



# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

## General Description

The MAX9311/MAX9313 are low-skew, 1-to-10 differential drivers designed for clock and data distribution. These devices allow selection between two inputs. The selected input is reproduced at 10 differential outputs. The differential inputs can be adapted to accept single-ended inputs by connecting the on-chip  $V_{BB}$  supply to one input as a reference voltage.

The MAX9311/MAX9313 feature low part-to-part skew (30ps) and output-to-output skew (12ps), making them ideal for clock and data distribution across a backplane or a board. For interfacing to differential HSTL and LVPECL signals, these devices operate over a +2.25V to +3.8V supply range, allowing high-performance clock or data distribution in systems with a nominal +2.5V or +3.3V supply. For differential LVECL operation, these devices operate from a -2.25V to -3.8V supply.

The MAX9311 features an on-chip  $V_{BB}$  reference output of 1.425V below the positive supply voltage. The MAX9313 offers an on-chip  $V_{BB}$  reference output of 1.32V below the positive supply voltage.

Both devices are offered in space-saving, 32-pin 5mm x 5mm TQFP, 5mm x 5mm QFN, and industry-standard 32-pin 7mm x 7mm LQFP packages.

## Applications

Precision Clock Distribution  
Low-Jitter Data Repeater

## Features

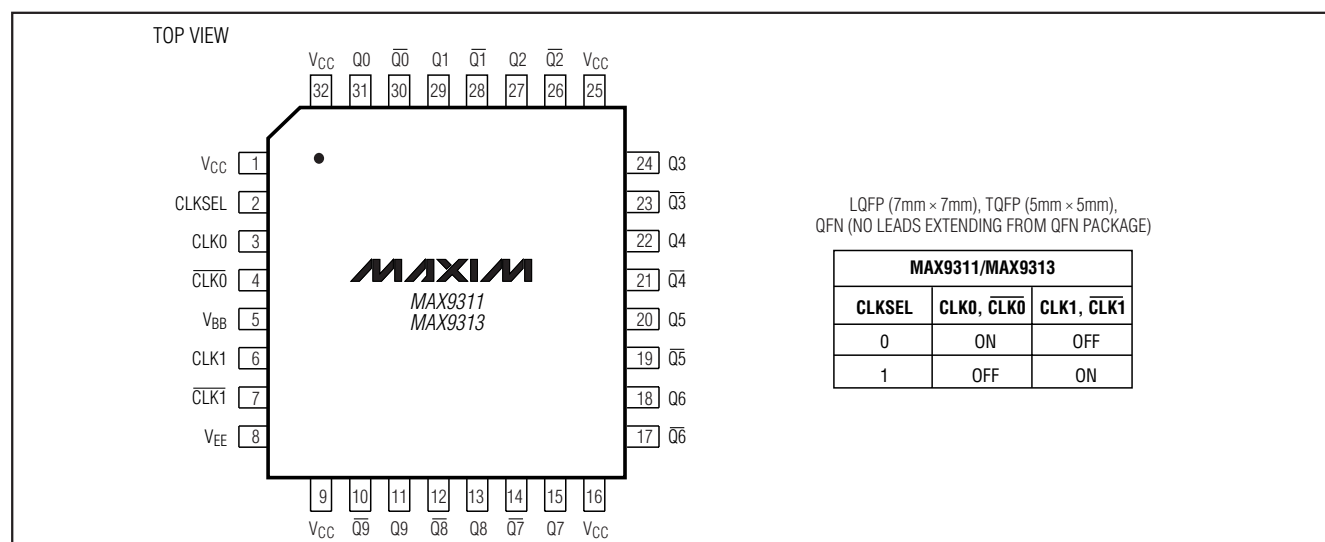
- ◆ +2.25V to +3.8V Differential HSTL/LVPECL Operation
- ◆ -2.25V to -3.8V LVECL Operation
- ◆ 30ps (typ) Part-to-Part Skew
- ◆ 12ps (typ) Output-to-Output Skew
- ◆ 312ps (typ) Propagation Delay
- ◆  $\geq 300\text{mV}$  Differential Output at 3GHz
- ◆ On-Chip Reference for Single-Ended Inputs
- ◆ Output Low with Open Input
- ◆ Pin Compatible with MC100LVEP111 (MAX9311) and MC100EP111 (MAX9313)
- ◆ Offered in Tiny QFN\* Package (70% Smaller Footprint than LQFP)

## Ordering Information

| PART        | TEMP. RANGE    | PIN-PACKAGE         |
|-------------|----------------|---------------------|
| MAX9311ECJ  | -40°C to +85°C | 32 LQFP (7mm x 7mm) |
| MAX9311EGJ* | -40°C to +85°C | 32 QFN (5mm x 5mm)  |
| MAX9311EHJ* | -40°C to +85°C | 32 TQFP (5mm x 5mm) |
| MAX9313ECJ  | -40°C to +85°C | 32 LQFP (7mm x 7mm) |
| MAX9313EGJ* | -40°C to +85°C | 32 QFN (5mm x 5mm)  |
| MAX9313EHJ* | -40°C to +85°C | 32 TQFP (5mm x 5mm) |

\*Future product—contact factory for availability.

## Pin Configuration



# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

## ABSOLUTE MAXIMUM RATINGS

|                                                                                         |                                    |
|-----------------------------------------------------------------------------------------|------------------------------------|
| $V_{CC} - V_{EE}$ .....                                                                 | 4.1V                               |
| Inputs (CLK <sub>-</sub> , CLK <sub>-</sub> , CLKSEL).....                              | $V_{EE} - 0.3V$ to $V_{CC} + 0.3V$ |
| CLK <sub>-</sub> to CLK <sub>-</sub> .....                                              | $\pm 3.0V$                         |
| Continuous Output Current .....                                                         | 50mA                               |
| Surge Output Current .....                                                              | 100mA                              |
| $V_{BB}$ Sink/Source Current .....                                                      | $\pm 0.65mA$                       |
| Junction-to-Ambient Thermal Resistance in Still Air<br>7mm x 7mm LQFP .....             | $+90^{\circ}C/W$                   |
| Junction-to-Ambient Thermal Resistance with<br>500 LFPM Airflow<br>7mm x 7mm LQFP ..... | $+60^{\circ}C/W$                   |

|                                                                                                                                         |                                   |
|-----------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|
| Junction-to-Case Thermal Resistance<br>7mm x 7mm LQFP .....                                                                             | $+12^{\circ}C/W$                  |
| Operating Temperature Range .....                                                                                                       | $-40^{\circ}C$ to $+85^{\circ}C$  |
| Junction Temperature .....                                                                                                              | $+150^{\circ}C$                   |
| Storage Temperature Range .....                                                                                                         | $-65^{\circ}C$ to $+150^{\circ}C$ |
| ESD Protection<br>Human Body Model (CLKSEL, CLK <sub>-</sub> , CLK <sub>-</sub> ,<br>Q <sub>-</sub> , Q <sub>-</sub> , $V_{BB}$ ) ..... | 2kV                               |
| Soldering Temperature (10s) .....                                                                                                       | $+300^{\circ}C$                   |

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 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

( $V_{CC} - V_{EE} = +2.25V$  to  $+3.8V$ , outputs loaded with  $50\Omega \pm 1\%$  to  $V_{CC} - 2V$ , CLKSEL = high or low, unless otherwise noted.) (Notes 1–4)

| PARAMETER                                                  | SYMBOL          | CONDITIONS                                                                                                                   |         | -40°C                   |                         | +25°C                   |                         | +85°C                   |                         | UNITS |
|------------------------------------------------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------|
|                                                            |                 |                                                                                                                              |         | MIN                     | MAX                     | MIN                     | MAX                     | MIN                     | MAX                     |       |
| SINGLE-ENDED INPUT (CLKSEL)                                |                 |                                                                                                                              |         |                         |                         |                         |                         |                         |                         |       |
| Input High Voltage                                         | V <sub>IH</sub> | Internal V <sub>BB</sub> threshold                                                                                           | MAX9311 | V <sub>CC</sub> - 1.23  | V <sub>CC</sub>         | V <sub>CC</sub> - 1.23  | V <sub>CC</sub>         | V <sub>CC</sub> - 1.23  | V <sub>CC</sub>         | V     |
|                                                            |                 |                                                                                                                              | MAX9313 | V <sub>CC</sub> - 1.165 | V <sub>CC</sub>         | V <sub>CC</sub> - 1.165 | V <sub>CC</sub>         | V <sub>CC</sub> - 1.165 | V <sub>CC</sub>         |       |
| Input Low Voltage                                          | V <sub>IL</sub> | Internal V <sub>BB</sub> threshold                                                                                           | MAX9311 | V <sub>EE</sub>         | V <sub>CC</sub> - 1.62  | V <sub>EE</sub>         | V <sub>CC</sub> - 1.62  | V <sub>EE</sub>         | V <sub>CC</sub> - 1.62  | V     |
|                                                            |                 |                                                                                                                              | MAX9313 | V <sub>EE</sub>         | V <sub>CC</sub> - 1.475 | V <sub>EE</sub>         | V <sub>CC</sub> - 1.475 | V <sub>EE</sub>         | V <sub>CC</sub> - 1.475 |       |
| Input High Current                                         | I <sub>IH</sub> |                                                                                                                              |         | 150                     |                         | 150                     |                         | 150                     |                         | μA    |
| Input Low Current                                          | I <sub>IL</sub> |                                                                                                                              |         | -10      +10            |                         | -10      +10            |                         | -10      +10            |                         | μA    |
| DIFFERENTIAL INPUTS (CLK <sub>-</sub> , CLK <sub>-</sub> ) |                 |                                                                                                                              |         |                         |                         |                         |                         |                         |                         |       |
| Single-Ended Input High Voltage                            | V <sub>IH</sub> | V <sub>BB</sub> connected to CLK <sub>-</sub> (V <sub>IL</sub> for V <sub>BB</sub> connected to CLK <sub>-</sub> ), Figure 1 | MAX9311 | V <sub>CC</sub> - 1.23  | V <sub>CC</sub>         | V <sub>CC</sub> - 1.23  | V <sub>CC</sub>         | V <sub>CC</sub> - 1.23  | V <sub>CC</sub>         | V     |
|                                                            |                 |                                                                                                                              | MAX9313 | V <sub>CC</sub> - 1.165 | V <sub>CC</sub>         | V <sub>CC</sub> - 1.165 | V <sub>CC</sub>         | V <sub>CC</sub> - 1.165 | V <sub>CC</sub>         |       |

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

MAX9311/MAX9313

## DC ELECTRICAL CHARACTERISTICS (continued)

( $V_{CC} - V_{EE} = +2.25V$  to  $+3.8V$ , outputs loaded with  $50\Omega \pm 1\%$  to  $V_{CC} - 2V$ , CLKSEL = high or low, unless otherwise noted.) (Notes 1–4)

| PARAMETER                                  | SYMBOL                              | CONDITIONS                                                                                                                   |         | -40°C                   |                                   | +25°C                   |                                   | +85°C                   |                                   | UNITS |
|--------------------------------------------|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------|-----------------------------------|-------------------------|-----------------------------------|-------------------------|-----------------------------------|-------|
|                                            |                                     |                                                                                                                              |         | MIN                     | MAX                               | MIN                     | MAX                               | MIN                     | MAX                               |       |
| Single-Ended Input Low Voltage             | V <sub>IL</sub>                     | V <sub>BB</sub> connected to CLK <sub>-</sub> (V <sub>IH</sub> for V <sub>BB</sub> connected to CLK <sub>-</sub> ), Figure 1 | MAX9311 | V <sub>EE</sub>         | V <sub>CC</sub> - 1.62            | V <sub>EE</sub>         | V <sub>CC</sub> - 1.62            | V <sub>EE</sub>         | V <sub>CC</sub> - 1.62            | V     |
|                                            |                                     |                                                                                                                              | MAX9313 | V <sub>EE</sub>         | V <sub>CC</sub> - 1.475           | V <sub>EE</sub>         | V <sub>CC</sub> - 1.475           | V <sub>EE</sub>         | V <sub>CC</sub> - 1.475           |       |
| High Voltage of Differential Input         | V <sub>IHD</sub>                    |                                                                                                                              |         | V <sub>EE</sub> + 1.2   | V <sub>CC</sub>                   | V <sub>EE</sub> + 1.2   | V <sub>CC</sub>                   | V <sub>EE</sub> + 1.2   | V <sub>CC</sub>                   | V     |
| Low Voltage of Differential Input          | V <sub>ILD</sub>                    |                                                                                                                              |         | V <sub>EE</sub>         | V <sub>CC</sub> - 0.095           | V <sub>EE</sub>         | V <sub>CC</sub> - 0.095           | V <sub>EE</sub>         | V <sub>CC</sub> - 0.095           | V     |
| Differential Input Voltage                 | V <sub>IHD</sub> - V <sub>ILD</sub> | For V <sub>CC</sub> - V <sub>EE</sub> < 3.0V                                                                                 |         | 0.095                   | V <sub>CC</sub> - V <sub>EE</sub> | 0.095                   | V <sub>CC</sub> - V <sub>EE</sub> | 0.095                   | V <sub>CC</sub> - V <sub>EE</sub> | V     |
|                                            |                                     | For V <sub>CC</sub> - V <sub>EE</sub> ≥ 3.0V                                                                                 |         | 0.095                   | 3.0                               | 0.095                   | 3.0                               | 0.095                   | 3.0                               |       |
| Input High Current                         | I <sub>IH</sub>                     |                                                                                                                              |         |                         | 150                               |                         | 150                               |                         | 150                               | μA    |
| CLK <sub>-</sub> Input Low Current         | I <sub>ILCLK</sub>                  |                                                                                                                              |         | -10                     | +10                               | -10                     | +10                               | -10                     | +10                               | μA    |
| CLK <sub>-</sub> Input Low Current         | I <sub>ILCLK</sub>                  |                                                                                                                              |         | -150                    |                                   | -150                    |                                   | -150                    |                                   | μA    |
| OUTPUTS (Q <sub>-</sub> , Q <sub>-</sub> ) |                                     |                                                                                                                              |         |                         |                                   |                         |                                   |                         |                                   |       |
| Single-Ended Output High Voltage           | V <sub>OH</sub>                     | Figure 1                                                                                                                     |         | V <sub>CC</sub> - 1.025 | V <sub>CC</sub> - 0.900           | V <sub>CC</sub> - 1.025 | V <sub>CC</sub> - 0.900           | V <sub>CC</sub> - 1.025 | V <sub>CC</sub> - 0.900           | V     |
| Single-Ended Output Low Voltage            | V <sub>OL</sub>                     | Figure 1                                                                                                                     |         | V <sub>CC</sub> - 1.93  | V <sub>CC</sub> - 1.695           | V <sub>CC</sub> - 1.93  | V <sub>CC</sub> - 1.695           | V <sub>CC</sub> - 1.93  | V <sub>CC</sub> - 1.695           | V     |
| Differential Output Voltage                | V <sub>OH</sub> - V <sub>OL</sub>   | Figure 1                                                                                                                     |         | 670                     | 950                               | 670                     | 950                               | 670                     | 950                               | mV    |
| REFERENCE (V <sub>BB</sub> )               |                                     |                                                                                                                              |         |                         |                                   |                         |                                   |                         |                                   |       |
| Reference Voltage Output (Note 5)          | V <sub>BB</sub>                     | I <sub>BB</sub> = ±0.5mA                                                                                                     | MAX9311 | V <sub>CC</sub> - 1.525 | V <sub>CC</sub> - 1.325           | V <sub>CC</sub> - 1.525 | V <sub>CC</sub> - 1.325           | V <sub>CC</sub> - 1.525 | V <sub>CC</sub> - 1.325           | V     |
|                                            |                                     |                                                                                                                              | MAX9313 | V <sub>CC</sub> - 1.38  | V <sub>CC</sub> - 1.26            | V <sub>CC</sub> - 1.38  | V <sub>CC</sub> - 1.26            | V <sub>CC</sub> - 1.38  | V <sub>CC</sub> - 1.26            |       |
| POWER SUPPLY                               |                                     |                                                                                                                              |         |                         |                                   |                         |                                   |                         |                                   |       |
| Supply Current (Note 6)                    | I <sub>EE</sub>                     |                                                                                                                              |         |                         | 75                                |                         | 82                                |                         | 95                                | mA    |

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

## AC ELECTRICAL CHARACTERISTICS

( $V_{CC} - V_{EE} = 2.25V$  to  $3.8V$ , outputs loaded with  $50\Omega \pm 1\%$  to  $V_{CC} - 2V$ , input frequency =  $1.5GHz$ , input transition time =  $125ps$  (20% to 80%), CLKSEL = high or low,  $V_{IHD} = V_{EE} + 1.2V$  to  $V_{CC}$ ,  $V_{ILD} = V_{EE}$  to  $V_{CC} - 0.15V$ ,  $V_{IHD} - V_{ILD} = 0.15V$  to the smaller of  $3V$  or  $V_{CC} - V_{EE}$ , unless otherwise noted. Typical values are at  $V_{CC} - V_{EE} = 3.3V$ ,  $V_{IHD} = V_{CC} - 1V$ ,  $V_{ILD} = V_{CC} - 1.5V$ .) (Note 7)

| PARAMETER                            | SYMBOL                  | CONDITIONS                                             | -40°C |     |     | +25°C |     |     | +85°C |     |     | UNITS    |
|--------------------------------------|-------------------------|--------------------------------------------------------|-------|-----|-----|-------|-----|-----|-------|-----|-----|----------|
|                                      |                         |                                                        | MIN   | TYP | MAX | MIN   | TYP | MA  | MIN   | TYP | MAX |          |
| Differential Input-to-Output Delay   | $t_{PLHD}$ , $t_{PHLD}$ | Figure 2                                               | 220   | 321 | 380 | 220   | 312 | 410 | 260   | 322 | 400 | ps       |
| Output-to-Output Skew (Note 8)       | $t_{SKOO}$              |                                                        |       | 12  | 46  |       | 12  | 46  |       | 10  | 35  | ps       |
| Part-to-Part Skew (Note 9)           | $t_{SKPP}$              |                                                        |       | 30  | 160 |       | 30  | 190 |       | 30  | 140 | ps       |
| Added Random Jitter (Note 10)        | $t_{RJ}$                | $f_{IN} = 1.5GHz$ , Clock pattern                      |       | 1.2 | 2.5 |       | 1.2 | 2.5 |       | 1.2 | 2.5 | ps (RMS) |
|                                      |                         | $f_{IN} = 3.0GHz$ , Clock pattern                      |       | 1.2 | 2.6 |       | 1.2 | 2.6 |       | 1.2 | 2.6 |          |
| Added Deterministic Jitter (Note 10) | $t_{DJ}$                | 3Gbps, 2 <sup>23</sup> -1 PRBS pattern                 |       | 80  | 95  |       | 80  | 95  |       | 80  | 95  | ps (p-p) |
| Switching Frequency                  | $f_{MAX}$               | $V_{OH} - V_{OL} \geq 350mV$ , Clock pattern, Figure 2 | 2.0   |     |     | 2.0   | 3.0 |     | 2.0   |     |     | GHz      |
|                                      |                         | $V_{OH} - V_{OL} \geq 500mV$ , Clock pattern, Figure 2 | 1.5   |     |     | 1.5   |     |     | 1.5   |     |     |          |
| Output Rise/Fall Time (20% to 80%)   | $t_R$ , $t_F$           | Figure 2                                               | 100   | 112 | 140 | 100   | 116 | 140 | 100   | 121 | 140 | ps       |

**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:** Single-ended input operation using  $V_{BB}$  is limited to  $V_{CC} - V_{EE} = 3.0V$  to  $3.8V$  for the MAX9311 and  $V_{CC} - V_{EE} = 2.7V$  to  $3.8V$  for the MAX9313.

**Note 4:** DC parameters production tested at  $T_A = +25^\circ C$ . Guaranteed by design and characterization over the full operating temperature range.

**Note 5:** Use  $V_{BB}$  only for inputs that are on the same device as the  $V_{BB}$  reference.

**Note 6:** All pins open except  $V_{CC}$  and  $V_{EE}$ .

**Note 7:** Guaranteed by design and characterization. Limits are set at  $\pm 6$  sigma.

**Note 8:** Measured between outputs of the same part at the signal crossing points for a same-edge transition.

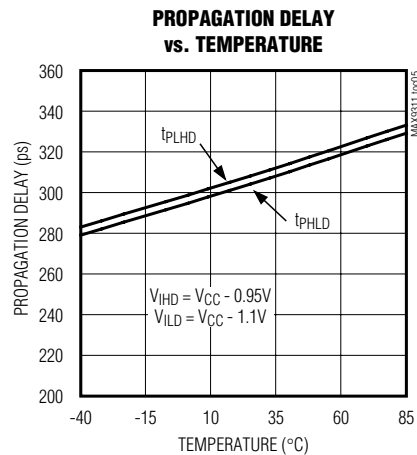
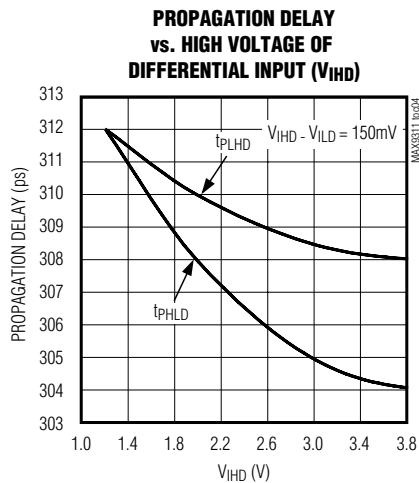
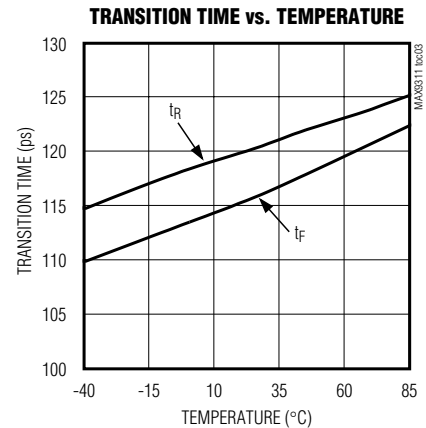
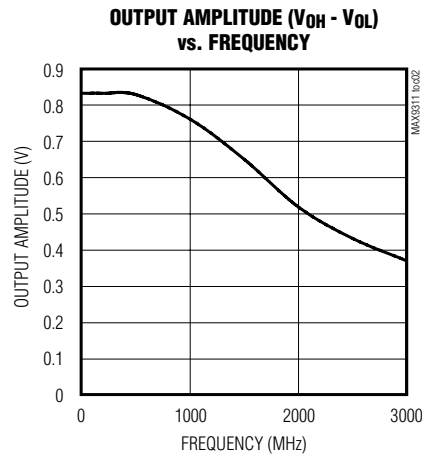
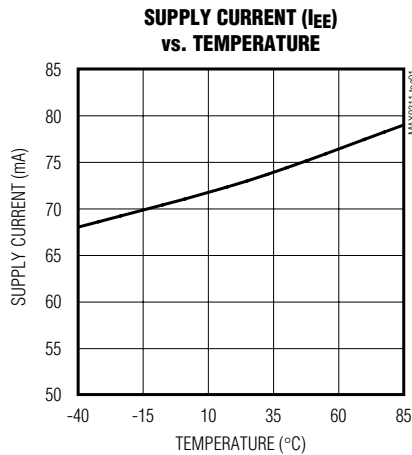
**Note 9:** Measured between outputs of different parts at the signal crossing points under identical conditions for a same-edge transition.

**Note 10:** Device jitter added to the input signal.

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

## Typical Operating Characteristics

( $V_{CC} = +3.3V$ ,  $V_{EE} = 0$ ,  $V_{IHD} = V_{CC} - 0.95V$ ,  $V_{ILD} = V_{CC} - 1.25V$ , input transition time = 125ps (20% to 80%),  $f_{IN} = 1.5GHz$ , outputs loaded with  $50\Omega$  to  $V_{CC} - 2V$ ,  $T_A = +25^\circ C$ , unless otherwise noted.)



MAX9311/MAX9313

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## Pin Description

| PIN                 | NAME                     | FUNCTION                                                                                                                                                                                                                                                                                                                                                                                                            |
|---------------------|--------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 9, 16,<br>25, 32 | V <sub>CC</sub>          | Positive Supply Voltage. Bypass from 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                   | CLKSEL                   | Clock Select Input (Single-Ended). Drive low to select the CLK0, $\overline{\text{CLK0}}$ input. Drive high to select the CLK1, $\overline{\text{CLK1}}$ input. The CLKSEL threshold is V <sub>BB</sub> . If CLKSEL is not driven by a logic signal, use a 1kΩ pulldown to V <sub>EE</sub> to select CLK0, $\overline{\text{CLK0}}$ , or a 1kΩ pullup to V <sub>CC</sub> to select CLK1, $\overline{\text{CLK1}}$ . |
| 3                   | CLK0                     | Noninverting Differential Clock Input 0. Internal 75kΩ pulldown resistor.                                                                                                                                                                                                                                                                                                                                           |
| 4                   | $\overline{\text{CLK0}}$ | Inverting Differential Clock Input 0. Internal 75kΩ pullup and pulldown resistors.                                                                                                                                                                                                                                                                                                                                  |
| 5                   | V <sub>BB</sub>          | Reference Output Voltage. Connect to the inverting or noninverting clock input to provide a reference for single-ended operation. When used, bypass with a 0.01μF ceramic capacitor to V <sub>CC</sub> ; otherwise, leave open.                                                                                                                                                                                     |
| 6                   | CLK1                     | Noninverting Differential Clock Input 1. Internal 75kΩ pulldown resistor.                                                                                                                                                                                                                                                                                                                                           |
| 7                   | $\overline{\text{CLK1}}$ | Inverting Differential Clock Input 1. Internal 75kΩ pullup and pulldown resistors.                                                                                                                                                                                                                                                                                                                                  |
| 8                   | V <sub>EE</sub>          | Negative Supply Voltage                                                                                                                                                                                                                                                                                                                                                                                             |
| 10                  | $\overline{\text{Q9}}$   | Inverting Q9 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 11                  | Q9                       | Noninverting Q9 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 12                  | $\overline{\text{Q8}}$   | Inverting Q8 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 13                  | Q8                       | Noninverting Q8 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 14                  | $\overline{\text{Q7}}$   | Inverting Q7 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 15                  | Q7                       | Noninverting Q7 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 17                  | $\overline{\text{Q6}}$   | Inverting Q6 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 18                  | Q6                       | Noninverting Q6 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 19                  | $\overline{\text{Q5}}$   | Inverting Q5 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 20                  | Q5                       | Noninverting Q5 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 21                  | $\overline{\text{Q4}}$   | Inverting Q4 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 22                  | Q4                       | Noninverting Q4 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 23                  | $\overline{\text{Q3}}$   | Inverting Q3 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 24                  | Q3                       | Noninverting Q3 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 26                  | $\overline{\text{Q2}}$   | Inverting Q2 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 27                  | Q2                       | Noninverting Q2 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 28                  | $\overline{\text{Q1}}$   | Inverting Q1 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 29                  | Q1                       | Noninverting Q1 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |
| 30                  | $\overline{\text{Q0}}$   | Inverting Q0 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                                 |
| 31                  | Q0                       | Noninverting Q0 Output. Typically terminate with 50Ω resistor to V <sub>CC</sub> - 2V.                                                                                                                                                                                                                                                                                                                              |

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

## Detailed Description

The MAX9311/MAX9313 are low skew, 1-to-10 differential drivers designed for clock and data distribution.

A 2:1 mux selects between the two differential inputs, CLK0,  $\overline{\text{CLK0}}$  and CLK1,  $\overline{\text{CLK1}}$ . The 2:1 mux is switched by the single-ended CLKSEL input. A logic low selects the CLK0,  $\overline{\text{CLK0}}$  input. A logic high selects the CLK1,  $\overline{\text{CLK1}}$  input. The logic threshold for CLKSEL is set by an internal  $V_{\text{BB}}$  voltage reference. The CLKSEL input can be driven to  $V_{\text{CC}}$  and  $V_{\text{EE}}$  or by a single-ended LVPECL/LVECL signal. The selected input is reproduced at 10 differential outputs.

For interfacing to differential HSTL and LVPECL signals, these devices operate over a +2.25V to +3.8V supply range, allowing high-performance clock or data distribution in systems with a nominal +2.5V or +3.3V supply. For differential LVECL operation, these devices operate from a -2.25V to -3.8V supply.

The differential inputs can be configured to accept single-ended inputs when operating at approximately  $V_{\text{CC}} - V_{\text{EE}} = +3.0\text{V}$  to +3.8V for the MAX9311 or  $V_{\text{CC}} - V_{\text{EE}} = +2.7\text{V}$  to +3.8V for the MAX9313. This is accomplished by connecting the on-chip reference voltage,  $V_{\text{BB}}$ , to an input as a reference. For example, the differential CLK0,  $\overline{\text{CLK0}}$  input is converted to a noninverting, single-ended input by connecting  $V_{\text{BB}}$  to  $\overline{\text{CLK0}}$  and connecting the single-ended input to CLK0. Similarly, an inverting input is obtained by connecting  $V_{\text{BB}}$  to CLK0 and connecting the single-ended input to  $\overline{\text{CLK0}}$ . With a differential input configured as single-ended (using  $V_{\text{BB}}$ ), the single-ended input can be driven to  $V_{\text{CC}}$  and  $V_{\text{EE}}$  or with a single-ended LVPECL/LVECL signal.

When a differential input is configured as a single-ended input (using  $V_{\text{BB}}$ ), the approximate supply range is  $V_{\text{CC}} - V_{\text{EE}} = +3.0\text{V}$  to +3.8V for the MAX9311 and  $V_{\text{CC}} - V_{\text{EE}} = +2.7\text{V}$  to +3.8V for the MAX9313. This is because one of the inputs must be  $V_{\text{EE}} + 1.2\text{V}$  or higher for proper operation of the input stage.  $V_{\text{BB}}$  must be at least  $V_{\text{EE}} + 1.2\text{V}$  because it becomes the high-level input when the other (single-ended) input swings below it. Therefore, minimum  $V_{\text{BB}} = V_{\text{EE}} + 1.2\text{V}$ .

The minimum  $V_{\text{BB}}$  output for the MAX9311 is  $V_{\text{CC}} - 1.525\text{V}$  and the minimum  $V_{\text{BB}}$  output for the MAX9313 is  $V_{\text{CC}} - 1.38\text{V}$ . Substituting the minimum  $V_{\text{BB}}$  output for each device into  $V_{\text{BB}} = V_{\text{EE}} + 1.2\text{V}$  results in a minimum supply of 2.725V for the MAX9311 and 2.58V for the MAX9313. Rounding up to standard supplies gives the single-ended operating supply ranges of  $V_{\text{CC}} - V_{\text{EE}} = 3.0\text{V}$  to 3.8V for the MAX9311 and  $V_{\text{CC}} - V_{\text{EE}} = 2.7\text{V}$  to 3.8V for the MAX9313.

When using the  $V_{\text{BB}}$  reference output, bypass it with a 0.01 $\mu\text{F}$  ceramic capacitor to  $V_{\text{CC}}$ . If the  $V_{\text{BB}}$  reference is not used, it can be left open. The  $V_{\text{BB}}$  reference can source or sink 0.5mA, which is sufficient to drive two inputs. Use  $V_{\text{BB}}$  only for inputs that are on the same device as the  $V_{\text{BB}}$  reference.

The maximum magnitude of the differential input from CLK\_ to  $\overline{\text{CLK}}$  is 3.0V or  $V_{\text{CC}} - V_{\text{EE}}$ , whichever is less. This limit also applies to the difference between any reference voltage input and a single-ended input.

The differential inputs have bias resistors that drive the outputs to a differential low when the inputs are open. The inverting inputs ( $\overline{\text{CLK0}}$  and  $\overline{\text{CLK1}}$ ) are biased with a 75k $\Omega$  pullup to  $V_{\text{CC}}$  and a 75k $\Omega$  pulldown to  $V_{\text{EE}}$ . The noninverting inputs (CLK0 and CLK1) are biased with a 75k $\Omega$  pulldown to  $V_{\text{EE}}$ . The single-ended CLKSEL input does not have a bias resistor. If not driven, pull CLKSEL up or down with a 1k $\Omega$  resistor (see *Pin Description*).

Specifications for the high and low voltages of a differential input ( $V_{\text{IHD}}$  and  $V_{\text{ILD}}$ ) and the differential input voltage ( $V_{\text{IHD}} - V_{\text{ILD}}$ ) apply simultaneously ( $V_{\text{ILD}}$  cannot be higher than  $V_{\text{IHD}}$ ).

Output levels are referenced to  $V_{\text{CC}}$  and are considered LVPECL or LVECL, depending on the level of the  $V_{\text{CC}}$  supply. With  $V_{\text{CC}}$  connected to a positive supply and  $V_{\text{EE}}$  connected to GND, the outputs are LVPECL. The outputs are LVECL when  $V_{\text{CC}}$  is connected to GND and  $V_{\text{EE}}$  is connected to a negative supply.

A single-ended input of at least  $V_{\text{BB}} \pm 95\text{mV}$  or a differential input of at least 95mV switches the outputs to the  $V_{\text{OH}}$  and  $V_{\text{OL}}$  levels specified in the *DC Electrical Characteristics* table.

## Applications Information

### Supply Bypassing

Bypass  $V_{\text{CC}}$  to  $V_{\text{EE}}$  with high-frequency surface-mount ceramic 0.1 $\mu\text{F}$  and 0.01 $\mu\text{F}$  capacitors in parallel as close to the device as possible, with the 0.01 $\mu\text{F}$  value capacitor closest to the device. Use multiple parallel vias for low inductance. When using the  $V_{\text{BB}}$  reference output, bypass it with a 0.01 $\mu\text{F}$  ceramic capacitor to  $V_{\text{CC}}$  (if the  $V_{\text{BB}}$  reference is not used, it can be left open).

### Traces

Input and output trace characteristics affect the performance of the MAX9311/MAX9313. Connect each signal of a differential input or output to a 50 $\Omega$  characteristic impedance trace. Minimize the number of vias to prevent impedance discontinuities. Reduce reflections by maintaining the 50 $\Omega$  characteristic impedance through connectors and across cables. Reduce skew within a

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

differential pair by matching the electrical length of the traces.

## Output Termination

Terminate outputs through  $50\Omega$  to  $V_{CC} - 2V$  or use an equivalent Thevenin termination. When a single-ended signal is taken from a differential output, terminate both outputs. For example, if Q0 is used as a single-ended output, terminate both Q0 and  $\overline{Q0}$ .

## Chip Information

TRANSISTOR COUNT: 250

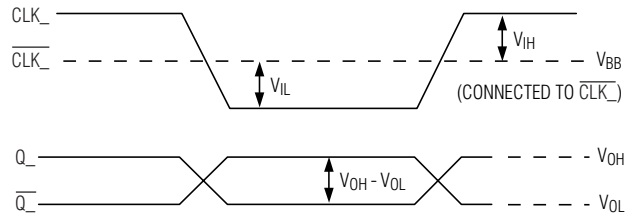


Figure 1. Switching with Single-Ended Input

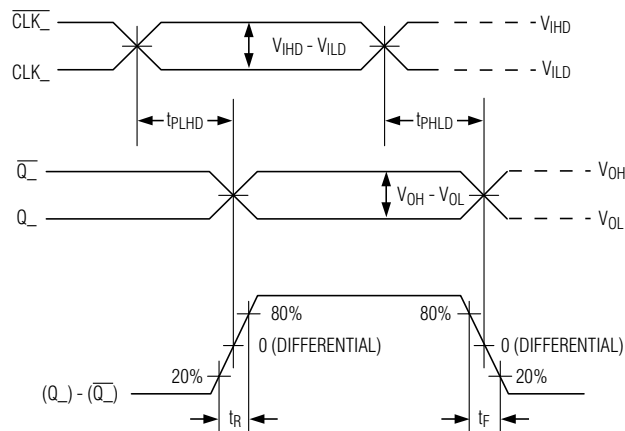
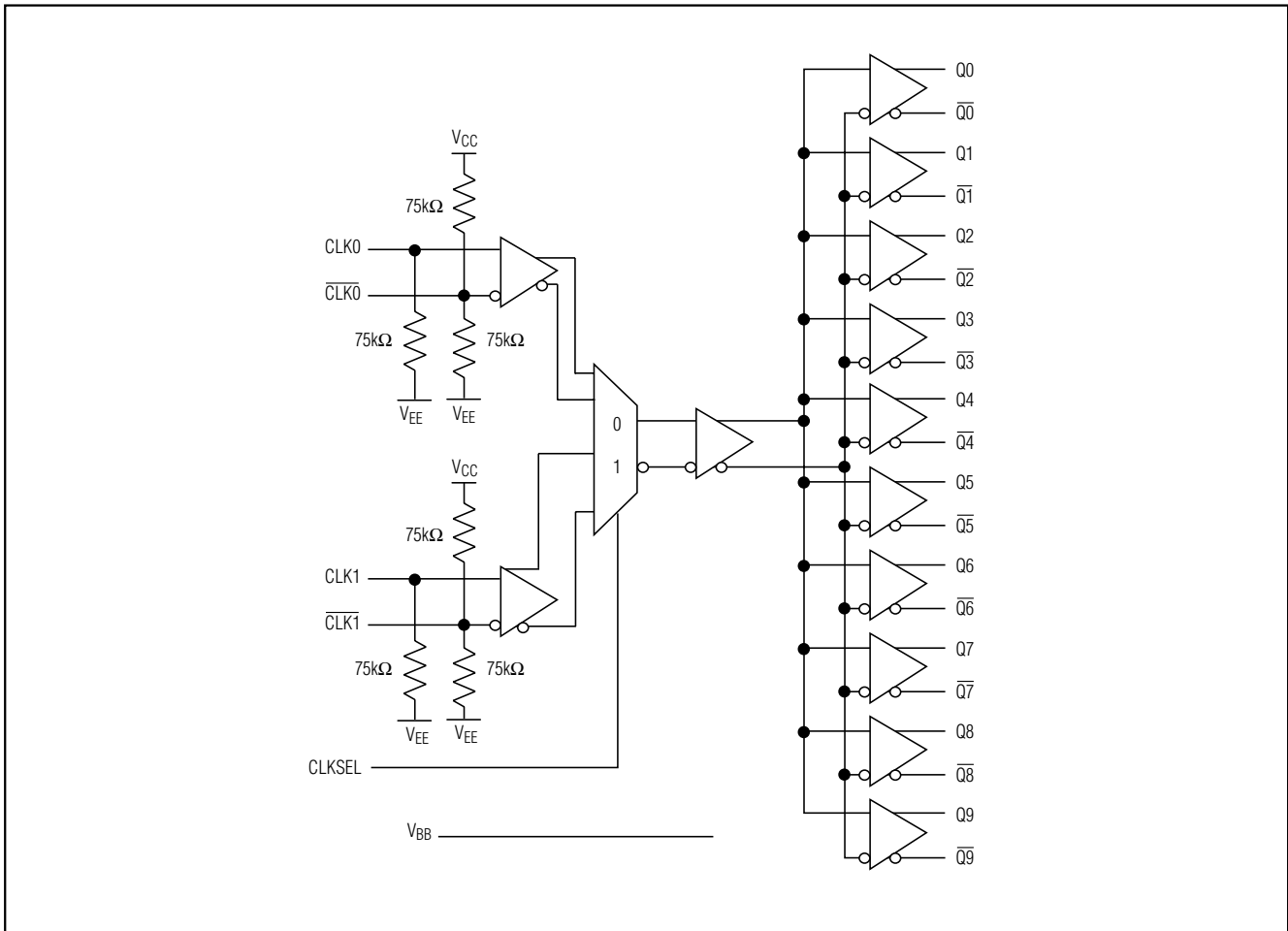


Figure 2. Differential Transition Time and Propagation Delay Timing Diagram

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

**Functional Diagram**

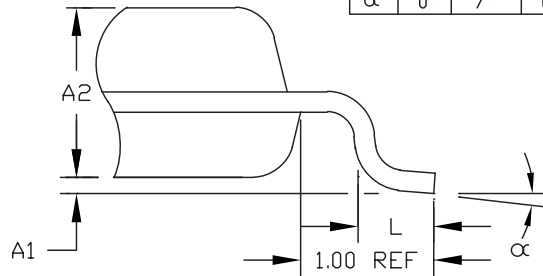
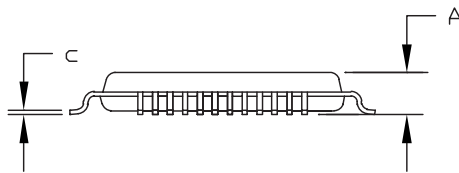
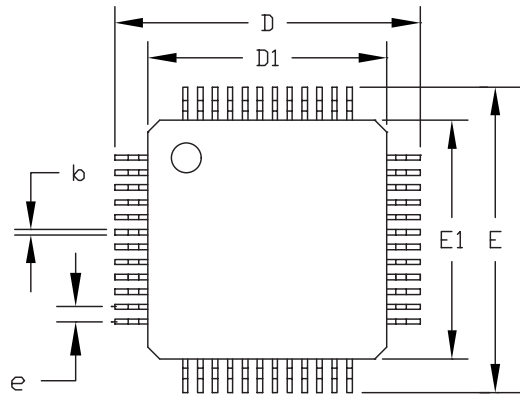


**MAX9311/MAX9313**

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

## 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).)



| JEDEC VARIATION |         |      |         |      |
|-----------------|---------|------|---------|------|
|                 | BC      |      | BE      |      |
|                 | 32 LEAD |      | 48 LEAD |      |
|                 | MIN.    | MAX. | MIN.    | MAX. |
| A               | ---     | 1.60 | ---     | 1.60 |
| A <sub>1</sub>  | 0.05    | 0.15 | 0.05    | 0.15 |
| A <sub>2</sub>  | 1.35    | 1.45 | 1.35    | 1.45 |
| D               | 8.90    | 9.10 | 8.90    | 9.10 |
| D <sub>1</sub>  | 7.00    | BSC. | 7.00    | BSC. |
| E               | 8.90    | 9.10 | 8.90    | 9.10 |
| E <sub>1</sub>  | 7.00    | BSC. | 7.00    | BSC. |
| e               | 0.8     | BSC. | 0.5     | BSC. |
| L               | 0.45    | 0.75 | 0.45    | 0.75 |
| b               | 0.30    | 0.45 | 0.17    | 0.27 |
| c               | 0.09    | 0.20 | 0.09    | 0.20 |
| $\alpha$        | 0°      | 7°   | 0°      | 7°   |

### NOTES:

1. ALL DIMENSIONING AND TOLERANCING CONFORM TO ANSI Y14.5-1982.
2. CONTROLLING DIMENSION: MILLIMETER.
3. THIS OUTLINE CONFORMS TO JEDEC PUBLICATION 95 REGISTRATION MD-136, VARIATIONS BC AND BE.
4. LEADS SHALL BE COPLANAR WITHIN .004 INCH.

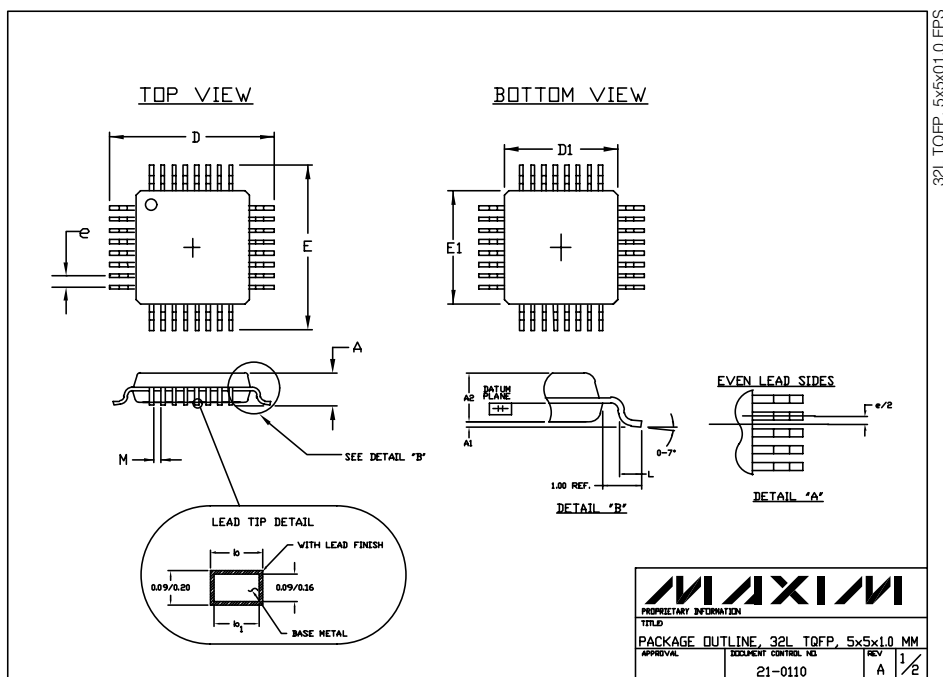
| MAXIM                                              |                      |     |     |
|----------------------------------------------------|----------------------|-----|-----|
| PROPRIETARY INFORMATION                            |                      |     |     |
| TITLE: PACKAGE OUTLINE,<br>32/48L, 7x7x1.4 MM TQFP |                      |     |     |
| APPROVAL                                           | DOCUMENT CONTROL NO. | REV | 1/1 |
|                                                    | 21-0054              | D   |     |

32/48L TQFP EPS

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

## Package Information (continued)

(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).)



- NOTES:
1. ALL DIMENSIONING AND TOLERANCING CONFORM TO ANSI Y14.5-1982.
  2. DATUM PLANE [EE] IS LOCATED AT MOLD PARTING LINE AND COINCIDENT WITH LEAD, WHERE LEAD EXITS PLASTIC BODY AT BOTTOM OF PARTING LINE.
  3. DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION. ALLOWABLE MOLD PROTRUSION IS 0.254 MM ON D1 AND E1 DIMENSIONS.
  4. THE TOP OF PACKAGE IS SMALLER THAN THE BOTTOM OF PACKAGE BY 0.15 MILLIMETERS.
  5. DIMENSION b DOES NOT INCLUDE DAMBAR PROTRUSION. ALLOWABLE DAMBAR PROTRUSION SHALL BE 0.08 MM TOTAL IN EXCESS OF THE b DIMENSION AT MAXIMUM MATERIAL CONDITION.
  6. CONTROLLING DIMENSION: MILLIMETER.
  7. THIS OUTLINE CONFORMS TO JEDEC PUBLICATION 95, REGISTRATION MD-136.
  8. LEADS SHALL BE COPLANAR WITHIN .004 INCH.

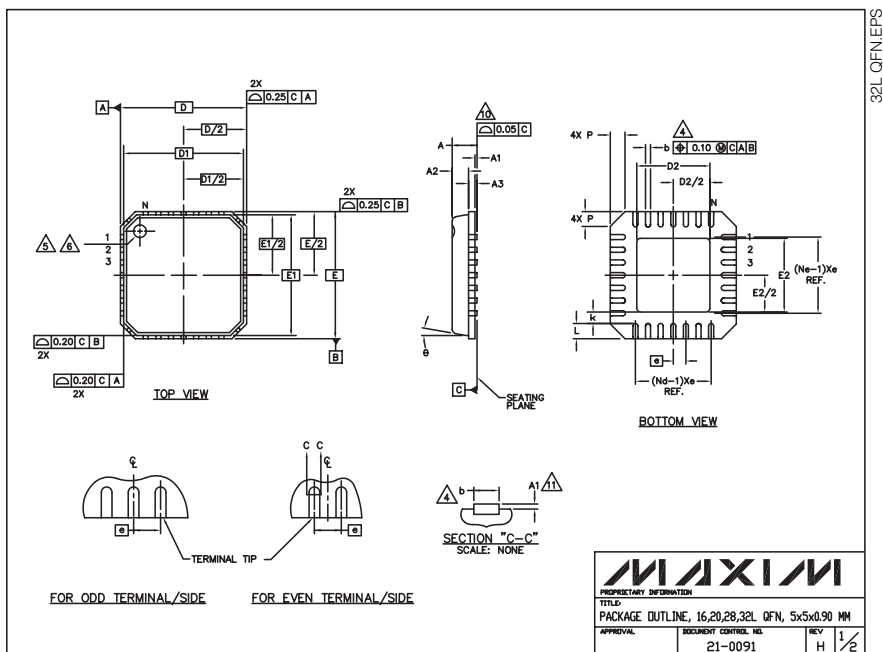
| JEDEC VARIATIONS          |           |
|---------------------------|-----------|
| DIMENSIONS IN MILLIMETERS |           |
| AA                        |           |
| 5x5x1.0 MM                |           |
|                           | MIN. MAX. |
| A                         | ~ 1.20    |
| A1                        | 0.05 0.15 |
| A2                        | 0.95 1.05 |
| D                         | 7.00 BSC. |
| D1                        | 5.00 BSC. |
| E                         | 7.00 BSC. |
| E1                        | 5.00 BSC. |
| L                         | 0.45 0.75 |
| M                         | 0.15 ~    |
| N                         | 32        |
| e                         | 0.50 BSC. |
| b                         | 0.17 0.27 |
| b1                        | 0.17 0.23 |

| MAXIM                                        |                           |
|----------------------------------------------|---------------------------|
| PROPRIETARY INFORMATION                      |                           |
| TITLE: PACKAGE OUTLINE, 32L TOFP, 5x5x1.0 MM |                           |
| APPROVAL:                                    | DOCUMENT CONTROL: 21-0110 |
| REV: A                                       | 1/2                       |

# 1:10 Differential LVPECL/LVECL/HSTL Clock and Data Drivers

## Package Information (continued)

(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).)



| 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 |
| θ                 | 0°       |      |      | 12°      |      |      | 12°      |      |      | 12°      |      |      |

| EXPOSED PAD VARIATIONS |      |      |      |      |      |      |
|------------------------|------|------|------|------|------|------|
| PKG CODES              | DE   |      |      | 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 |
| 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 |
| 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. N<sub>D</sub> IS THE NUMBER OF TERMINALS IN X-DIRECTION & N<sub>e</sub> 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.
- 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 M0220.
- THIS PACKAGE OUTLINE APPLIES TO ANVIL SINGULATION (STEPPED SIDES).

**MAXIM**  
PROPRIETARY INFORMATION  
TITLE: PACKAGE OUTLINE, 16,20,28,32L QFN, 5x5x0.90 MM  
APPROVAL: 21-0091 REV H 2/2

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### Офис по работе с юридическими лицами:

105318, г.Москва, ул.Щербаковская д.3, офис 1107, 1118, ДЦ «Щербаковский»

Телефон: +7 495 668-12-70 (многоканальный)

Факс: +7 495 668-12-70 (доб.304)

E-mail: [info@moschip.ru](mailto:info@moschip.ru)

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