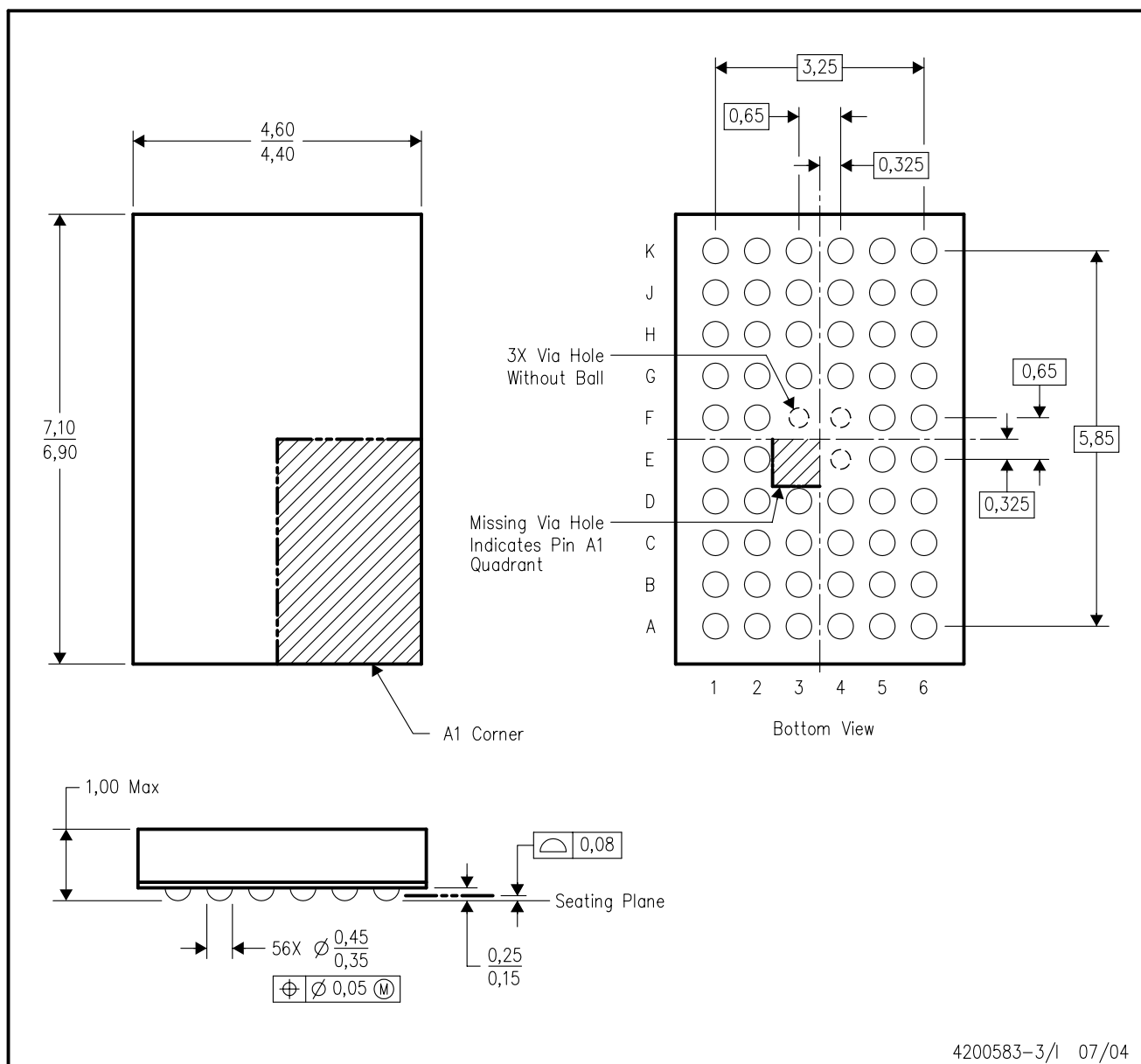
PLASTIC BALL GRID ARRAY



- 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).

GQL (R-PBGA-N56)

PLASTIC BALL GRID ARRAY

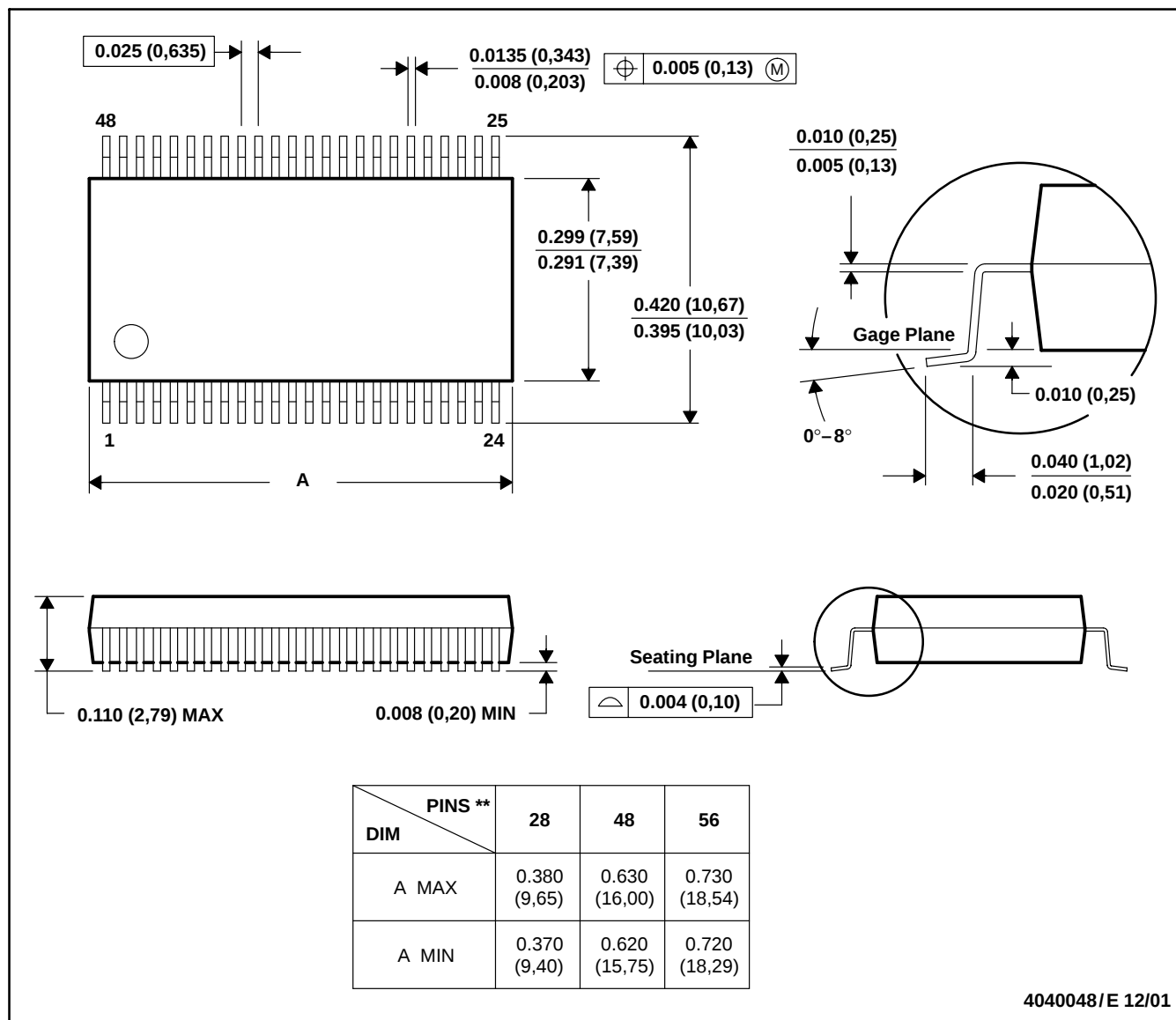


- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Falls within JEDEC MO-225 variation BA.
 - This package is tin-lead (SnPb). Refer to the 56 ZQL package (drawing 4204437) for lead-free.

DL (R-PDSO-G**)

PLASTIC SMALL-OUTLINE PACKAGE

48 PINS SHOWN



- 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 MO-118

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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