

# MAXIM

## Quad Differential LVECL/LVPECL Buffer/Receivers

### General Description

The MAX9400/MAX9402/MAX9403/MAX9405 are extremely fast, low-skew quad LVECL/ECL or LVPECL/PECL buffer/receivers designed for high-speed data and clock driver applications. These devices feature an ultra-low propagation delay of 335ps and channel-to-channel skew of 16ps in asynchronous mode with 86mA supply current.

The four channels can be operated synchronously with an external clock, or in asynchronous mode determined by the state of the SEL input. An enable input provides the ability to force all the outputs to a differential low state.

A variety of input and output terminations are offered for maximum design flexibility. The MAX9400 has open inputs and open emitter outputs. The MAX9402 has open inputs and 50Ω series outputs. The MAX9403 has 100Ω differential input impedance and open emitter outputs. The MAX9405 has 100Ω differential input impedance and 50Ω series outputs.

These devices operate with a supply voltage of ( $V_{CC} - V_{EE}$ ) = 2.375V to 5.5V, and are specified for operation from -40°C to +85°C. These devices are offered in space-saving 32-pin 5mm x 5mm TQFP and 32-lead 5mm x 5mm QFN packages.

### Applications

Data and Clock Driver and Buffer  
 Central Office Backplane Clock Distribution  
 DSLAM Backplane  
 Base Station  
 ATE

Functional Diagram appears at end of data sheet.

### Features

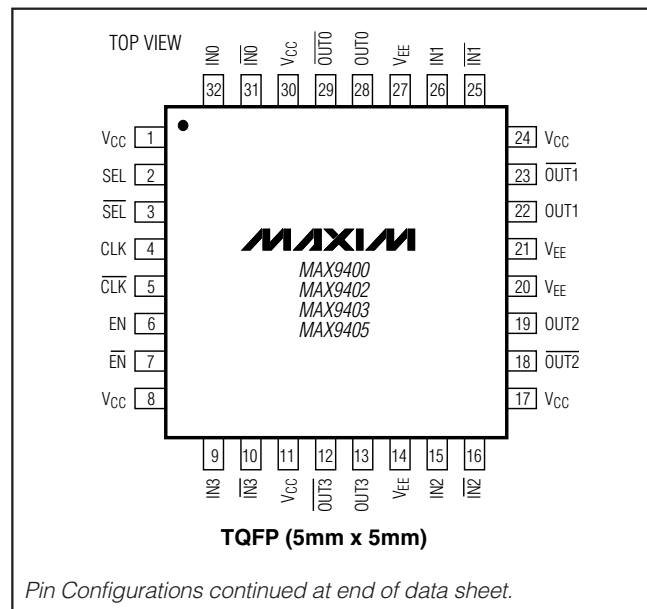
- ◆ 400mV Differential Output at 3.0GHz Data Rate
- ◆ 335ps Propagation Delay in Asynchronous Mode
- ◆ 8ps Channel-to-Channel Skew in Synchronous Mode
- ◆ Integrated 50Ω Outputs (MAX9402/MAX9405)
- ◆ Integrated 100Ω Inputs (MAX9403/MAX9405)
- ◆ Synchronous/Asynchronous Operation

### Ordering Information

PART	TEMP RANGE	PIN-PACKAGE	DATA INPUT	OUTPUT
MAX9400EHJ	-40°C to +85°C	32 TQFP	Open	Open
MAX9400EGJ*	-40°C to +85°C	32 QFN	Open	Open
MAX9402EHJ	-40°C to +85°C	32 TQFP	Open	50Ω
MAX9402EGJ*	-40°C to +85°C	32 QFN	Open	50Ω
MAX9403EHJ	-40°C to +85°C	32 TQFP	100Ω	Open
MAX9403EGJ*	-40°C to +85°C	32 QFN	100Ω	Open
MAX9405EHJ	-40°C to +85°C	32 TQFP	100Ω	50Ω
MAX9405EGJ*	-40°C to +85°C	32 QFN	100Ω	50Ω

\*Future product—contact factory for availability.

### Pin Configurations



MAX9400/MAX9402/MAX9403/MAX9405

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## ABSOLUTE MAXIMUM RATINGS

V <sub>CC</sub> to V <sub>EE</sub> .....	-0.3V to +6V	Junction-to-Ambient Thermal Resistance with 500LFPM Airflow	
Inputs to V <sub>EE</sub> .....	-0.3V to (V <sub>CC</sub> + 0.3V)	32-Pin 5mm x 5mm TQFP.....	+73°C/W
Differential Input Voltage .....	±3V	Junction-to-Case Thermal Resistance	
Continuous Output Current.....	50mA	32-Pin 5mm x 5mm TQFP.....	+25°C/W
Surge Output Current.....	100mA	32-Lead 5mm x 5mm QFN .....	+2°C/W
Continuous Power Dissipation (T <sub>A</sub> = +70°C)		Operating Temperature Range .....	-40°C to +85°C
32-Pin 5mm x 5mm TQFP		Junction Temperature.....	+150°C
(derate 9.5mW/°C above +70°C).....	761mW	Storage Temperature Range .....	-65°C to +150°C
32-Lead 5mm x 5mm QFN		ESD Protection	
(derate 21.3mW/°C above +70°C).....	1.7W	Human Body Model (Inputs and Outputs) .....	2kV
Junction-to-Ambient Thermal Resistance in Still Air		Soldering Temperature (10s).....	+300°C
32-Pin 5mm x 5mm TQFP .....	+105°C/W		
32-Lead 5mm x 5mm QFN .....	+47°C/W		

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 in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## DC ELECTRICAL CHARACTERISTICS

(V<sub>CC</sub> - V<sub>EE</sub> = 2.375V to 5.5V, MAX9400/MAX9403 outputs terminated with 50Ω ±1% to V<sub>CC</sub> - 2.0V. Typical values are at V<sub>CC</sub> - V<sub>EE</sub> = 3.3V, V<sub>IHD</sub> = V<sub>CC</sub> - 0.9V, V<sub>I LD</sub> = V<sub>CC</sub> - 1.7V, T<sub>A</sub> = +25°C, unless otherwise noted.) (Notes 1, 2, and 3)

PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
<b>INPUTS (IN<sub>-</sub>, IN<sub>-</sub>, CLK, CLK, EN, EN, SEL, SEL)</b>							
Differential Input High Voltage	V <sub>IHD</sub>	Figure 1		V <sub>EE</sub> + 1.4		V <sub>CC</sub>	V
Differential Input Low Voltage	V <sub>I LD</sub>	Figure 1		V <sub>EE</sub>		V <sub>CC</sub> - 0.2	V
Differential Input Voltage	V <sub>ID</sub>	Figure 1	V <sub>CC</sub> - V <sub>EE</sub> < +3.0V	0.2		V <sub>CC</sub> - V <sub>EE</sub>	V
			V <sub>CC</sub> - V <sub>EE</sub> ≥ +3.0V	0.2		3.0	
Input Current	I <sub>IH</sub> , I <sub>IL</sub>	MAX9400/ MAX9402	EN, EN, SEL, SEL, IN <sub>-</sub> , IN <sub>-</sub> , CLK, or CLK = V <sub>IHD</sub> or V <sub>I LD</sub>	-10		25	μA
		MAX9403/ MAX9405	EN, EN, SEL, SEL, CLK, or CLK = V <sub>IHD</sub> or V <sub>I LD</sub>	-10		25	
Differential Input Resistance	R <sub>IN</sub>	MAX9403/MAX9405		86		114	Ω
<b>OUTPUTS (OUT<sub>-</sub>, OUT<sub>-</sub>)</b>							
Differential Output Voltage	V <sub>OH</sub> - V <sub>OL</sub>	Figure 1		600	660		mV
Output Common-Mode Voltage	V <sub>OCM</sub>	Figure 1		V <sub>CC</sub> - 1.5	V <sub>CC</sub> - 1.25	V <sub>CC</sub> - 1.1	V
Internal Current Source	I <sub>SINK</sub>	MAX9402/MAX9405, Figure 2		6.5	8.3	10	mA
Output Impedance	R <sub>OUT</sub>	MAX9402/MAX9405, Figure 2		40	50	60	Ω
<b>POWER SUPPLY</b>							
Supply Current	I <sub>EE</sub>	MAX9402/MAX9405			150	180	mA
		MAX9400/MAX9403			86	118	

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MAX9400/MAX9402/MAX9403/MAX9405

## AC ELECTRICAL CHARACTERISTICS

( $V_{CC} - V_{EE} = 2.375V$  to  $5.5V$ , outputs terminated with  $50\Omega \pm 1\%$  to  $V_{CC} - 2.0V$ , enabled,  $CLK = 3.2GHz$ ,  $f_{IN} = 1.6GHz$ , input transition time =  $125ps$  (20% to 80%),  $V_{IHD} = V_{EE} + 1.2V$  to  $V_{CC}$ ,  $V_{ILD} = V_{EE}$  to  $V_{CC} - 0.2V$ ,  $V_{IHD} - V_{ILD} = 0.2V$  to smaller of  $V_{CC} - V_{EE}$  or  $3V$ , unless otherwise noted. Typical values are at  $V_{CC} - V_{EE} = 3.3V$ ,  $V_{IHD} = V_{CC} - 0.9V$ ,  $V_{ILD} = V_{CC} - 1.7V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.) (Notes 1, 4)

PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNITS
IN-to-OUT Differential Propagation Delay	$t_{PLH1}$	MAX9400/MAX9403	237	335	437	ps
	$t_{PHL1}$	MAX9402/MAX9405				
CLK-to-OUT Differential Propagation Delay	$t_{PLH2}$	MAX9400/MAX9403	397	475	597	ps
	$t_{PHL2}$	MAX9402/MAX9405				
IN-to-OUT Channel-to-Channel Skew (Note 5)	$t_{SKD1}$	SEL = high		16	80	ps
CLK-to-OUT Channel-to-Channel Skew (Note 5)	$t_{SKD2}$	SEL = low		8	55	ps
Maximum Clock Frequency	$f_{CLK(MAX)}$	$V_{OH} - V_{OL} \geq 500mV$ , SEL = low	3.0			GHz
Maximum Data Frequency	$f_{IN(MAX)}$	$V_{OH} - V_{OL} \geq 400mV$ , SEL = high	2			GHz
Added Random Jitter (Note 6)	$t_{RJ}$	SEL = low, $f_{CLK} = 3.0GHz$ clock, $f_{IN} = 1.5GHz$		0.64	1.3	ps(RMS)
		SEL = high, $f_{IN} = 2GHz$		0.74	1.5	
Added Deterministic Jitter (Note 6)	$t_{DJ}$	SEL = low, $f_{CLK} = 3.0GHz$ , $IN_+ = 3.0Gbps$ $2^{23} - 1$ PRBS pattern		17	30	ps(P-P)
		SEL = high, $IN_+ = 2.0Gbps$ $2^{23} - 1$ PRBS pattern		40	55	
IN-to-CLK Setup Time	$t_S$	Figure 4	80			ps
CLK-to-IN Hold Time	$t_H$	Figure 4	80			ps
Output Rise Time	$t_R$	Figure 3		80	120	ps
Output Fall Time	$t_F$	Figure 3		80	120	ps
Propagation Delay Temperature Coefficient	$\Delta t_{PD} / \Delta T$			0.2	1	ps/ $^\circ C$

**Note 1:** Measurements are made with the device in thermal equilibrium.

**Note 2:** Current into a pin is defined as positive. Current out of a pin is defined as negative.

**Note 3:** DC parameters are production tested at  $+25^\circ C$ . DC limits are guaranteed by design and characterization over the full operating temperature range.

**Note 4:** Guaranteed by design and characterization. Limits are set to  $\pm 6$  sigma.

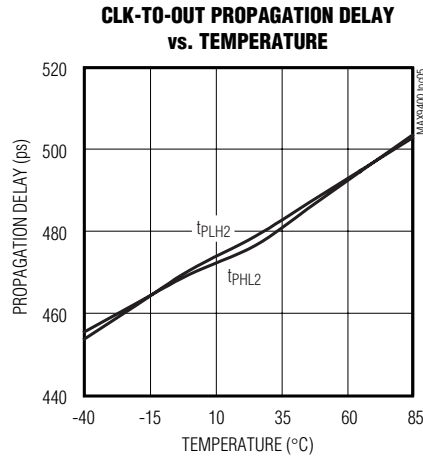
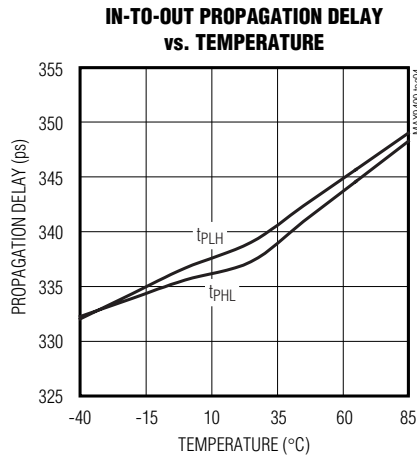
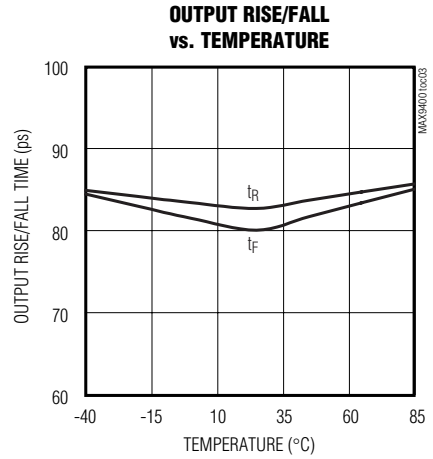
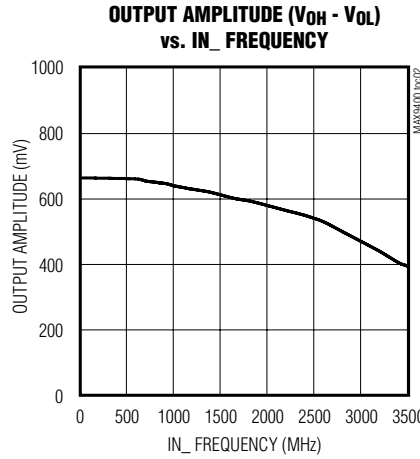
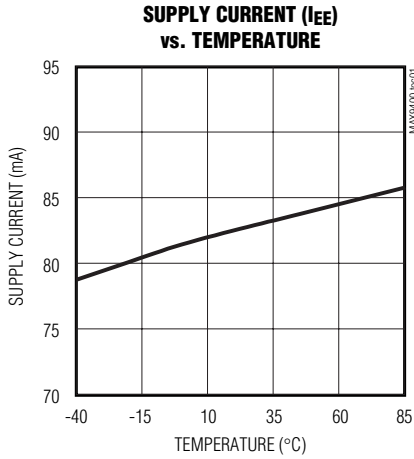
**Note 5:** Measured between outputs of the same part at the signal crossing points for a same-edge transition.

**Note 6:** Device jitter added to the input signal.

# Quad Differential LVECL/LVPECL Buffer/Receivers

## Typical Operating Characteristics

( $V_{CC} - V_{EE} = 3.3V$ , MAX9400, outputs terminated with  $50\Omega \pm 1\%$  to  $V_{CC} - 2.0V$ , enabled, SEL = high, CLK = 2.0GHz,  $f_{IN} = 1.0GHz$ , input transition time = 125ps (20% to 80%),  $V_{IHD} = V_{CC} - 1.0V$ ,  $V_{ILD} = V_{CC} - 1.5V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



# Quad Differential LVECL/LVPECL Buffer/Receivers

## Pin Description

PIN	NAME	FUNCTION
1, 8, 11, 17, 24, 30	V <sub>CC</sub>	Positive Supply Voltage. Bypass V <sub>CC</sub> to V <sub>EE</sub> with 0.1μF and 0.01μF ceramic capacitors. Place the capacitors as close to the device as possible with the smaller value capacitor closest to the device.
2	SEL	Noninverting Differential Select Input. Setting SEL = high and $\overline{\text{SEL}}$ = low (differential high) enables all four channels to operate asynchronously. Setting SEL = low and $\overline{\text{SEL}}$ = high (differential low) enables all four channels to operate in synchronous mode.
3	$\overline{\text{SEL}}$	Inverting Differential Select Input
4	CLK	Noninverting Differential Clock Input
5	$\overline{\text{CLK}}$	Inverting Differential Clock Input. A rising edge on CLK (and falling on $\overline{\text{CLK}}$ ) transfers data from the inputs to the outputs when SEL = low.
6	EN	Noninverting Differential Output Enable Input. Setting EN = high and $\overline{\text{EN}}$ = low (differential high) enables the outputs. Setting EN = low and $\overline{\text{EN}}$ = high (differential low) drives outputs low.
7	$\overline{\text{EN}}$	Inverting Differential Output Enable Input
9	IN3	Noninverting Differential Input 3
10	$\overline{\text{IN3}}$	Inverting Differential Input 3
12	$\overline{\text{OUT3}}$	Inverting Differential Output 3
13	OUT3	Noninverting Differential Output 3
14, 20, 21, 27	V <sub>EE</sub>	Negative Supply Voltage
15	IN2	Noninverting Differential Input 2
16	$\overline{\text{IN2}}$	Inverting Differential Input 2
18	$\overline{\text{OUT2}}$	Inverting Differential Output 2
19	OUT2	Noninverting Differential Output 2
22	OUT1	Noninverting Differential Output 1
23	$\overline{\text{OUT1}}$	Inverting Differential Output 1
25	$\overline{\text{IN1}}$	Inverting Differential Input 1
26	IN1	Noninverting Differential Input 1
28	OUT0	Noninverting Differential Output 0
29	$\overline{\text{OUT0}}$	Inverting Differential Output 0
31	$\overline{\text{IN0}}$	Inverting Differential Input 0
32	IN0	Noninverting Differential Input 0
—	EP	Exposed Paddle (MAX940_EGJ only). Connected to V <sub>EE</sub> internally. See package dimensions.

MAX9400/MAX9402/MAX9403/MAX9405

# Quad Differential LVECL/LVPECL Buffer/Receivers

## Detailed Description

The MAX9400/MAX9402/MAX9403/MAX9405 are extremely fast, low-skew quad LVECL/ECL or LVPECL/PECL buffer/receivers designed for high-speed data and clock driver applications. The devices feature an ultra-low propagation delay of 335ps and channel-to-channel skew of 16ps in asynchronous mode with an 86mA supply current.

The four channels can be operated synchronously with an external clock, or in asynchronous mode, determined by the state of the SEL input. An enable input provides the ability to force all the outputs to a differential low state.

A variety of input and output terminations are offered for maximum design flexibility. The MAX9400 has open inputs and open-emitter outputs. The MAX9402 has open inputs and 50Ω series outputs. The MAX9403 has 100Ω differential input impedance and open-emitter outputs. The MAX9405 has 100Ω differential input impedance and 50Ω series outputs.

### Supply Voltage

The MAX9400/MAX9402/MAX9403/MAX9405 are designed for operation with a single supply. Using a single negative supply of  $V_{EE} = -2.375V$  to  $-5.5V$  ( $V_{CC} = \text{ground}$ ) yields LVECL/ECL-compatible input and output levels. Using a single positive supply of  $V_{CC} = 2.375V$  to  $5.5V$  ( $V_{EE} = \text{ground}$ ) yields LVPECL/PECL input and output levels.

### Data Inputs

The MAX9400/MAX9402 have open inputs and require external termination. The MAX9403/MAX9405 have integrated 100Ω differential input termination resistors from  $\overline{IN}_-$  to  $\overline{IN}_+$ , reducing external component count.

### Outputs

The MAX9402/MAX9405 have internal 50Ω series output termination resistors and 8mA internal pulldown current sources. Using integrated resistors reduces external component count.

The MAX9400/MAX9403 have open-emitter outputs. An external termination is required. See the *Output Termination* section.

### Enable

Setting  $\overline{EN} = \text{high}$  and  $\overline{EN} = \text{low}$  enables the device. Setting  $\overline{EN} = \text{low}$  and  $\overline{EN} = \text{high}$  forces the outputs to a differential low, and all changes on CLK, SEL, and  $\overline{IN}_-$  are ignored.

### Asynchronous Operation

Setting SEL = high and  $\overline{SEL} = \text{low}$  enables the four channels to operate independently as buffer/receivers.

The CLK signal is ignored in this mode. In asynchronous mode, the CLK signal should be set to either a logic low or high state to minimize noise coupling.

### Synchronous Operation

Setting SEL = low and  $\overline{SEL} = \text{high}$  enables all four channels to operate in synchronous mode. In this mode, buffered inputs are clocked into flip-flops simultaneously on the rising edge of the differential clock input (CLK and  $\overline{CLK}$ ).

### Differential Signal Input Limit

The maximum signal magnitude of the differential inputs is  $V_{CC} - V_{EE}$  or 3V, whichever is less.

## Applications Information

### Input Bias

Unused inputs should be biased or driven as shown in Figure 5. This avoids noise coupling that might cause toggling at the unused outputs.

### Output Termination

Terminate open-emitter outputs (MAX9400/MAX9403) through 50Ω to  $V_{CC} - 2V$  or use an equivalent Thevenin termination. Terminate both outputs and use identical termination on each for the lowest output-to-output skew. When a single-ended signal is taken from a differential output, terminate both outputs. For example, if  $\overline{OUT}_-$  is used as a single-ended output, terminate both  $\overline{OUT}_-$  and  $\overline{OUT}_+$ .

Ensure that the output currents do not exceed the current limits as specified in the *Absolute Maximum Ratings* table. Under all operating conditions, the device's total thermal limits should be observed.

### Power-Supply Bypassing

Adequate power-supply bypassing is necessary to maximize the performance and noise immunity. Bypass  $V_{CC}$  to  $V_{EE}$  with high-frequency surface-mount ceramic 0.1μF and 0.01μF capacitors as close to the device as possible with the 0.01μF capacitor closest to the device pins. Use multiple bypass vias for connection to minimize inductance.

### Circuit Board Traces

Input and output trace characteristics affect the performance of the MAX9400/MAX9402/MAX9403/MAX9405. Connect each of the inputs and outputs to a 50Ω characteristic impedance trace. Avoid discontinuities in differential impedance and maximize common-mode noise immunity by maintaining the distance between differential traces and avoid sharp corners. Minimize the number of vias to prevent impedance discontinuities. Reduce reflections by maintaining the 50Ω char-

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characteristic impedance through connectors and across cables. Minimize skew by matching the electrical length of the traces.

## Chip Information

TRANSISTOR COUNT: 713

PROCESS: Bipolar

MAX9400/MAX9402/MAX9403/MAX9405

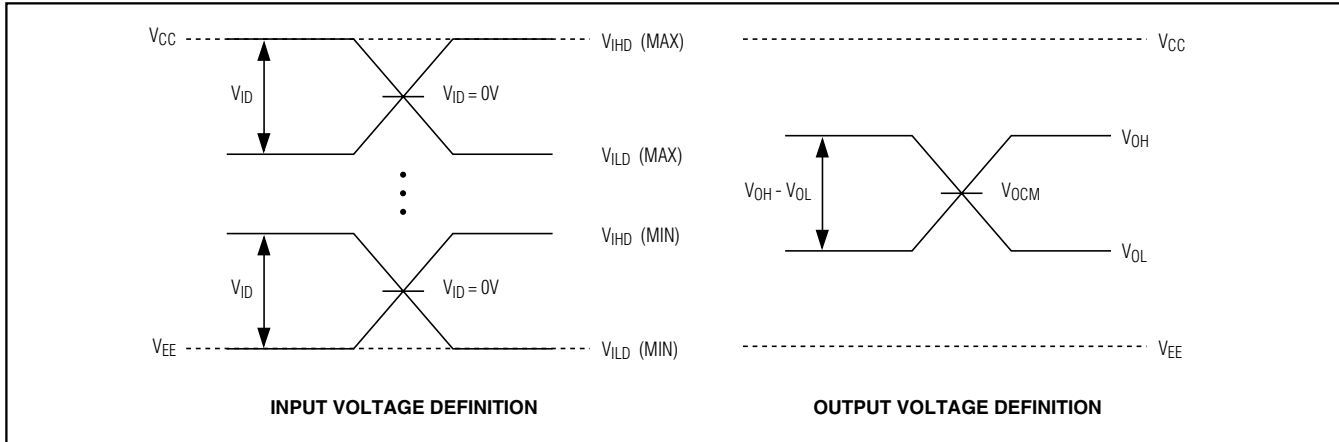


Figure 1. Input and Output Voltage Definitions

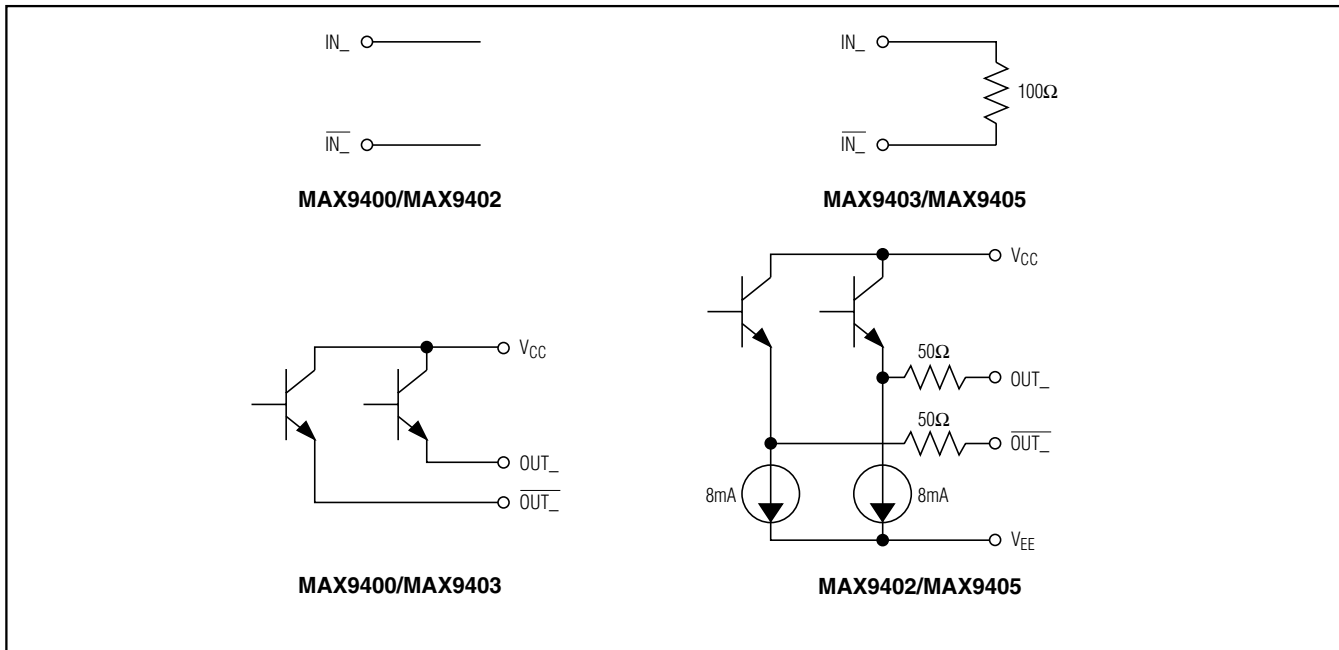


Figure 2. Input and Output Configurations

# Quad Differential LVECL/LVPECL Buffer/Receivers

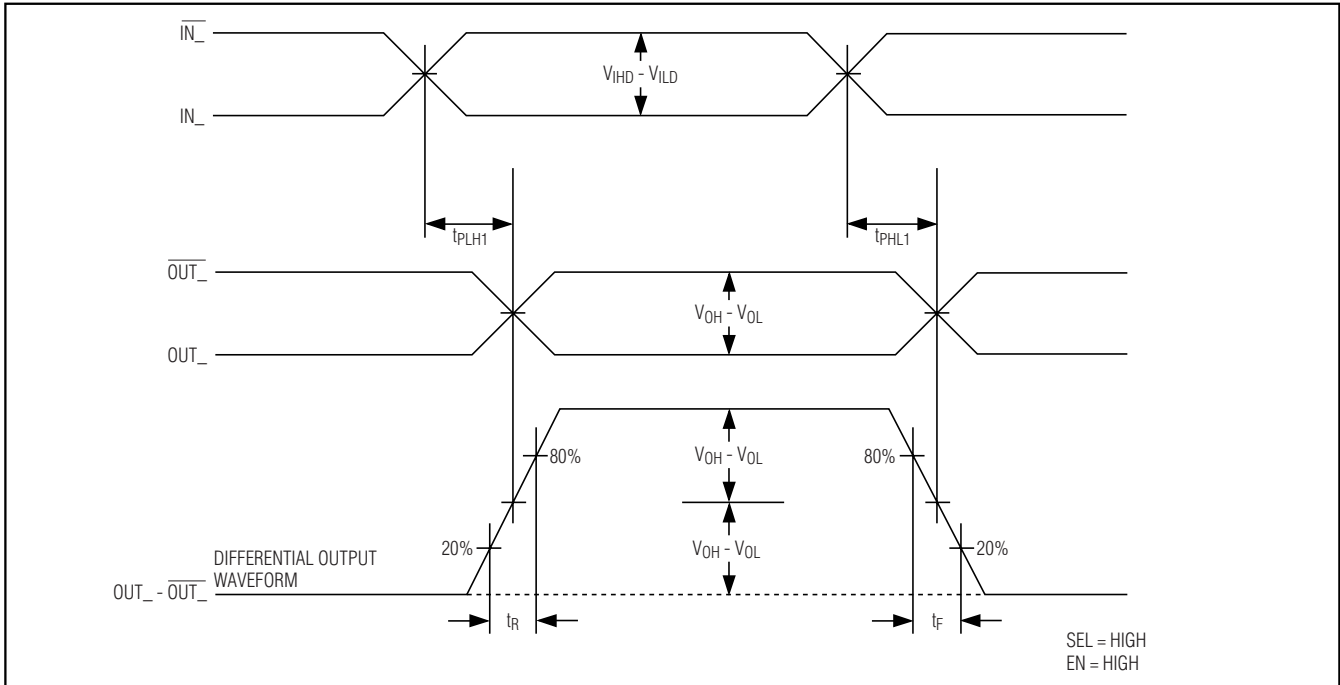


Figure 3. IN-to-OUT Propagation Delay and Transition Timing Diagram

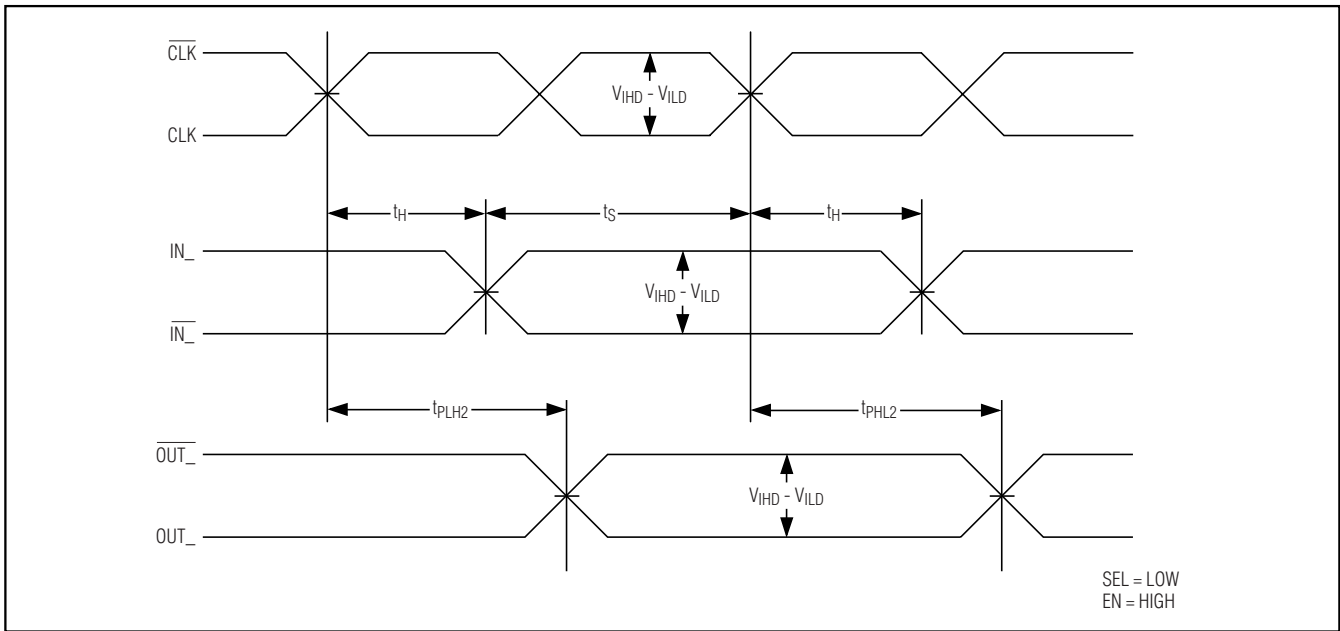


Figure 4. CLK-to-OUT Propagation Delay Timing Diagram



# Quad Differential LVECL/LVPECL Buffer/Receivers

MAX9400/MAX9402/MAX9403/MAX9405

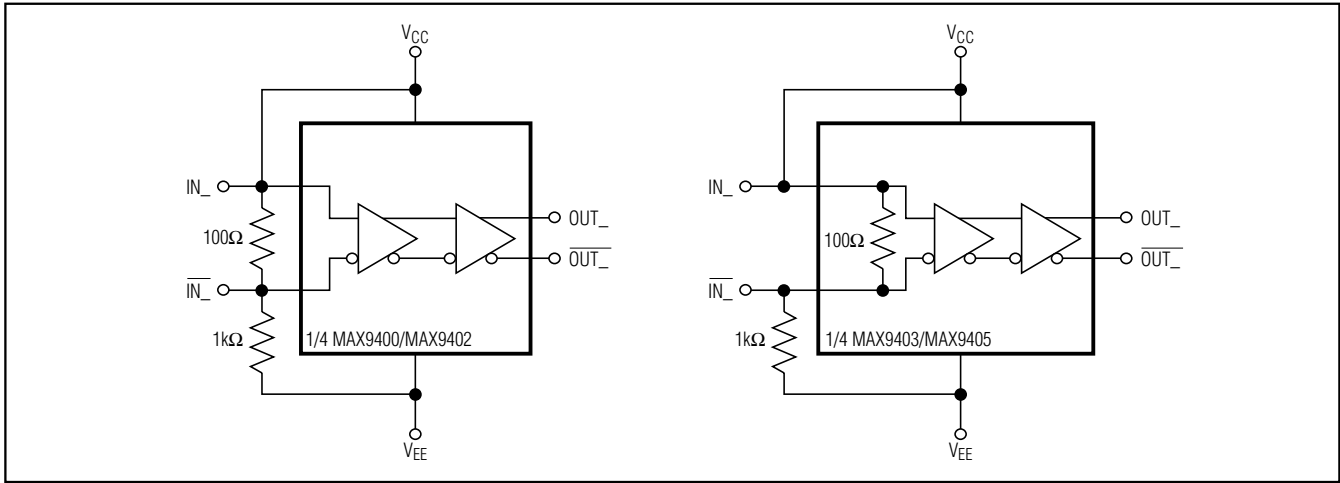
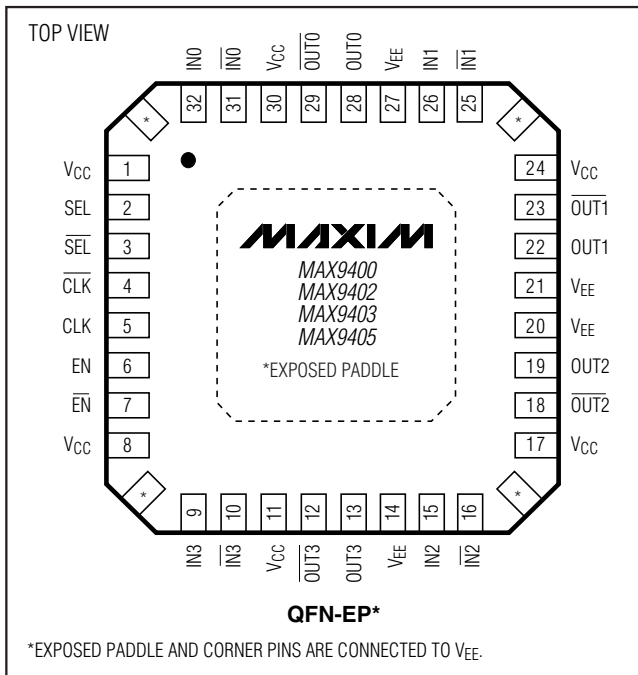


Figure 5. Input Bias Circuits for Unused Inputs

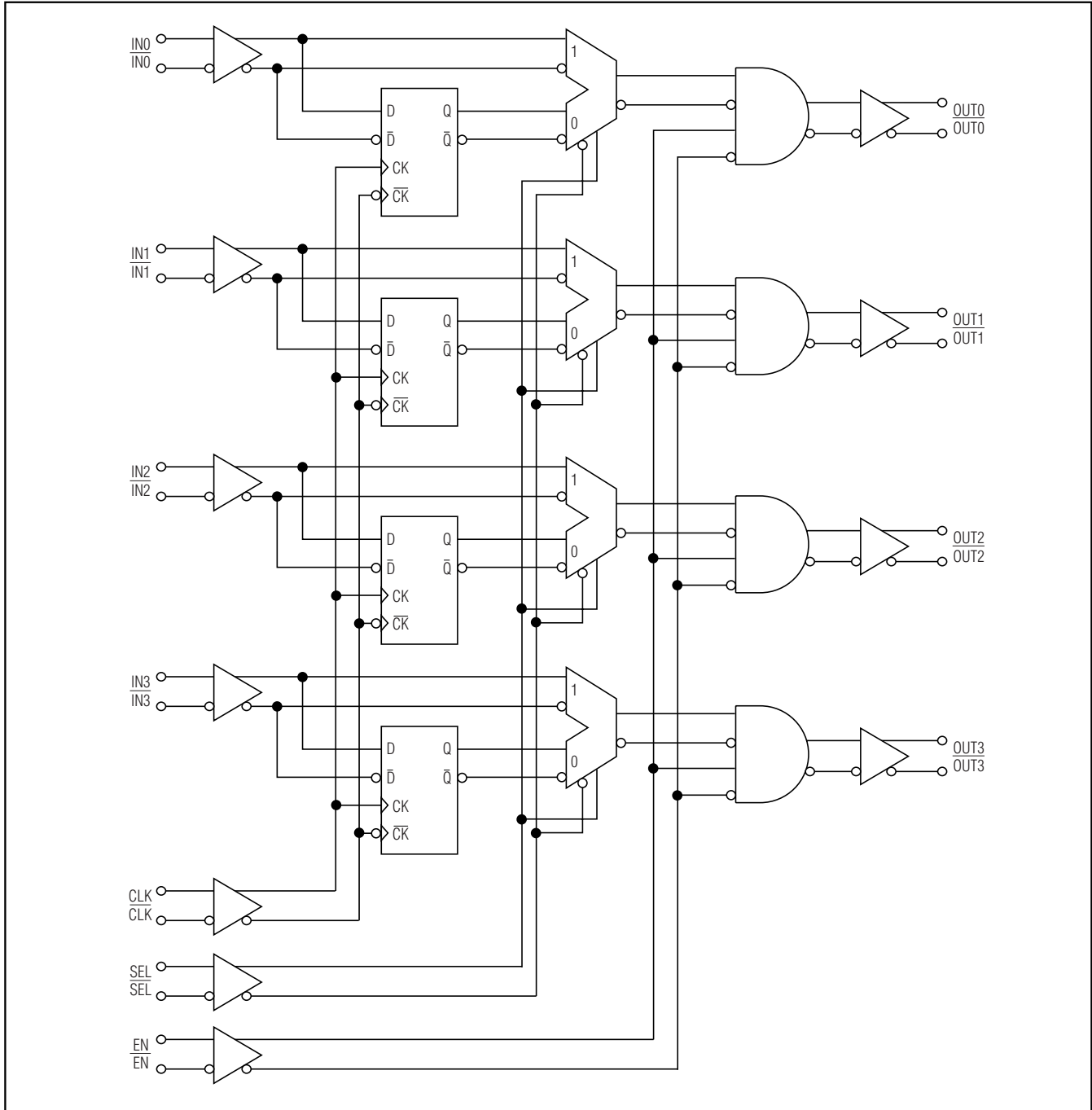
## Pin Configurations (continued)



# Quad Differential LVECL/LVPECL Buffer/Receivers

Functional Diagram

MAX9400/MAX9402/MAX9403/MAX9405

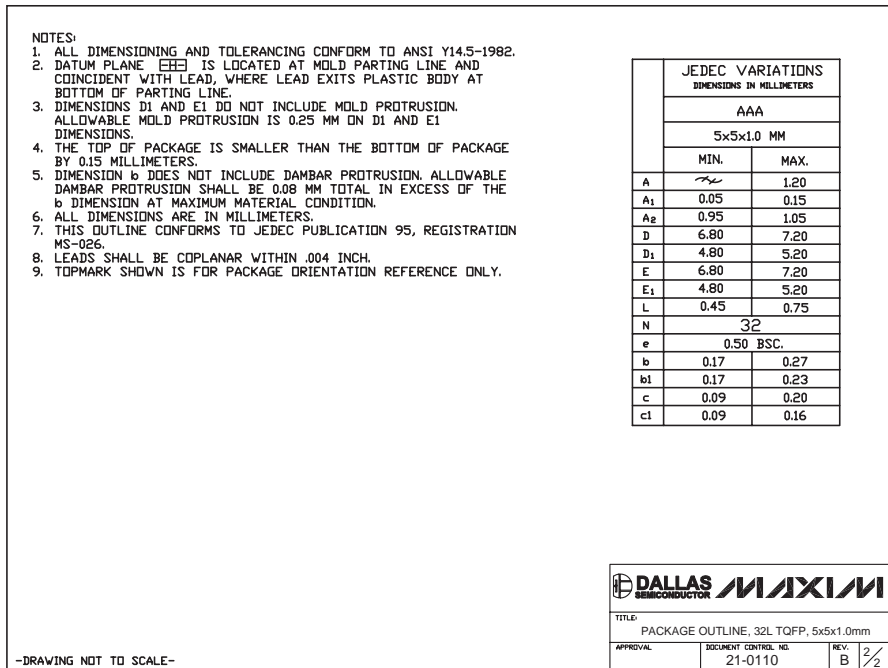
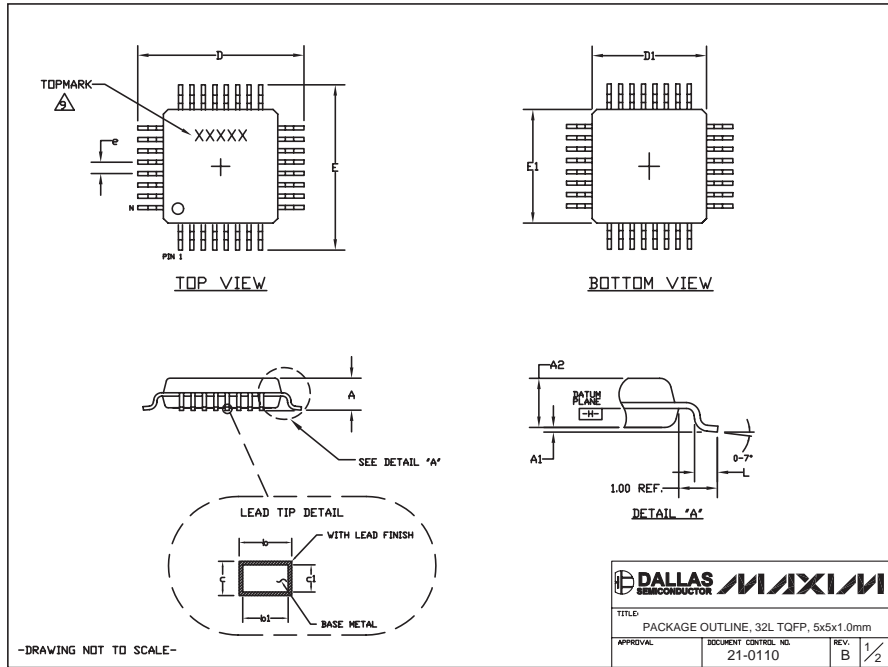


# Quad Differential LVECL/LVPECL Buffer/Receivers

## Package Information

(The package drawing(s) in this data sheet may not reflect the most current specifications. For the latest package outline information, go to [www.maxim-ic.com/packages](http://www.maxim-ic.com/packages).)

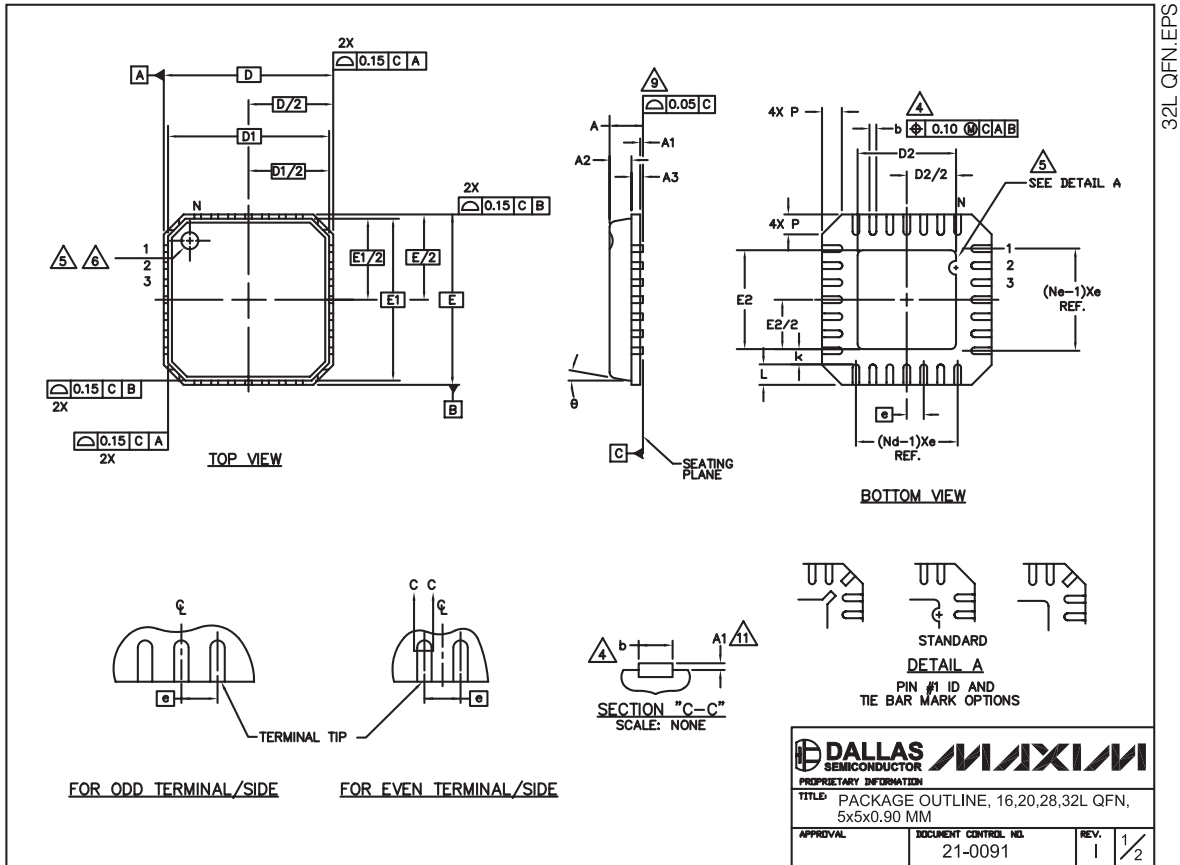
MAX9400/MAX9402/MAX9403/MAX9405



# Quad Differential LVECL/LVPECL Buffer/Receivers

## Package Information (continued)

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# Quad Differential LVECL/LVPECL Buffer/Receivers

## Package Information (continued)

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MAX9400/MAX9402/MAX9403/MAX9405

COMMON DIMENSIONS												
PKG	16L 5x5			20L 5x5			28L 5x5			32L 5x5		
SYMBOL	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
A	0.80	0.90	1.00	0.80	0.90	1.00	0.80	0.90	1.00	0.80	0.90	1.00
A1	0.00	0.01	0.05	0.00	0.01	0.05	0.00	0.01	0.05	0.00	0.01	0.05
A2	0.00	0.65	1.00	0.00	0.65	1.00	0.00	0.65	1.00	0.00	0.65	1.00
A3	0.20 REF			0.20 REF			0.20 REF			0.20 REF		
b	0.28	0.33	0.40	0.23	0.28	0.35	0.18	0.23	0.30	0.18	0.23	0.30
D	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10
D1	4.75 BSC			4.75 BSC			4.75 BSC			4.75 BSC		
E	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10	4.90	5.00	5.10
E1	4.75 BSC			4.75 BSC			4.75 BSC			4.75 BSC		
e	0.80 BSC			0.65 BSC			0.50 BSC			0.50 BSC		
k	0.25	—	—	0.25	—	—	0.25	—	—	0.25	—	—
L	0.35	0.55	0.75	0.35	0.55	0.75	0.35	0.55	0.75	0.30	0.40	0.50
N	16			20			28			32		
ND	4			5			7			8		
NE	4			5			7			8		
P	0.00	0.42	0.60	0.00	0.42	0.60	0.00	0.42	0.60	0.00	0.42	0.60
ϕ	0"		12"	0"		12"	0"		12"	0"		12"

EXPOSED PAD VARIATIONS						
PKG. CODES	D2			E2		
	MIN.	NOM.	MAX.	MIN.	NOM.	MAX.
G1655-3	2.95	3.10	3.25	2.95	3.10	3.25
G2055-1	2.55	2.70	2.85	2.55	2.70	2.85
G2055-2	2.95	3.10	3.25	2.95	3.10	3.25
G2855-1	2.55	2.70	2.85	2.55	2.70	2.85
G2855-2	2.95	3.10	3.25	2.95	3.10	3.25
G3255-1	2.95	3.10	3.25	2.95	3.10	3.25

**NOTES:**

- DIE THICKNESS ALLOWABLE IS 0.305mm MAXIMUM (.012 INCHES MAXIMUM)
- DIMENSIONING & TOLERANCES CONFORM TO ASME Y14.5M. — 1994.
- N IS THE NUMBER OF TERMINALS.  
Nd IS THE NUMBER OF TERMINALS IN X-DIRECTION & Ne IS THE NUMBER OF TERMINALS IN Y-DIRECTION.
- DIMENSION b APPLIES TO PLATED TERMINAL AND IS MEASURED BETWEEN 0.20 AND 0.25mm FROM TERMINAL TIP.
- THE PIN #1 IDENTIFIER MUST BE EXISTED ON THE TOP SURFACE OF THE PACKAGE BY USING INDENTATION MARK OR INK/LASER MARKED. DETAILS OF PIN #1 IDENTIFIER IS OPTIONAL, BUT MUST BE LOCATED WITHIN ZONE INDICATED.
- EXACT SHAPE AND SIZE OF THIS FEATURE IS OPTIONAL.
- ALL DIMENSIONS ARE IN MILLIMETERS.
- PACKAGE WARPAGE MAX 0.05mm.
- APPLIED FOR EXPOSED PAD AND TERMINALS. EXCLUDE EMBEDDED PART OF EXPOSED PAD FROM MEASURING.
- MEETS JEDEC MO220; EXCEPT DIMENSION "b".
- APPLIED FOR EXPOSED PAD AND TERMINALS. EXCLUDE EMBEDDING PART OF EXPOSED PAD FROM MEASURING.
- THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES).

PROPRIETARY INFORMATION			
TITLE: PACKAGE OUTLINE, 16,20,28,32L QFN, 5x5x0.90 MM			
APPROVAL	DOCUMENT CONTROL NO.	REV.	
	21-0091	1	2/2

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