

## MAX14955

## Single-Lane PCIe Gen III Redriver with Equalization and Extended Temperature Operation

### General Description

The MAX14955 dual equalizer/redriver improves PCI Express® (PCIe) signal integrity by providing programmable input equalization. This feature reduces deterministic jitter and redrives circuitry to reestablish deemphasis, which compensates for circuit-board loss at high frequencies. The device permits optimal placement of key PCIe components and allows for longer runs of stripline, microstrip, or cable.

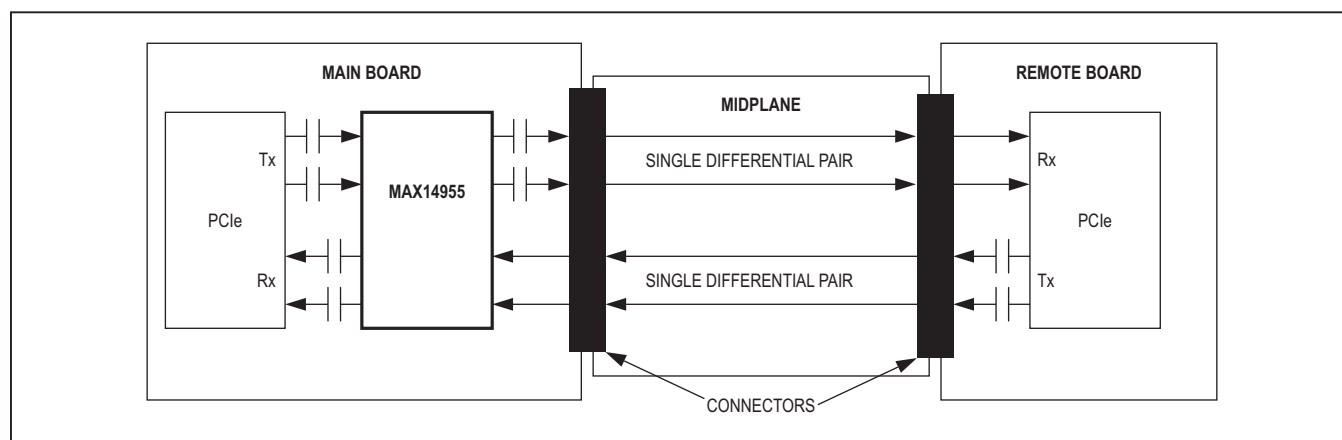
The device contains two identical channels capable of equalizing PCIe Gen III (8GT/s), Gen II (5GT/s), and Gen I (2.5GT/s) signals and features electrical idle and receiver detection.

The MAX14955 is available in a small, 40-pin, 5.0mm x 5.0mm TQFN package with flow-through traces for optimal layout and minimal space requirements. The device is specified over the -40°C to +85°C extending operating temperature range.

### Applications

- Industrial/Embedded PCs
- Computer on Modules
- Carrier Boards
- Test Equipment
- Rack Server Industrial PCs
- Medical Equipment

### Typical Operating Circuit



PCI Express is a registered service mark of PCI-SIG Corporation.

### Benefits and Features

- Fully Integrated for Ease of Use and Design Flexibility
  - Optimized for PCIe Gen III (8.0GT/s), Gen II (5.0GT/s), Gen I (2.5 GT/s) Compatible
  - Four Levels of Input Equalization up to 16dB
  - Eight Levels of Output Deemphasis up to 9dB
- High Level of Performance to Overcome Noise in Lossy Channels
  - Random Jitter: 0.5ps<sub>RMS</sub> (typ)
  - Deterministic Jitter: 7ps<sub>p-p</sub> (typ)
  - Equalization Permits Placement Up to 30in FR4
- Robust Solution for Harsh Environments
  - Industrial Temperature Rated: -40°C to +85°C
  - ±4kV Human Body Model (HBM) Protection on All Pins
  - Housed in a Flow-Through (5mm x 5mm) TQFN Package for Resistance to Vibration/Shocks

**Ordering Information** appears at end of data sheet.

For related parts and recommended products to use with this part, refer to [www.maximintegrated.com/MAX14955.related](http://www.maximintegrated.com/MAX14955.related).

## Absolute Maximum Ratings

(Voltages referenced to GND.)

|                                                                                |                                   |
|--------------------------------------------------------------------------------|-----------------------------------|
| V <sub>CC</sub> .....                                                          | -0.3V to +4.0V                    |
| All Other Pins (Note 1) .....                                                  | -0.3V to (V <sub>CC</sub> + 0.3V) |
| Continuous Current IN_P, IN_M,<br>OUT_P, OUT_M .....                           | ±30mA                             |
| Peak Current IN_P, IN_M, OUT_P, OUT_M<br>(pulsed for 1μs, 1% duty cycle) ..... | ±100mA                            |

Continuous Power Dissipation (T<sub>A</sub> = +70°C)

|                                          |                 |
|------------------------------------------|-----------------|
| TQFN (derate 35.7mW/°C above +70°C)..... | 2857mW          |
| Operating Temperature Range .....        | -40°C to +85°C  |
| Junction Temperature Range .....         | -40°C to +150°C |
| Storage Temperature Range .....          | -65°C to +150°C |
| Lead Temperature (soldering, 10s) .....  | +300°C          |
| Soldering Temperature (reflow) .....     | +260°C          |

**Note 1:** All I/O pins are clamped by internal diodes.

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.

## Package Thermal Characteristics (Note 2)

TQFN

Junction-to-Ambient Thermal Resistance (θ<sub>JA</sub>)..... 28°C/WJunction-to-Case Thermal Resistance (θ<sub>JC</sub>).....2°C/W

**Note 2:** Package thermal resistances were obtained using the method described in JEDEC specification JESD51-7, using a four-layer board. For detailed information on package thermal considerations, refer to [www.maximintegrated.com/thermal-tutorial](http://www.maximintegrated.com/thermal-tutorial).

## Electrical Characteristics

(V<sub>CC</sub> = +3.0V to +3.6V, C<sub>CL</sub> = 200nF coupling capacitor on each output, R<sub>L</sub> = 50Ω on each output, T<sub>A</sub> = -40°C to +85°C, unless otherwise noted. Typical values are at V<sub>CC</sub> = +3.3V and T<sub>A</sub> = +25°C.) (Note 3)

| PARAMETER          | SYMBOL          | CONDITIONS           |                                               | MIN | TYP | MAX | UNITS |
|--------------------|-----------------|----------------------|-----------------------------------------------|-----|-----|-----|-------|
| DC PERFORMANCE     |                 |                      |                                               |     |     |     |       |
| Power-Supply Range | V <sub>CC</sub> |                      |                                               | 3.0 | 3.3 | 3.6 | V     |
| Supply Current     | I <sub>CC</sub> | EN = V <sub>CC</sub> | OEQ_2 = OEQ_1 = OEQ_0 = GND                   | 102 |     | 135 | mA    |
|                    |                 |                      | OEQ_2 = OEQ_1 = GND, OEQ_0 = V <sub>CC</sub>  | 106 |     | 140 |       |
|                    |                 |                      | OEQ_2 = OEQ_0 = GND, OEQ_1 = V <sub>CC</sub>  | 107 |     | 140 |       |
|                    |                 |                      | OEQ_2 = GND, OEQ_1 = OEQ_0 = V <sub>CC</sub>  | 125 |     | 160 |       |
|                    |                 |                      | OEQ_2 = V <sub>CC</sub> , OEQ_1 = OEQ_0 = GND | 106 |     | 140 |       |
|                    |                 |                      | OEQ_2 = OEQ_0 = V <sub>CC</sub> , OEQ_1 = GND | 132 |     | 170 |       |
|                    |                 |                      | OEQ_2 = OEQ_1 = V <sub>CC</sub> , OEQ_0 = GND | 140 |     | 180 |       |
|                    |                 |                      | OEQ_2 = OEQ_1 = OEQ_0 = V <sub>CC</sub>       | 165 |     | 210 |       |

**Electrical Characteristics (continued)**

( $V_{CC} = +3.0V$  to  $+3.6V$ ,  $C_{CL} = 200nF$  coupling capacitor on each output,  $R_L = 50\Omega$  on each output,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted. Typical values are at  $V_{CC} = +3.3V$  and  $T_A = +25^\circ C$ .) (Note 3)

| PARAMETER                                                    | SYMBOL                           | CONDITIONS                           |                                        | MIN | TYP | MAX | UNITS      |
|--------------------------------------------------------------|----------------------------------|--------------------------------------|----------------------------------------|-----|-----|-----|------------|
| Standby Current                                              | $I_{STBY}$                       | EN = GND                             | OEQ_2 = OEQ_1 = OEQ_0 = GND            |     | 57  | 80  | mA         |
|                                                              |                                  |                                      | OEQ_2 = OEQ_1 = GND, OEQ_0 = $V_{CC}$  |     | 61  | 85  |            |
|                                                              |                                  |                                      | OEQ_2 = OEQ_0 = GND, OEQ_1 = $V_{CC}$  |     | 62  | 85  |            |
|                                                              |                                  |                                      | OEQ_2 = GND, OEQ_1 = OEQ_0 = $V_{CC}$  |     | 75  | 100 |            |
|                                                              |                                  |                                      | OEQ_2 = $V_{CC}$ , OEQ_1 = OEQ_0 = GND |     | 62  | 80  |            |
|                                                              |                                  |                                      | OEQ_2 = OEQ_0 = $V_{CC}$ , OEQ_1 = GND |     | 85  | 110 |            |
|                                                              |                                  |                                      | OEQ_2 = OEQ_1 = $V_{CC}$ , OEQ_0 = GND |     | 92  | 120 |            |
|                                                              |                                  |                                      | OEQ_2 = OEQ_1 = OEQ_0 = $V_{CC}$       |     | 120 | 150 |            |
| Differential Input Impedance                                 | $Z_{RX-DIFF-DC}$                 | DC                                   |                                        | 80  | 100 | 120 | $\Omega$   |
| Differential Output Impedance                                | $Z_{TX-DIFF-DC}$                 | DC                                   |                                        | 80  | 100 | 120 | $\Omega$   |
| Common-Mode Resistance to GND, Input Termination Not Powered | $Z_{RX-HIGH-IMP-DC}$             | $-150mV \leq V_{IN\_CM} \leq +200mV$ |                                        | 50  |     |     | k $\Omega$ |
| Common-Mode Resistance to GND, Input Termination Powered     | $Z_{RX-DC}$                      |                                      |                                        | 20  | 25  | 30  | $\Omega$   |
| Output Short-Circuit Current                                 | $I_{TX-SHORT}$                   | Single-ended (Note 4)                |                                        | 90  |     |     | mA         |
| Common-Mode Delta, Between Active and Idle States            | $V_{TX-CM-DC-ACTIVE-IDLE-DELTA}$ |                                      |                                        |     |     | 100 | mV         |
| DC Output Offset, During Active State                        | $V_{TX-ACTIVE-DIFF-DC}$          | $ V_{OUT\_P} - V_{OUT\_M} $          |                                        |     |     | 65  | mV         |
| DC Output Offset, During Electrical Idle                     | $V_{TX-IDLE-DIFF-DC}$            | $ V_{OUT\_P} - V_{OUT\_M} $          |                                        |     |     | 65  | mV         |

**Electrical Characteristics (continued)**

( $V_{CC} = +3.0V$  to  $+3.6V$ ,  $C_{CL} = 200nF$  coupling capacitor on each output,  $R_L = 50\Omega$  on each output,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted. Typical values are at  $V_{CC} = +3.3V$  and  $T_A = +25^\circ C$ .) (Note 3)

| PARAMETER                                                       | SYMBOL                             | CONDITIONS                                                                    | MIN | TYP  | MAX  | UNITS             |
|-----------------------------------------------------------------|------------------------------------|-------------------------------------------------------------------------------|-----|------|------|-------------------|
| <b>AC PERFORMANCE (Note 4)</b>                                  |                                    |                                                                               |     |      |      |                   |
| Input Return Loss, Differential                                 | RL <sub>RX-DIFF</sub>              | f = 0.05GHz to 1.25GHz                                                        | 9   |      |      | dB                |
|                                                                 |                                    | f = 1.25GHz to 2.5GHz                                                         | 8   |      |      | dB                |
|                                                                 |                                    | f = 2.5GHz to 4GHz                                                            | 5   |      |      | dB                |
| Input Return Loss, Common Mode                                  | RL <sub>RX-CM</sub>                | f = 0.05GHz to 2.5GHz                                                         | 6   |      |      | dB                |
|                                                                 |                                    | f = 2.5GHz to 4GHz                                                            | 4   |      |      | dB                |
| Output Return Loss, Differential                                | RL <sub>TX-DIFF</sub>              | f = 0.05GHz to 1.25GHz                                                        | 10  |      |      | dB                |
|                                                                 |                                    | f = 1.25GHz to 2.5GHz                                                         | 8   |      |      | dB                |
|                                                                 |                                    | f = 2.5GHz to 4GHz                                                            | 4   |      |      | dB                |
| Output Return Loss, Common Mode                                 | RL <sub>TX-CM</sub>                | f = 0.05GHz to 2.5GHz                                                         | 6   |      |      | dB                |
|                                                                 |                                    | f = 2.5GHz to 4GHz                                                            | 4   |      |      | dB                |
| Redriver-Operation Differential Input-Signal Range              | V <sub>RX-DIFF-PP</sub>            |                                                                               | 100 |      | 1200 | mV <sub>P-P</sub> |
| Full-Swing Differential Output Voltage (No Deemphasis)          | V <sub>TX-DIFF-PP</sub>            | 2 x  (V <sub>OUT_P</sub> - V <sub>OUT_M</sub> ) , OEQ_2 = OEQ_1 = OEQ_0 = GND | 800 | 1000 | 1400 | mV <sub>P-P</sub> |
| Output Deemphasis Ratio, 0dB                                    | V <sub>TX-DE-RATIO-0dB</sub>       | OEQ_2 = OEQ_1 = OEQ_0 = GND, Figure 1                                         |     | 0    |      | dB                |
| Output Deemphasis Ratio, 3.5dB                                  | V <sub>TX-DE-RATIO-3.5dB</sub>     | OEQ_2 = OEQ_1 = GND, OEQ_0 = V <sub>CC</sub> , Figure 1                       |     | 3.5  |      | dB                |
| Output Deemphasis Ratio, 6dB                                    | V <sub>TX-DE-RATIO-6dB</sub>       | OEQ_2 = OEQ_0 = GND, OEQ_1 = V <sub>CC</sub> , Figure 1                       |     | 6    |      | dB                |
| Output Deemphasis Ratio, 6dB with Higher Amplitude              | V <sub>TX-DE-HA-RATIO-6dB</sub>    | OEQ_2 = GND, OEQ_1 = OEQ_0 = V <sub>CC</sub> , Figure 1                       |     | 6    |      | dB                |
| Output Deemphasis Ratio, 3.5dB with Preshoot                    | V <sub>TX-DE-PS-RATIO-3.5dB</sub>  | OEQ_2 = V <sub>CC</sub> , OEQ_1 = OEQ_0 = GND, Figure 1                       |     | 3.5  |      | dB                |
| Output Deemphasis Ratio, 6dB with Preshoot                      | V <sub>TX-DE-PS-RATIO-6dB</sub>    | OEQ_2 = OEQ_0 = V <sub>CC</sub> , OEQ_1 = GND, Figure 1                       |     | 6    |      | dB                |
| Output Deemphasis Ratio, 9dB with Preshoot                      | V <sub>TX-DE-PS-RATIO-9dB</sub>    | OEQ_2 = OEQ_1 = V <sub>CC</sub> , OEQ_0 = GND, Figure 1                       |     | 9    |      | dB                |
| Output Deemphasis Ratio, 9dB with Preshoot and Higher Amplitude | V <sub>TX-DE-PS-HA-RATIO-9dB</sub> | OEQ_2 = OEQ_1 = OEQ_0 = V <sub>CC</sub> , Figure 1                            |     | 9    |      | dB                |
| Input Equalization, 5dB                                         | V <sub>RX-EQ-5dB</sub>             | INEQ_1 = INEQ_0 = GND (Note 5)                                                |     | 5    |      | dB                |

**Electrical Characteristics (continued)**

( $V_{CC} = +3.0V$  to  $+3.6V$ ,  $C_{CL} = 200nF$  coupling capacitor on each output,  $R_L = 50\Omega$  on each output,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted. Typical values are at  $V_{CC} = +3.3V$  and  $T_A = +25^\circ C$ .) (Note 3)

| PARAMETER                                  | SYMBOL                     | CONDITIONS                                                                                  | MIN | TYP     | MAX  | UNITS             |
|--------------------------------------------|----------------------------|---------------------------------------------------------------------------------------------|-----|---------|------|-------------------|
| Input Equalization, 8dB                    | $V_{RX-EQ-8dB}$            | INEQ_1 = GND, INEQ_0 = $V_{CC}$ (Note 5)                                                    |     | 8       |      | dB                |
| Input Equalization, 12dB                   | $V_{RX-EQ-12dB}$           | INEQ_1 = $V_{CC}$ , INEQ_0 = GND (Note 5)                                                   |     | 12      |      | dB                |
| Input Equalization, 16dB                   | $V_{RX-EQ-16dB}$           | INEQ_1 = INEQ_0 = $V_{CC}$ (Note 5)                                                         |     | 16      |      | dB                |
| Output Common-Mode Voltage                 | $V_{TX-CM-AC-PP}$          | $MAX(V_{OUT\_P} + V_{OUT\_M})/2 - MIN(V_{OUT\_P} + V_{OUT\_M})/2$                           |     |         | 100  | mV <sub>P-P</sub> |
| Propagation Delay                          | $t_{PD}$                   |                                                                                             | 120 | 160     | 240  | ps                |
| Rise/Fall Time                             | $t_{TX-RISE-FALL}$         | (Note 6)                                                                                    | 20  |         |      | ps                |
| Rise/Fall Time Mismatch                    | $t_{TX-RF-MISMATCH}$       | (Note 6)                                                                                    |     |         | 20   | ps                |
| Deterministic Jitter                       | $t_{TX-DJ-DD}$             | K28.5 pattern, AC-coupled, $R_L = 50\Omega$ , no deemphasis, no preshoot, data rate = 8GT/s |     | 7       | 23.5 | ps <sub>P-P</sub> |
| Random Jitter                              | $t_{TX-RJ-DD}$             | D10.2 pattern, no deemphasis, no preshoot, data rate = 8GT/s                                |     | 0.5     | 1.5  | ps <sub>RMS</sub> |
| Electrical Idle Entry Delay                | $t_{TX-IDLE-SET-TO-IDLE}$  | From input to output, D10.2 pattern, data rate = 1GT/s                                      |     | 5       |      | ns                |
| Electrical Idle Exit Delay                 | $t_{TX-IDLE-TO-DIFF-DATA}$ | From input to output, D10.2 pattern, data rate = 1GT/s                                      |     | 5       |      | ns                |
| Electrical Idle Detect Threshold           | $V_{TX-IDLE-THRESH}$       | D10.2 pattern, data rate = 1GT/s (Note 3)                                                   | 50  | 112     | 190  | mV <sub>P-P</sub> |
|                                            |                            | D10.2 pattern, data rate = 1GT/s to 8GT/s                                                   |     | 112     |      |                   |
| Output Voltage During Electrical Idle (AC) | $V_{TX-IDLE-DIFF-AC-P}$    | $ V_{OUT\_P} - V_{OUT\_M} $                                                                 |     |         | 20   | mV <sub>P-P</sub> |
| Receiver-Detect Pulse Amplitude            | $V_{TX-RCV-DETECT}$        | Voltage change in positive direction                                                        |     | 600     |      | mV                |
| Receiver-Detect Pulse Width                |                            |                                                                                             |     | 100     |      | ns                |
| Receiver-Detect Retry Period               |                            |                                                                                             |     | 200     |      | ns                |
| <b>CONTROL LOGIC</b>                       |                            |                                                                                             |     |         |      |                   |
| Input-Logic Level Low                      | $V_{IL}$                   |                                                                                             |     |         | 0.6  | V                 |
| Input-Logic Level High                     | $V_{IH}$                   |                                                                                             | 1.4 |         |      | V                 |
| Input-Logic Hysteresis                     | $V_{HYST}$                 |                                                                                             |     | 0.1     |      | V                 |
| Input Pulldown Resistance                  | $R_{PD}$                   |                                                                                             | 200 | 375     |      | k $\Omega$        |
| <b>ESD PROTECTION</b>                      |                            |                                                                                             |     |         |      |                   |
| ESD Voltage                                |                            | Human Body Model (HBM)                                                                      |     | $\pm 4$ |      | kV                |

**Electrical Characteristics (continued)**

( $V_{CC} = +3.0V$  to  $+3.6V$ ,  $C_{CL} = 200nF$  coupling capacitor on each output,  $R_L = 50\Omega$  on each output,  $T_A = -40^\circ C$  to  $+85^\circ C$ , unless otherwise noted. Typical values are at  $V_{CC} = +3.3V$  and  $T_A = +25^\circ C$ .) (Note 3)

**Note 3:** All devices are 100% production tested at  $T_A = +85^\circ C$ . Specifications over operating temperature range are guaranteed by design.

**Note 4:** Guaranteed by design, unless otherwise noted.

**Note 5:** Equivalent to same amount of deemphasis driving the input.

**Note 6:** Rise and fall times are measured using 20% and 80% levels.

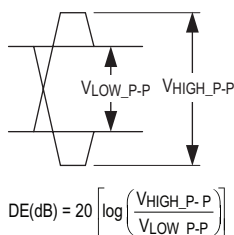
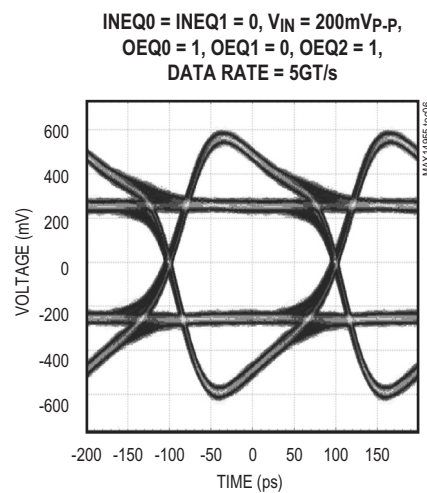
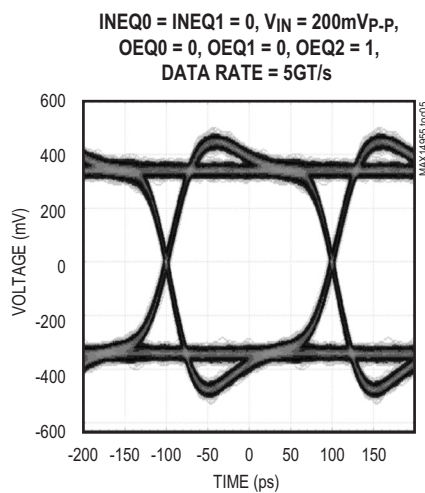
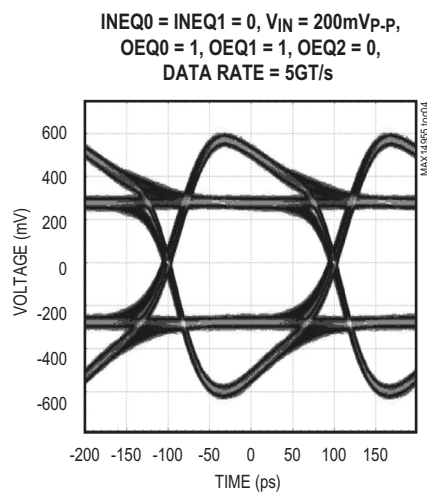
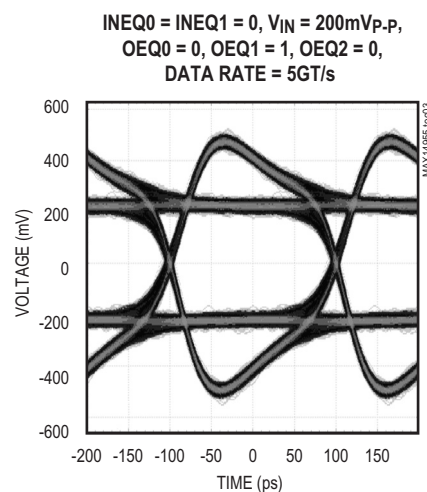
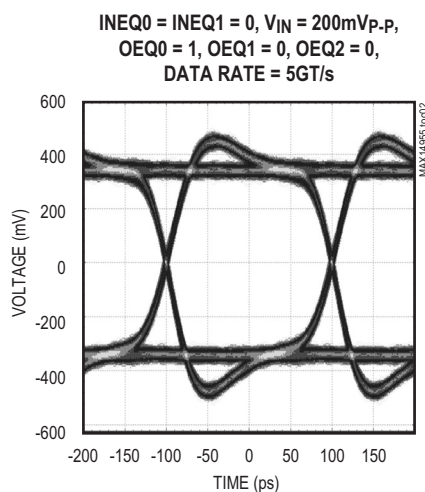
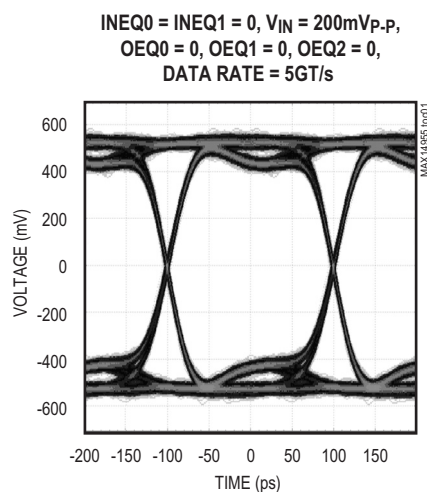
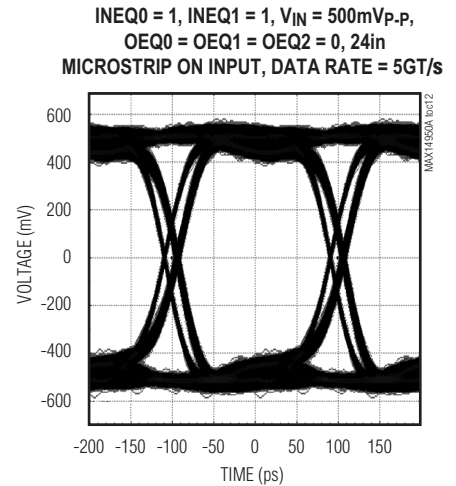
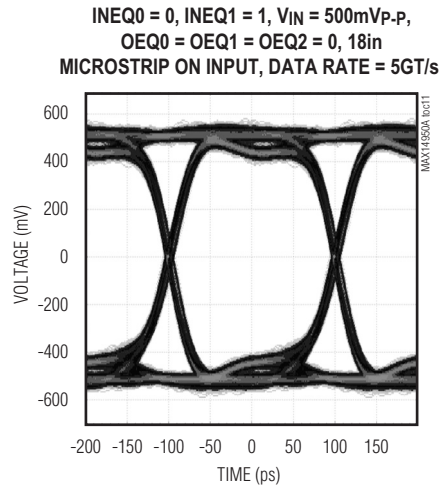
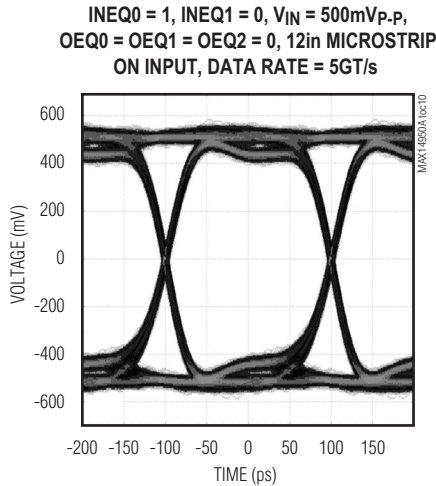
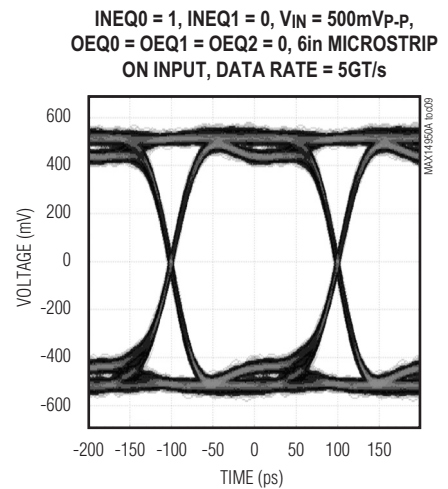
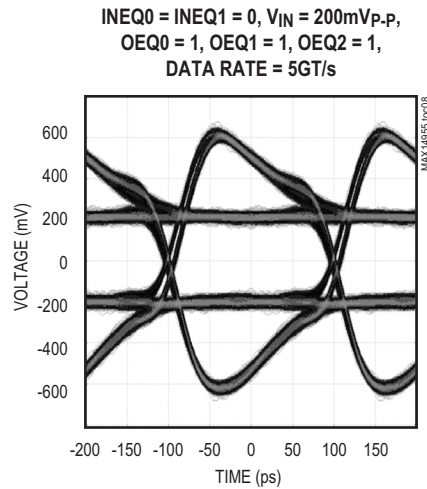
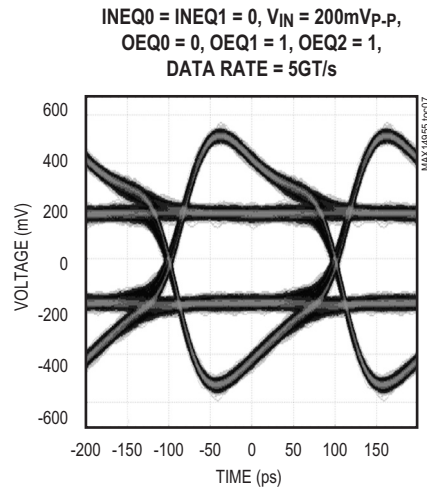


Figure 1. Illustration of Output Deemphasis

## Typical Operating Characteristics

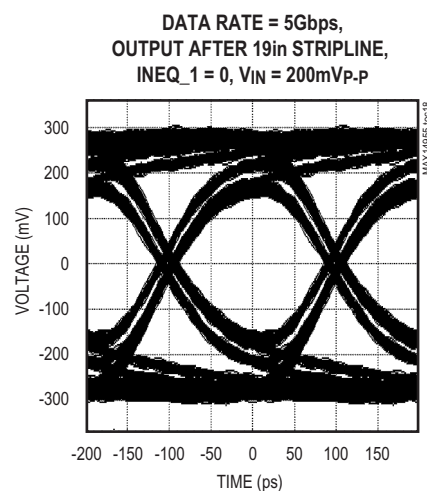
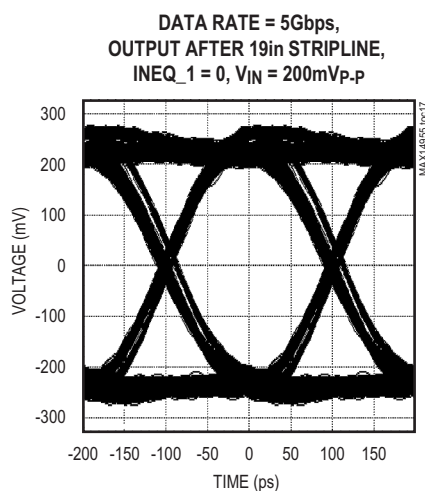
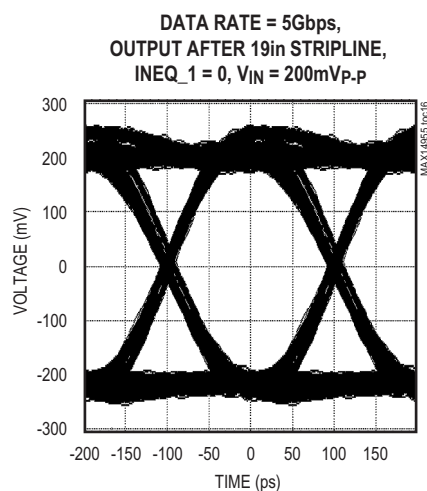
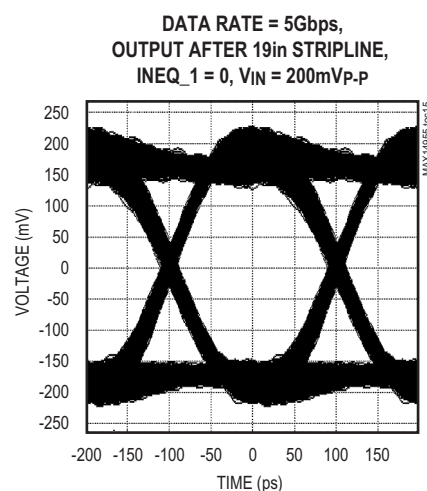
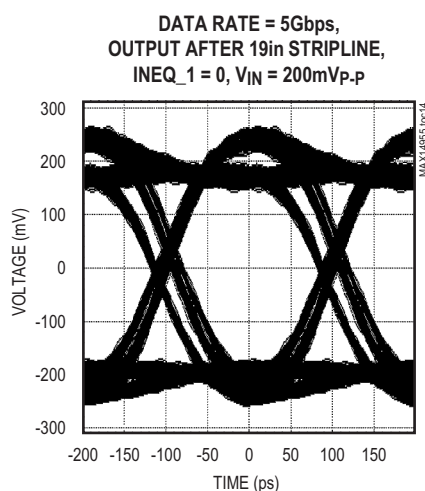
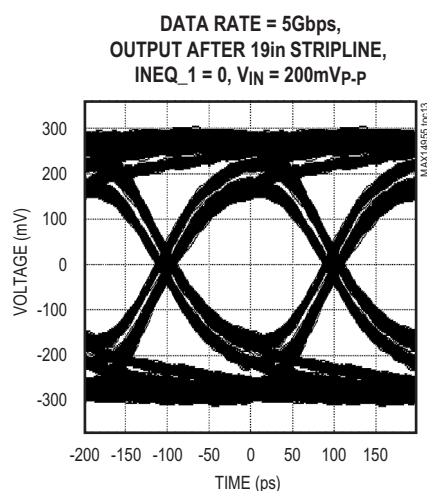
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## Typical Operating Characteristics (continued)

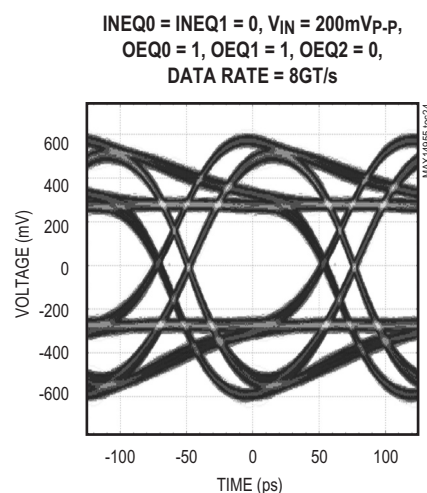
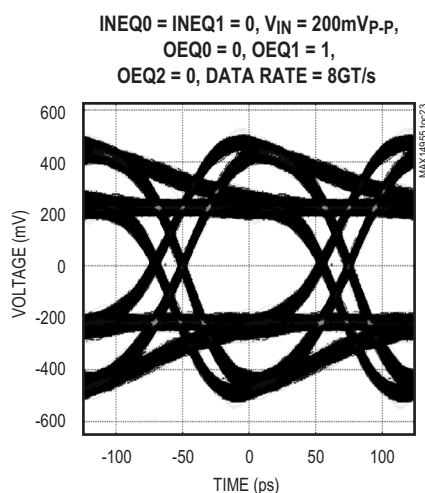
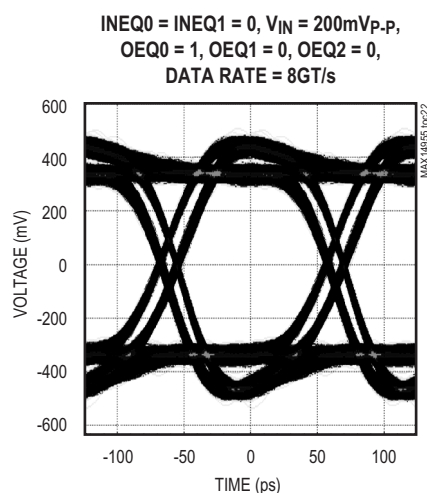
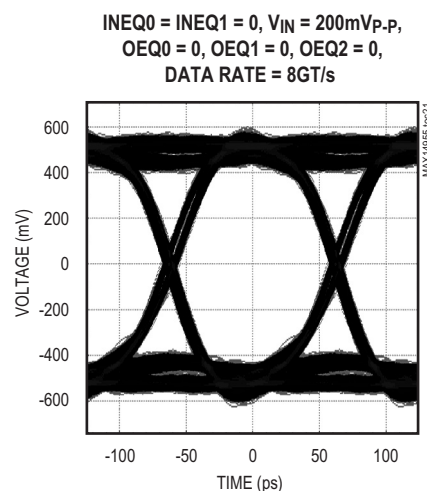
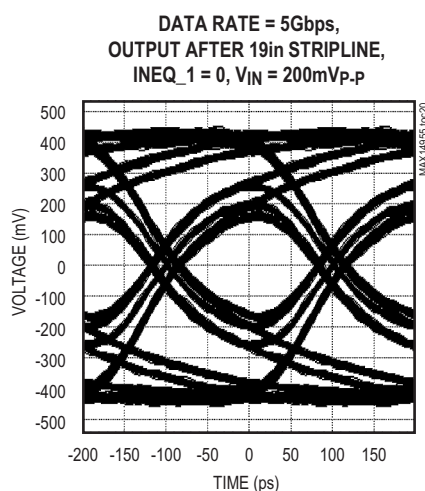
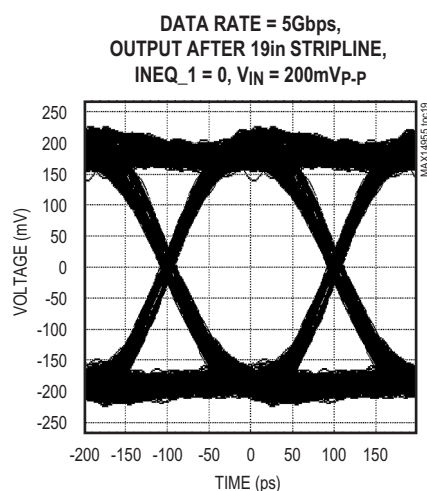
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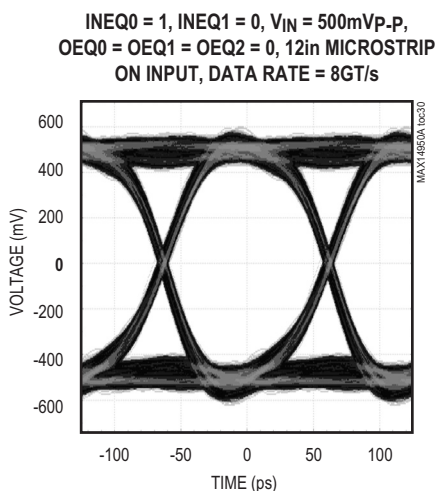
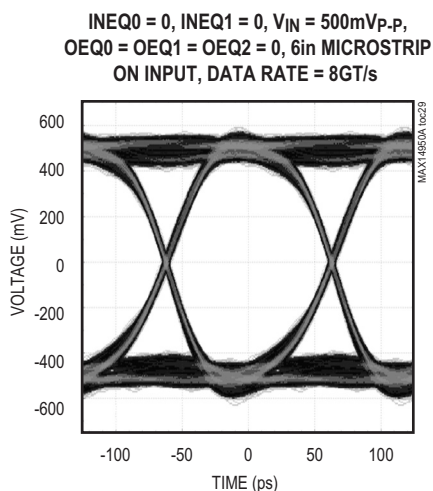
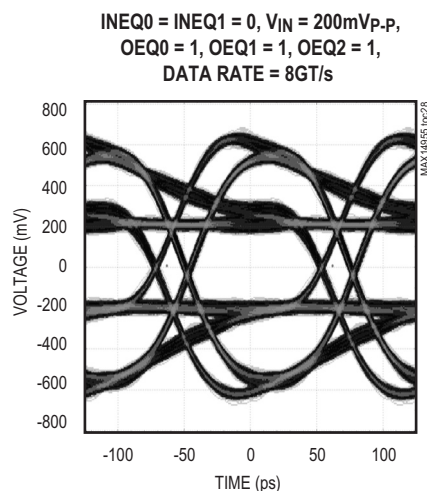
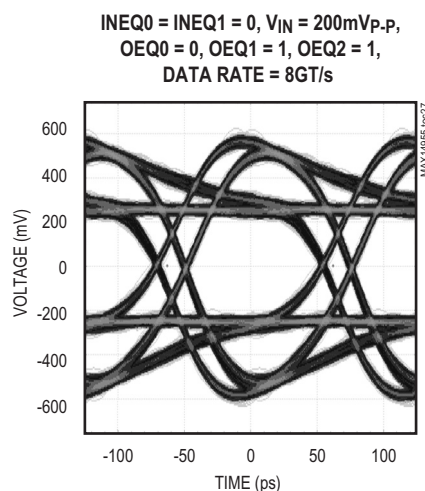
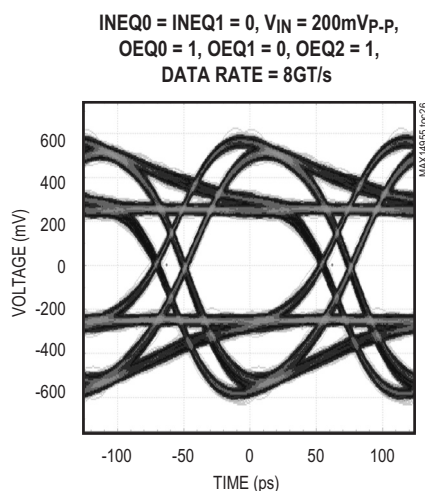
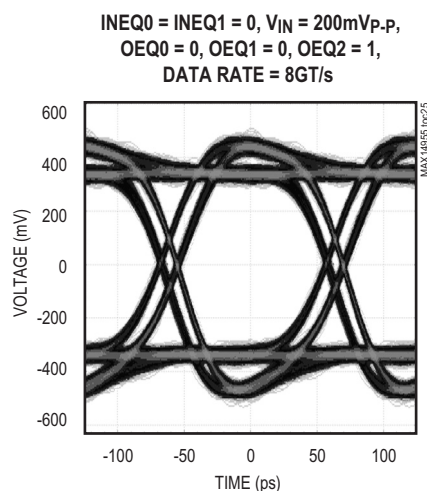
## Typical Operating Characteristics (continued)

(V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.)

## Typical Operating Characteristics (continued)

(V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.)

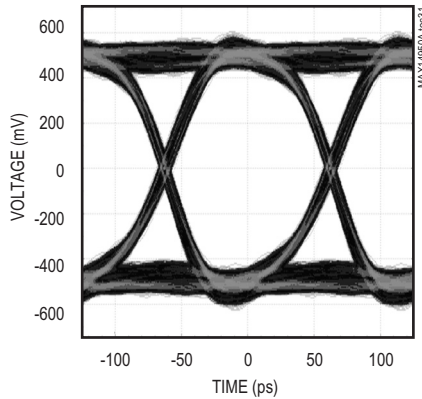
## Typical Operating Characteristics (continued)

(V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.)

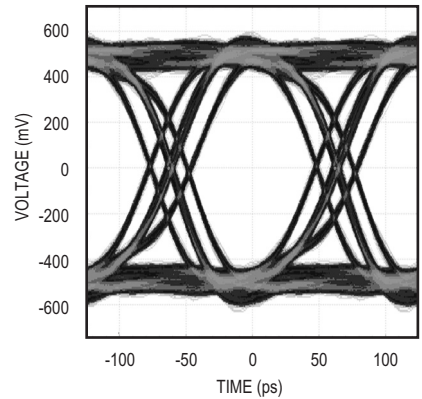
## Typical Operating Characteristics (continued)

(V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.)

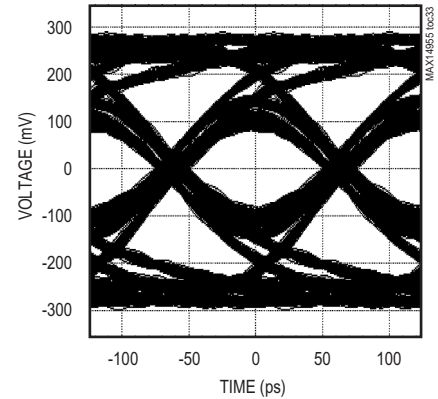
INEQ0 = 0, INEQ1 = 1, V<sub>IN</sub> = 500mVp.p,  
OEQ0 = OEQ1 = OEQ2 = 0, 18in MICROSTRIP  
ON INPUT, DATA RATE = 8GT/s



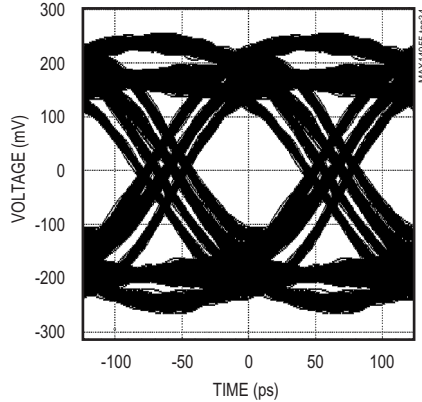
INEQ0 = 1, INEQ1 = 1, V<sub>IN</sub> = 500mVp.p,  
OEQ0 = OEQ1 = OEQ2 = 0, 24in MICROSTRIP  
ON INPUT, DATA RATE = 8GT/s



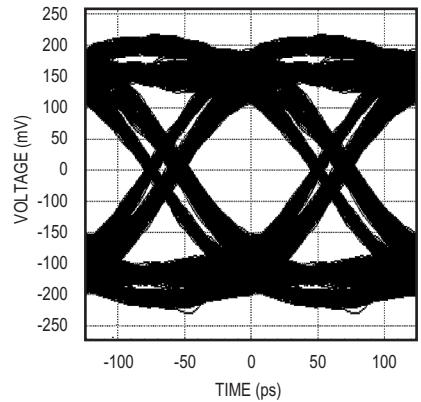
DATA RATE = 8Gbps, OUTPUT AFTER  
19in STRIPLINE, INEQ\_0 = INEQ\_1 = 0,  
V<sub>IN</sub> = 200mVp.p



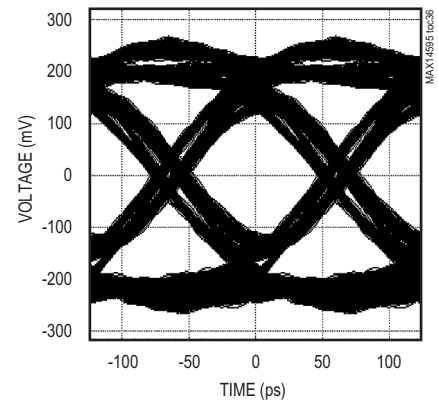
DATA RATE = 8Gbps, OUTPUT AFTER  
19in STRIPLINE, INEQ\_0 = INEQ\_1 = 0,  
V<sub>IN</sub> = 200mVp.p



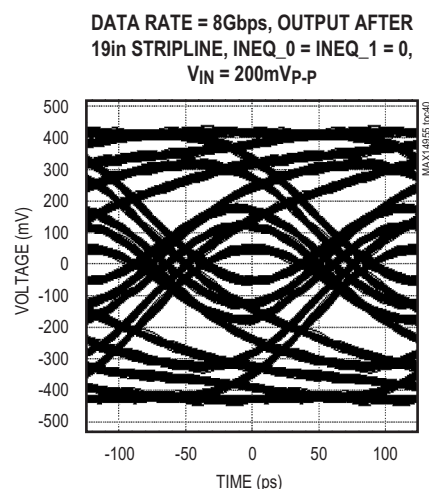
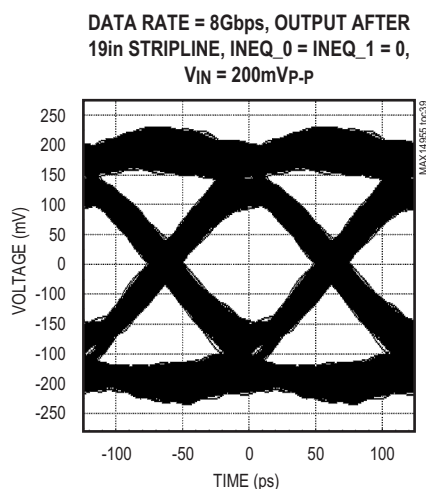
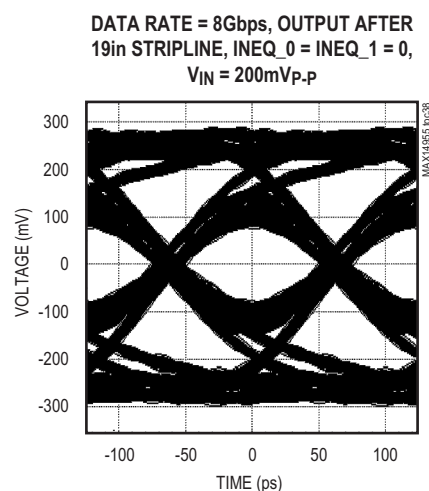
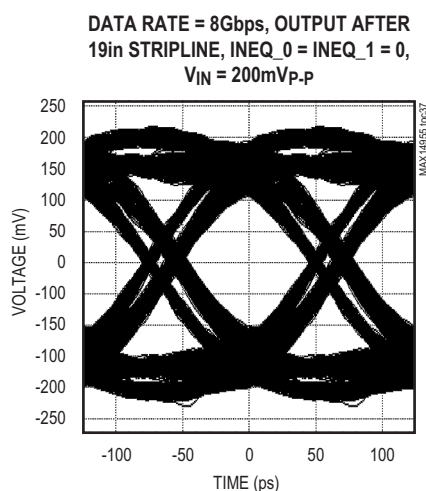
DATA RATE = 8Gbps, OUTPUT AFTER  
19in STRIPLINE, INEQ\_0 = INEQ\_1 = 0,  
V<sub>IN</sub> = 200mVp.p



DATA RATE = 8Gbps, OUTPUT AFTER  
19in STRIPLINE, INEQ\_0 = INEQ\_1 = 0,  
V<sub>IN</sub> = 200mVp.p



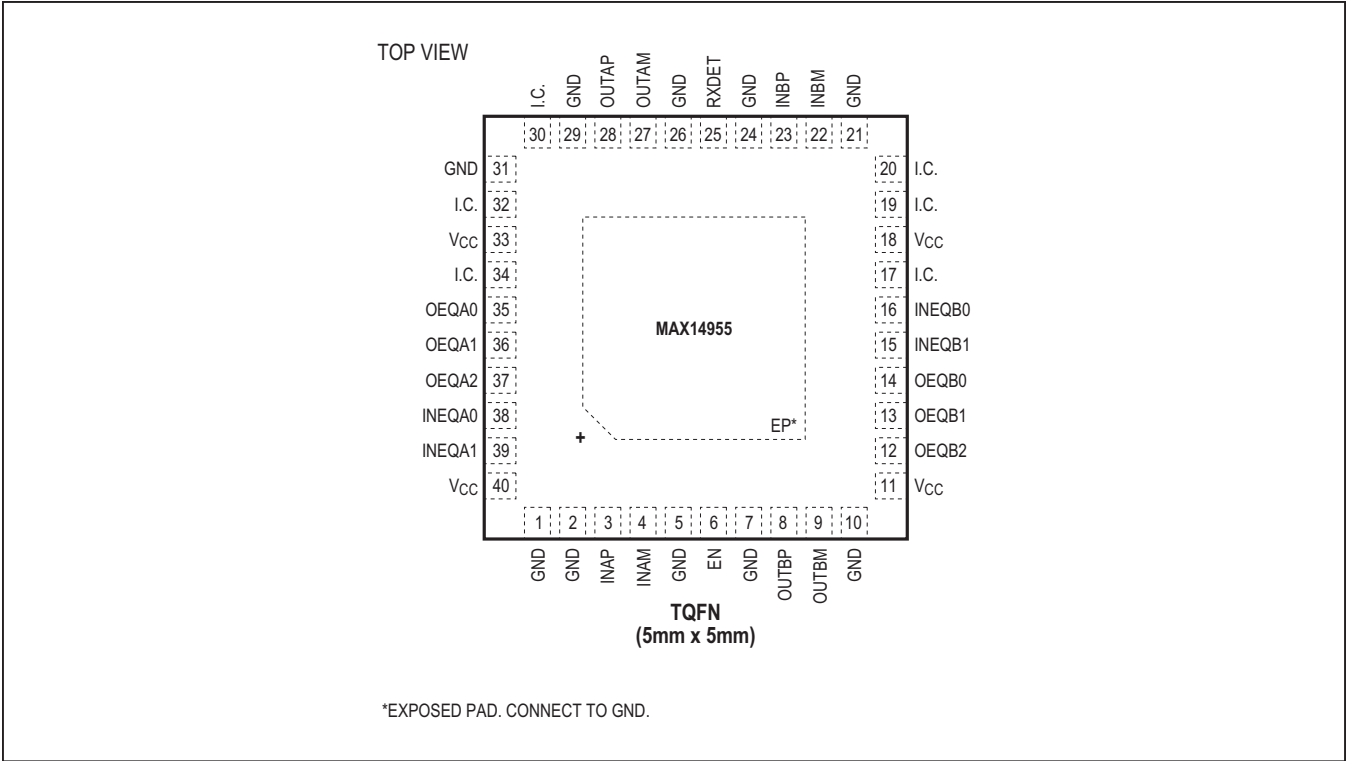
## Typical Operating Characteristics (continued)

(V<sub>CC</sub> = +3.3V, T<sub>A</sub> = +25°C, unless otherwise noted.)

MAX14955

Single-Lane PCIe Gen III Redriver  
with Equalization and Extended  
Temperature Operation

Pin Configuration



Pin Description

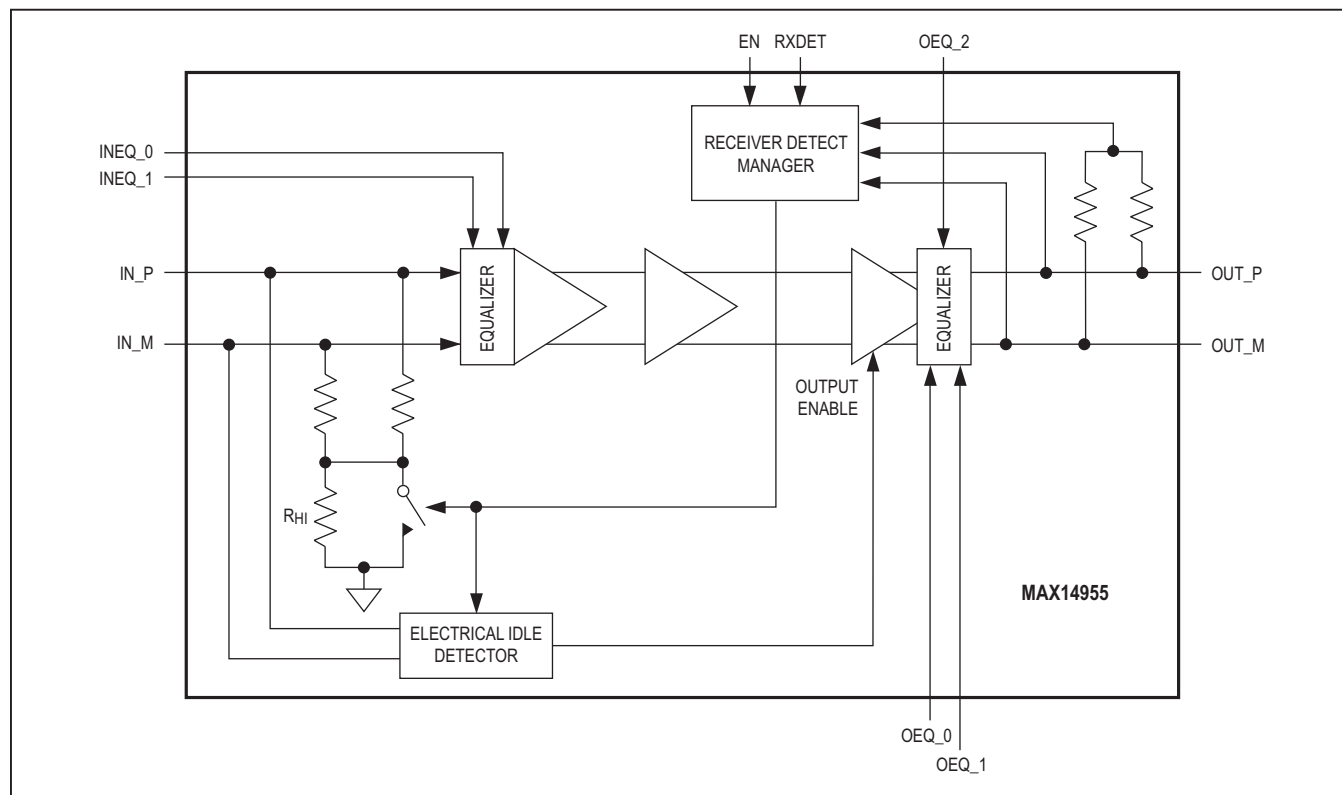
| PIN                                | NAME            | FUNCTION                                                                                                                                       |
|------------------------------------|-----------------|------------------------------------------------------------------------------------------------------------------------------------------------|
| 1, 2, 5, 7, 10, 21, 24, 26, 29, 31 | GND             | Ground                                                                                                                                         |
| 3                                  | INAP            | Noninverting Input, Channel A                                                                                                                  |
| 4                                  | INAM            | Inverting Input, Channel A                                                                                                                     |
| 6                                  | EN              | Enable Input. Drive EN low for standby mode. Drive EN high for normal mode. EN has a 375k $\Omega$ (typ) internal pulldown resistor.           |
| 8                                  | OUTBP           | Noninverting Output, Channel B                                                                                                                 |
| 9                                  | OUTBM           | Inverting Output, Channel B                                                                                                                    |
| 11, 18, 33, 40                     | V <sub>CC</sub> | Power-Supply Input. Bypass V <sub>CC</sub> to GND with 0.1 $\mu$ F and 0.01 $\mu$ F capacitors in parallel as close as possible to the device. |
| 12                                 | OEQB2           | Output Deemphasis Control MSB, Channel B. OEQB2 has a 375k $\Omega$ (typ) internal pulldown resistor.                                          |
| 13                                 | OEQB1           | Output Deemphasis Bit 1, Channel B. OEQB1 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                |

## Pin Description (continued)

| PIN                       | NAME   | FUNCTION                                                                                                                                                                                      |
|---------------------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 14                        | OEQB0  | Output Deemphasis Control LSB, Channel B. OEQB0 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                                                         |
| 15                        | INEQB1 | Input Equalization Control MSB, Channel B. INEQB1 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                                                       |
| 16                        | INEQB0 | Input Equalization Control LSB, Channel B. INEQB0 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                                                       |
| 17, 19, 20,<br>30, 32, 24 | I.C.   | Internally Connected. Leave I.C. unconnected.                                                                                                                                                 |
| 22                        | INBM   | Inverting Input, Channel B                                                                                                                                                                    |
| 23                        | INBP   | Noninverting Input, Channel B                                                                                                                                                                 |
| 25                        | RXDET  | Receiver Detection Control Bit. Toggle RXDET to initiate receiver detection. RXDET has a 375k $\Omega$ (typ) internal pulldown resistor.                                                      |
| 27                        | OUTAM  | Inverting Output, Channel A                                                                                                                                                                   |
| 28                        | OUTAP  | Noninverting Output, Channel A                                                                                                                                                                |
| 35                        | OEQA0  | Output Deemphasis Control LSB, Channel A. OEQA0 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                                                         |
| 36                        | OEQA1  | Output Deemphasis Control Bit 1, Channel A. OEQA1 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                                                       |
| 37                        | OEQA2  | Output Deemphasis Control MSB, Channel A. OEQA2 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                                                         |
| 38                        | INEQA0 | Input Equalization Control LSB, Channel A. INEQA0 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                                                       |
| 39                        | INEQA1 | Input Equalization Control MSB, Channel A. INEQA1 has a 375k $\Omega$ (typ) internal pulldown resistor.                                                                                       |
| —                         | EP     | Exposed Pad. Internally connected to GND. Connect EP to a large ground plane to maximize thermal performance and ground conductivity to the device. Do not use EP as the only GND connection. |



## Functional Diagram



## Detailed Description

The MAX14955 dual equalizer/redriver supports Gen III (8GT/s), Gen II (5GT/s), and Gen I (2.5GT/s) PCIe data rates. The device contains two identical drivers with idle/receive detect on each lane and equalization/deemphasis/preshoot to compensate for circuit board loss. Programmable input equalization circuitry reduces deterministic jitter, improving signal integrity. The device features programmable output deemphasis/preshoot, permitting optimal placement of key PCIe components and longer runs of stripline, microstrip, or cable.

## Programmable Input Equalization

Programmable input equalization for channel A is controlled by two bits: INEQA1 and INEQA0 and for channel B is controlled by two bits: INEQB1 and INEQB0 (Table 1.)

## Programmable Output Deemphasis

Programmable output deemphasis/preshoot for channel A is controlled by the three bits: OEQA2, OEQA1, OEQA0 and channel B is controlled by the three bits: OEQB2, OEQB1, OEQB0 (Table 2.)

## Receiver Detection

The device features receiver detection on each channel. Upon initial power-up, if EN is high, receiver detection initializes. Receiver detection can also be initiated on a rising or falling edge of the RXDET input when EN is high. During this time, the part remains in low-power standby mode and the outputs are squelched, despite the logic-high state of EN. Until a channel has detected a receiver, the receiver detection repeats indefinitely on each channel. If a channel detects a receiver, the other channel is limited to a few retries. Upon receiver detection, input common-mode termination and electrical idle detection are enabled (Table 3.)

### Table 1. Input Equalization

| INEQ_1 | INEQ_0 | INPUT EQUALIZATION (dB) |
|--------|--------|-------------------------|
| 0      | 0      | 5                       |
| 0      | 1      | 8                       |
| 1      | 0      | 12                      |
| 1      | 1      | 16                      |



**Table 2. Output Deemphasis/Preshoot**

| OEQ_2 | OEQ_1 | OEQ_0 | OUTPUT DEEMPHASIS<br>RATIO (dB) | PEAK-TO-PEAK<br>SWING | PRESHOOT |
|-------|-------|-------|---------------------------------|-----------------------|----------|
| 0     | 0     | 0     | 0                               | 1.0V                  | No       |
| 0     | 0     | 1     | 3.5                             | 1.0V                  | No       |
| 0     | 1     | 0     | 6                               | 1.0V                  | No       |
| 0     | 1     | 1     | 6                               | 1.2V                  | No       |
| 1     | 0     | 0     | 3.5                             | 1.0V                  | Yes      |
| 1     | 0     | 1     | 6                               | 1.0V                  | Yes      |
| 1     | 1     | 0     | 9                               | 0.9V                  | Yes      |
| 1     | 1     | 1     | 9                               | 1.0V                  | Yes      |

**Table 3. Receiver Detection Input Function**

| RXDET               | EN | DESCRIPTION                                                                                                                                                           |
|---------------------|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| X                   | 0  | Receiver detection is inactive.                                                                                                                                       |
| X                   | 1  | Following a rising edge of EN signal, indefinite retry until a receiver is detected for at least one channel. Retries stop a few times after any channel is detected. |
| Rising/falling edge | 1  | Initiate receiver detection.                                                                                                                                          |

X = Don't care.

### Electrical Idle Detection

The device features electrical idle detection to prevent unwanted noise from being redriven at the output. When the device detects the differential input has fallen below the electrical idle low threshold, it squelches the output. For differential input signals that are above the electrical idle high threshold, the device turns on the output and redrives the signal.

## Applications Information

### Layout

Circuit board layout and design can significantly affect the performance of the device. Use good high-frequency design techniques, including minimizing ground inductance and using controlled-impedance transmission lines on data signals. Power-supply decoupling capacitors must be placed as close as possible to  $V_{CC}$ . Always connect  $V_{CC}$  to a power plane. It is recommended to run receive and transmit on different layers to minimize crosstalk.

### Exposed-Pad Package

The exposed-pad, 40-pin TQFN package incorporates features that provide a very low thermal resistance path for heat removal from the IC. The exposed pad on the device must be soldered to the circuit board ground plane for proper thermal performance. For more information on exposed-pad packages, refer to Maxim Application Note HFAN-08.1: *Thermal Considerations of QFN and Other Exposed-Paddle Packages*.

### Power-Supply Sequencing

**Caution: Do not exceed the absolute maximum ratings because stresses beyond the listed ratings can cause permanent damage to the device.**

Proper power-supply sequencing is recommended for all devices. Always apply GND then  $V_{CC}$  before applying signals, especially if the signal is not current limited.

# MAX14955

## Single-Lane PCIe Gen III Redriver with Equalization and Extended Temperature Operation

### Ordering Information

| PART         | TEMP RANGE     | PIN-PACKAGE |
|--------------|----------------|-------------|
| MAX14955ETL+ | -40°C to +85°C | 40 TQFN-EP* |

+Denotes a lead(Pb)-free/RoHS-compliant package.

\*EP = Exposed pad.

### Chip Information

PROCESS: BICMOS

### Package Information

For the latest package outline information and land patterns (foot-prints), go to [www.maximintegrated.com/packages](http://www.maximintegrated.com/packages). Note that a "+", "#", or "-" in the package code indicates RoHS status only. Package drawings may show a different suffix character, but the drawing pertains to the package regardless of RoHS status.

| PACKAGE TYPE | PACKAGE CODE | OUTLINE NO.             | LAND PATTERN NO.        |
|--------------|--------------|-------------------------|-------------------------|
| 40 TQFN-EP   | T4055+2      | <a href="#">21-0140</a> | <a href="#">90-0002</a> |

MAX14955

Single-Lane PCIe Gen III Redriver  
with Equalization and Extended  
Temperature Operation

Revision History

| REVISION<br>NUMBER | REVISION<br>DATE | DESCRIPTION     | PAGES<br>CHANGED |
|--------------------|------------------|-----------------|------------------|
| 0                  | 3/13             | Initial release | —                |

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim Integrated's website at [www.maximintegrated.com](http://www.maximintegrated.com).

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