General Description

The MAX3787 is a 1Gbps to 12.5Gbps equalization network that compensates for transmission medium losses encountered with FR4 and cables. The equalization network is composed entirely of passive components and functions equally well for 8b/10b or scrambled signals. It is packaged in a small 1.5mm x 1.5mm chip-scale package (UCSP™) that can be placed anywhere along the transmission medium to increase jitter margin for high-speed interconnects. Roughly the size of two 0603 components, the MAX3787 easily provides placement and routing flexibility.

At 8.5Gbps, the MAX3787 compensates for spans up to 18in of FR4 and 7m of cable. At 12.5Gbps, the MAX3787 compensates for spans up to 12in of FR4 and 3m of cable. Input and output impedance is 100Ω differential. The MAX3787 requires no power and operates over a -40°C to +125°C temperature range.

Features

- No Power Supply Required
- Small 1.5mm x 1.5mm Chip-Scale Package
- Passive Equalization Reduces ISI
- Operates from 1Gbps to 12.5Gbps
- Extends Board Link
- Extends Cable Link
- Coding Independent, 8b/10b or Scrambled

Applications

Backplane Interconnect Compensation
Cable Interconnect Compensation
Chip-to-Chip Link Extensions
Ethernet and Fibre-Channel Serial Modules
Chassis Life Extension

Ordering Information

<table>
<thead>
<tr>
<th>PART</th>
<th>TEMP RANGE</th>
<th>PIN-PACKAGE</th>
<th>PKG CODE</th>
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<tbody>
<tr>
<td>MAX3787ABL</td>
<td>-40°C to +125°C</td>
<td>4 UCSP</td>
<td>B9-7</td>
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<tr>
<td>MAX3787AWL+</td>
<td>-40°C to +125°C</td>
<td>4 WLP</td>
<td>W91B1+3</td>
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</table>

+Denotes a lead-free package.

Pin Configuration

UCSP is a trademark of Maxim Integrated Products, Inc.

Typical Application Circuits

For pricing, delivery, and ordering information, please contact Maxim Direct at 1-888-629-4642, or visit Maxim’s website at www.maxim-ic.com.
1Gbps to 12.5Gbps
Passive Equalizer for Backplanes and Cables

ABSOLUTE MAXIMUM RATINGS
Voltage between (IN+ and OUT+) or (IN- and OUT-)..............+2V
Voltage between (IN+ and IN-) or (OUT+ and OUT-).............+4V
Voltage between (IN+ and OUT-) or (IN- and OUT+).............+4V
Continuous Power Dissipation (T_A = +70°C)
4-Bump UCSP (derate 3.0mW/°C above +70°C).............238mW
Operating Junction Temperature........................................+150°C
Storage Ambient Temperature Range .......................-55°C to +150°C

Stresses beyond those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

OPERATING CONDITIONS

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Ambient Temperature</td>
<td>T_A</td>
<td>-40 +25 +125 °C</td>
<td></td>
<td></td>
<td></td>
<td>°C</td>
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<tr>
<td>Bit Rate</td>
<td></td>
<td>NRZ data</td>
<td>1</td>
<td>12.5</td>
<td></td>
<td>Gbps</td>
</tr>
<tr>
<td>CID Tolerance</td>
<td></td>
<td>Consecutive identical digits</td>
<td>100</td>
<td></td>
<td></td>
<td>Bits</td>
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ELECTRICAL CHARACTERISTICS
(Specifications guaranteed over specified operating conditions. Typical values measured at T_A = +25°C.)

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<thead>
<tr>
<th>PARAMETER</th>
<th>SYMBOL</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
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</thead>
<tbody>
<tr>
<td>Supply Current</td>
<td></td>
<td></td>
<td>0.0</td>
<td></td>
<td></td>
<td>mA</td>
</tr>
<tr>
<td>Input Swing</td>
<td></td>
<td>Measured differentially at point A in Figure 1</td>
<td>3600</td>
<td></td>
<td></td>
<td>mV-P</td>
</tr>
<tr>
<td>Compensation</td>
<td></td>
<td>5GHz relative to 100MHz</td>
<td>6</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Input Impedance</td>
<td></td>
<td>Differential, Z_LOAD = 100Ω</td>
<td>100</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Output Impedance</td>
<td></td>
<td>Differential, Z_SOURCE = 100Ω</td>
<td>100</td>
<td></td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Through Response</td>
<td></td>
<td>Relative to ideal load, see Figure 2 for setup</td>
<td>See Figure 3 for limits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Input Return Loss</td>
<td></td>
<td>100MHz to 6GHz</td>
<td>15</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Output Return Loss</td>
<td></td>
<td>100MHz to 6GHz</td>
<td>15</td>
<td></td>
<td></td>
<td>dB</td>
</tr>
<tr>
<td>Resistance IN+ to IN- and OUT+ to OUT-</td>
<td></td>
<td>No load, high impedance on all ports</td>
<td>112</td>
<td>152</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Resistance IN+ to OUT+ and IN- to OUT-</td>
<td></td>
<td>No load, high impedance on all ports</td>
<td>32</td>
<td>44</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>Resistance IN- to OUT- and IN- to OUT+</td>
<td></td>
<td>No load, high impedance on all ports</td>
<td>112</td>
<td>152</td>
<td></td>
<td>Ω</td>
</tr>
<tr>
<td>DC Gain (OUT/IN)</td>
<td></td>
<td>Z_LOAD = 100Ω</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual Deterministic Jitter</td>
<td></td>
<td>3.125Gbps and 6.25Gbps, 18in of 6mil microstrip FR4</td>
<td>0.05</td>
<td></td>
<td></td>
<td>UI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.5Gbps, 10.0Gbps, and 12.5Gbps, 18in of 6mil microstrip FR4</td>
<td>0.10</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Signal applied differentially at point A as shown in Figure 1. The deterministic jitter at point B is from media-induced loss, not from clock-source modulation. Deterministic jitter is measured at the 50% vertical level of the signal at point C.

Note 2: Difference in deterministic jitter between reference points A and C in Figure 1. Stress pattern: 27 PRBS, 100 zeros, 1, 0, 1, 0, 27 PRBS, 100 ones, 0, 1, 0, 1.
1Gbps to 12.5Gbps Passive Equalizer for Backplanes and Cables

Figure 1. Residual Deterministic Jitter Test Circuit

Figure 2. Frequency Response Test Circuit Using Vector Network Analyzer (VNA)
1Gbps to 12.5Gbps
Passive Equalizer for Backplanes and Cables

**Table 1. PCB Assumptions (Board Material is FR4)**

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>CONDITIONS</th>
<th>MIN</th>
<th>TYP</th>
<th>MAX</th>
<th>UNITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Line</td>
<td>Edge-coupled microstrip line</td>
<td>6</td>
<td></td>
<td></td>
<td>mil</td>
</tr>
<tr>
<td>Relative Permittivity at 1GHz</td>
<td>FR4 or similar</td>
<td>4.0</td>
<td></td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Loss Tangent</td>
<td>FR4 or similar</td>
<td>0.02</td>
<td></td>
<td></td>
<td>—</td>
</tr>
<tr>
<td>Metal Thickness</td>
<td>1oz copper</td>
<td>1.4</td>
<td></td>
<td></td>
<td>mil</td>
</tr>
<tr>
<td>Impedance</td>
<td>Differential</td>
<td>90</td>
<td>100</td>
<td>110</td>
<td>Ω</td>
</tr>
</tbody>
</table>

**Figure 3. Through Response Limits**

**FREQUENCY** | **MIN (dB)** | **TYP (dB)** | **MAX (dB)**
---|---|---|---
100MHz | -8.2 | -7.4 | -6.8
200MHz | -7.9 | -7.0 | -6.4
300MHz | -7.5 | -6.6 | -6.0
500MHz | -6.8 | -6.0 | -5.3
1.0GHz | -5.5 | -4.8 | -4.2
2.0GHz | -4.2 | -3.2 | -2.5
3.0GHz | -3.1 | -2.2 | -1.5
4.0GHz | -2.3 | -1.5 | -0.8
5.0GHz | -2.1 | -1.3 | -0.5
5.5GHz | -2.4 | -1.6 | -0.6
6.0GHz | -2.9 | -2.1 | -1.1
6.5GHz | —    | -2.6 | —
7.0GHz | —    | -3.1 | —
7.5GHz | —    | -3.6 | —
8.0GHz | —    | -4.1 | —
8.5GHz | —    | -4.7 | —
9.0GHz | —    | -5.5 | —
9.5GHz | —    | -7.0 | —
10.0GHz | —    | -9.0 | —
1Gbps to 12.5Gbps
Passive Equalizer for Backplanes and Cables

Typical Operating Characteristics

(\(T_A = +25^\circ\text{C}\), unless otherwise noted. All measurements were done with 1VP-p at the source. Stress pattern: \(2^7\) PRBS, 100 zeros, 1, 0, 1, 0, \(2^7\) PRBS, 100 ones, 0, 1, 0, 1. Residual deterministic jitter graphs were measured using Tektronix’s FrameScan®. Deterministic jitter of the system was subtracted from the measured value. Eye diagrams acquired by FrameScan include deterministic jitter of the system (approximately 9ps) but not random jitter. Twin-ax cable: Amphenol Spectra-Strip® Skewclear® 100Ω 24AWG.)

FrameScan is a registered trademark of Tektronix.
Spectra-Strip and Skewclear are registered trademarks of Amphenol.
Typical Operating Characteristics (continued)

(TA = +25°C, unless otherwise noted. All measurements were done with 1Vp-p at the source. Stress pattern: 27 PRBS, 100 zeros, 1, 0, 1, 0, 27 PRBS, 100 ones, 0, 1, 0, 1. Residual deterministic jitter graphs were measured using Tektronix’s FrameScan. Deterministic jitter of the system was subtracted from the measured value. Eye diagrams acquired by FrameScan include deterministic jitter of the system (approximately 9ps) but not random jitter. Twin-ax cable: Amphenol Spectra-Strip Skewclear 100Ω 24AWG.)
**1Gbps to 12.5Gbps**

**Passive Equalizer for Backplanes and Cables**

*Typical Operating Characteristics (continued)*

(\(T_A = +25^\circ C\), unless otherwise noted. All measurements were done with 1VP-p at the source. Stress pattern: \(2^7\) PRBS, 100 zeros, 1, 0, 1, 0, \(2^7\) PRBS, 100 ones, 0, 1, 0, 1. Residual deterministic jitter graphs were measured using Tektronix’s FrameScan. Deterministic jitter of the system was subtracted from the measured value. Eye diagrams acquired by FrameScan include deterministic jitter of the system (approximately 9ps) but not random jitter. Twin-ax cable: Amphenol Spectra-Strip Skewclear 100Ω 24AWG.)

---

**EYE DIAGRAM OF UNEQUALIZED SIGNAL**

(12 in FR4, 8.5Gbps, STRESS PATTERN)

- 120mV/div
- 22ps/div

**EYE DIAGRAM OF EQUALIZED SIGNAL**

(12 in FR4, 8.5Gbps, STRESS PATTERN)

- 120mV/div
- 22ps/div

**EYE DIAGRAM OF EQUALIZED SIGNAL (ZOOM)**

(12 in FR4, 8.5Gbps, STRESS PATTERN)

- 60mV/div
- 22ps/div

---

**EYE DIAGRAM OF UNEQUALIZED SIGNAL**

(18 in FR4, 6.25Gbps, STRESS PATTERN)

- 120mV/div
- 28ps/div

**EYE DIAGRAM OF EQUALIZED SIGNAL**

(18 in FR4, 6.25Gbps, STRESS PATTERN)

- 120mV/div
- 28ps/div

**EYE DIAGRAM OF EQUALIZED SIGNAL (ZOOM)**

(18 in FR4, 6.25Gbps, STRESS PATTERN)

- 50mV/div
- 28ps/div

---

**EYE DIAGRAM OF UNEQUALIZED SIGNAL**

(12 in FR4, 6.25Gbps, STRESS PATTERN)

- 120mV/div
- 28ps/div

**EYE DIAGRAM OF EQUALIZED SIGNAL**

(12 in FR4, 6.25Gbps, STRESS PATTERN)

- 120mV/div
- 28ps/div

**EYE DIAGRAM OF EQUALIZED SIGNAL (ZOOM)**

(12 in FR4, 6.25Gbps, STRESS PATTERN)

- 50mV/div
- 28ps/div
1Gbps to 12.5Gbps
Passive Equalizer for Backplanes and Cables

Typical Operating Characteristics (continued)

(TA = +25°C, unless otherwise noted. All measurements were done with 1Vp-p at the source. Stress pattern: 2⁷ PRBS, 100 zeros, 1, 0, 1,
0, 2⁷ PRBS, 100 ones, 0, 1, 0, 1. Residual deterministic jitter graphs were measured using Tektronix’s FrameScan. Deterministic jitter of
the system was subtracted from the measured value. Eye diagrams acquired by FrameScan include deterministic jitter of the system
(approximately 9ps) but not random jitter. Twin-ax cable: Amphenol Spectra-Strip Skewclear 100Ω 24AWG.)
1Gbps to 12.5Gbps Passive Equalizer for Backplanes and Cables

Typical Operating Characteristics (continued)

(TA = +25°C, unless otherwise noted. All measurements were done with 1VP-p at the source. Stress pattern: 2^7 PRBS, 100 zeros, 1, 0, 1, 0, 2^7 PRBS, 100 ones, 0, 1, 0, 1. Residual deterministic jitter graphs were measured using Tektronix’s FrameScan. Deterministic jitter of the system was subtracted from the measured value. Eye diagrams acquired by FrameScan which include deterministic jitter of the system (approximately 9ps) but not random jitter. Twin-ax cable: Amphenol Spectra-Strip Skewclear 100Ω 24AWG.)
Typical Operating Characteristics (continued)

(TA = +25°C, unless otherwise noted. All measurements were done with 1VP-p at the source. Stress pattern: 2^7 PRBS, 100 zeros, 1, 0, 1,
0, 2^7 PRBS, 100 ones, 0, 1, 0, 1. Residual deterministic jitter graphs were measured using Tektronix’s FrameScan. Deterministic jitter of
the system was subtracted from the measured value. Eye diagrams acquired by FrameScan include deterministic jitter of the system
(approximately 9ps) but not random jitter. Twin-ax cable: Amphenol Spectra-Strip Skewclear 100Ω 24AWG.)
Typical Operating Characteristics (continued)

(TA = +25°C, unless otherwise noted. All measurements were done with 1Vp-p at the source. Stress pattern: 2^7 PRBS, 100 zeros, 1, 0, 1, 0, 2^7 PRBS, 100 ones, 0, 1, 0, 1. Residual deterministic jitter graphs were measured using Tektronix’s FrameScan. Deterministic jitter of the system was subtracted from the measured value. Eye diagrams acquired by FrameScan include deterministic jitter of the system (approximately 9ps) but not random jitter. Twin-ax cable: Amphenol Spectra-Strip Skewclear 100Ω 24AWG.)
Typical Operating Characteristics (continued)

(TA = +25°C, unless otherwise noted. All measurements were done with 1Vp-p at the source. Stress pattern: 2^7 PRBS, 100 zeros, 1, 0, 1, 0, 2^7 PRBS, 100 ones, 0, 1, 0, 1. Residual deterministic jitter graphs were measured using Tektronix’s FrameScan. Deterministic jitter of the system was subtracted from the measured value. Eye diagrams acquired by FrameScan include deterministic jitter of the system (approximately 9ps) but not random jitter. Twin-ax cable: Amphenol Spectra-Strip Skewclear 100Ω 24AWG.)
**Detailed Description**

The MAX3787 is an entirely passive network composed of both resistive and reactive components (Figure 4). Two symmetric-T networks with bypassing for high-pass characteristics are used to create a differential symmetric-H network. The entire network acts as a filter specifically tuned to compensate for transmission medium losses encountered with FR4 and cables.

**Input and Output Terminations**

The MAX3787 input impedance is 100Ω differential with the output connected to a 100Ω differential load. The network is designed for 100Ω-balanced differential signals and is not intended for single-ended transmission.

**ESD Protection Diodes**

The MAX3787 contains ESD diodes that bypass the equalization network in case of static discharge (Figure 5).

**Applications Information**

**Equalizer Integration and Placement**

The MAX3787 is packaged in a small 1.5mm x 1.5mm UCSP that can be placed anywhere along the transmission medium. The small size allows placement and routing flexibility.

**UCSP Assembly Considerations**

For the latest application details on UCSP construction, dimensions, tape carrier information, PCB techniques, bump-pad layout, and recommended reflow temperature profile, as well as the latest information on reliability testing results, refer to Application Note 1891: UCSP–A Wafer-Level Chip-Scale Package available on Maxim’s website at [www.maxim-ic.com/ucsp](http://www.maxim-ic.com/ucsp).

**Chip Information**

TRANSISTOR COUNT: 0

PROCESS: SiGe BIPOLAR
1Gbps to 12.5Gbps Passive Equalizer for Backplanes and Cables

Typical Application Circuits (continued)

Package Information
(For the latest package outline information, go to www.maxim-ic.com/packages.)

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<th>PACKAGE TYPE</th>
<th>PACKAGE CODE</th>
<th>DOCUMENT NO.</th>
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<td>4 UCSP</td>
<td>B9-7</td>
<td>21-0093</td>
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<tr>
<td>4 WLP</td>
<td>W91B1+3</td>
<td>21-0067</td>
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1Gbps to 12.5Gbps Passive Equalizer for Backplanes and Cables

Revision History

<table>
<thead>
<tr>
<th>REVISION NUMBER</th>
<th>REVISION DATE</th>
<th>DESCRIPTION</th>
<th>PAGES CHANGED</th>
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</thead>
<tbody>
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<td>0</td>
<td>7/05</td>
<td>Initial release.</td>
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<tr>
<td>1</td>
<td>12/05</td>
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<td>2/08</td>
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<td>1, 14</td>
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