Molex I-Trac Reference Backplane Channel Performance for 10G Serial Backplane Ethernet Applications: 10GBASE-KR

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1. Introduction

With the advent of the IEEE 10G Backplane Ethernet Standard (Std. IEEE 802.3ap - 2007), industry adoption of 10G serial systems is expected to increase dramatically, lead by the blade server manufacturers and followed by switch and routing companies. Even now, systems intended for lower-speed operation are designed with headroom to ensure future scalability to 10 G and beyond.

This being the case, it becomes paramount for component manufacturers to bring viable, affordable and available channel solutions to the customers. With this purpose in mind, Molex has partnered with AMCC to demonstrate a robust 10Gbps data transmission over up to 1 meter "improved FR4" backplane channel, using Molex's state of the art I-Trac backplane connector system and AMCC's newly released QT2055 10Gbps Serial-to-XAUI SerDes. A PRBS-31 test pattern was transmitted through various available channels on the Backplane, all the way up to a 1 meter (~40") length. Error-free operation was observed for all the channels for reasonable test times (several days), resulting in a Bit-Error Rate performance better than $10^{-13}$.

In the following sections, overview of the Molex I-Trac Reference Backplane and AMCC's QT2055 Phy is given, and a description of test and demonstrations using the setup is presented.

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**IEEE 802.3ap Features**

- Support Existing media-independent interfaces
- Support operation over a single lane for two connectors over copper traces on improved FR-4 for links consistent with lengths up to at least 1m.
  - Define a 1 Gb's PHY
  - Define a 10 Gb/s PHY
- Define a 4-lane 10 Gb/s PHY for operation over the 802.3ap (informative) channel model.
- Support BER of $10^{-12}$ or better
The Molex I-Trac™ 12+Gbps Reference Backplane is a versatile evaluation platform for system-level performance demonstration. Its features include:

- **System design teams can use the Molex I-Trac™ Reference Backplane to quickly and accurately evaluate:**
- **Silicon Signal Recovery**
  - Verified error free, 10.3Gbps, 1m channel performance Various real world channel lengths:
  - 0.2m (single connector): SFI applications
  - 0.38m: Typical Customer application
  - 0.535m: Typical ATCA reach
  - 0.6m OIF: Typical intermediate-reach customer application, OIF CEI-11G MR target
  - 1m channels: Typical long-reach customer application OIF CEI-11G LR, IEEE 802.3ap target
- **PCB Channel Designs**
  - Two signal-to-ground patterns for nominal and very high speed signal layouts
  - Various trace widths: 5/5/5 tightly coupled, 6/7/6 medium coupled, 7/9/7 loosely coupled
  - Various Antipad and Pinfield Routing Configurations
  - Via Stub Variations
- **Board construction:**
  - Available in Isola™FR408 and Nelco™ 4000-12 with a Nelco 4000-12SI high performance channel
  - Backplane dimensions: 40x60cm, 6.2mm (244 mil) thick, 28 Layers
  - Daughter cards dimensions: 13x18cm and 2.4mm thick

i) Insertion Loss

The following graphs demonstrate insertion loss performance on the 1m Nelco 4000-12SI channel.
ii) Fitted Attenuation

The following graphs demonstrate fitted attenuation performance of the 1m Nelco 4000-12SI channel.

![Graph of Fitted Attenuation](image)

iii) Insertion Loss Deviation

The following graphs demonstrate the insertion-loss deviation performance of the 1m Nelco 4000-12SI channel.

![Graph of Insertion Loss Deviation](image)
iv) Return Loss

The following graphs demonstrate the return loss performance of the 1m Nelco 4000-12SI channel.

v) Insertion Loss to Crosstalk Ratio (ICR)

In the 10GBASE-KR spec, crosstalk alone is not considered. Instead, the quantity of relevance is the Insertion Loss to Crosstalk Ratio (ICR). This gives system designers a freedom of tradeoff, allowing for higher crosstalk for shorter (less attenuating) channels. Because of the I-Trac connectors flexible open-pin field design potentially allows for many different routing and pin-assignment configurations. This gives designers the opportunity to route lower-speed fabrics densely through the connectors, while designing the 10Gbps serial links so as to mitigate the effects of crosstalk. In particular, the 10G fabric can be routed such as to nullify any near-end crosstalk (NEXT) and to deal only with less problematic far-end crosstalk (FEXT). In our example, we have created a unidirectional link of 4 serial 10 Gbps channels running in close proximity of each other, while a similar link running in the opposite direction has been spatially separated in a different region of the connector (in a SGS configuration) and a different PCB layer. The figure below shows the ICR performance of such a channel.
To illustrate the tradeoffs allowed by ICR, the next graph shows a densely routed fabric in a shorter (0.535m) with both NEXT and FEXT featuring prominently.
4. Test Results

Real 10Gbps SerDes devices have been used to run 10 Gbps PRBS-31 data over the I-Trac backplane channels to demonstrate error-free performance (BER of $10^{-13}$ or better). The silicon devices used were Broadcom’s BCM8072, AMCC's QT2055, NetLogic’s AEL3020, Vitesse VSC8242 and Phyworks’ PHY1066.

AMCC:
The following table summarizes the test results over the I-Trac Reference Backplane with AMCC’s QT2055 SerDes (single-channel).

<table>
<thead>
<tr>
<th>Channel Length</th>
<th>Via Stub</th>
<th>Backplane Trace width/spacing</th>
<th>Error-Free</th>
</tr>
</thead>
<tbody>
<tr>
<td>1m VHP</td>
<td>0.1mm</td>
<td>7mil/9mil/7mil</td>
<td>Yes</td>
</tr>
<tr>
<td>1m</td>
<td>0.2mm</td>
<td>6mil/7mil/6mil</td>
<td>Yes</td>
</tr>
<tr>
<td>0.535 m</td>
<td>5.5mm</td>
<td>6mil/7mil/6mil</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Phyworks:
The following graph shows BER contours generated by the Phyworks PHY1066 device for the 1m I-Trac backplane channel in the presence of crosstalk. A BER of better than $10^{-14}$ has been achieved.

Additional test results available upon request
5. Summary and Conclusion

The demonstration of error-free 10 Gbps data transmission through Molex's I-Trac Reference Backplane offers viable, affordable and available solutions to enable 10GBASE-KR implementations.

Based on the described basic setup, further more complex demonstrations of the entire Backplane Ethernet ecosystem have been showcased at Interop 2007, NXTCom 2007, DesignCon 2008 and Interop 2008, featuring transmission of real Ethernet data packets with embedded streaming video through the backplane.

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