WHITE PAPER

X40 - A Collaboration for Economical 40 Gb/s Pluggable Transceivers

X40 is an industry collaborative to create a Multi Source Agreement (MSA) for hot-pluggable 40 Gb/s optical transceivers. The goal of the X40 MSA is to lower cost, extend reach and increase port density for telecom and datacom systems with 40 Gb/s interfaces.

As service providers see accelerating demand for 10 Gb/s services, they are upgrading the core network interfaces to 40 Gb/s to ensure adequate performance. Current 40 Gb/s optical modules are expensive, bulky, have limited reach and are not hot-pluggable. X40 envisions bringing the economics and operational ease of 10 Gb/s pluggable optical modules like XFP to 40 Gb/s modules.

Introduction - From 10 Gb/s to 40 Gb/s

Service providers are offering multi-Gb/s services (OC-192/STM-64 or 10GbE LAN/WAN PHY) to meet a new wave of bandwidth demand driven by IP video, 3G wireless, deep-fiber access networks and carrier Ethernet. Core networks typically deploy 4-10× the bandwidth of the highest speed service to ensure optimal network performance. Currently deployed techniques for higher speed network capacity like n ×10G Link Aggregation Groups (LAG) or Equal Cost Multi-path Protocol (ECMP) are inadequate as they rely on statistical flow distribution mechanisms. Designed to efficiently carry traffic consisting of many aggregated small flows, these non-deterministic mechanisms break down as individual applications demand multi-Gb/s bandwidths. Moreover, these techniques still require multiple lower-speed physical interfaces with the associated disadvantages of higher cost and lower port density. Thus, there is a strong need for a truly deterministic 40 Gb/s interface. One solution now emerging on high-end IP routers is OC-768 Packet Over SONET (POS).

Currently, OC-768 POS router line cards use 40 Gb/s transponders based on the industry-standard 300 pin MSA along with ITU VSR2000-3R2 serial optics. While they are now beginning deployment in demanding carrier environments, these 300-pin transponders still suffer from high costs, limited volumes, limited reach, high power dissipation and the lack of hot pluggability. The high costs primarily stem from the use of low-volume SiGe electronics (instead of silicon CMOS) and the still nascent serial 40 Gb/s optical components.

X40 MSA leverages the huge investment in 10 Gb/s technology to enable low-cost 40 Gb/s hot-pluggable optical transceivers.

On the other hand, the huge investment by the industry in 10 Gb/s optical modules has propelled 10 Gb/s optics along a steep cost-volume curve and has helped develop a stable of mature optical and electronic technologies. X40 envisions leveraging the investment and success of 10 Gb/s modules to enable low-cost, high-density, low-power, pluggable 40 Gb/s optical modules for SONET/SDH, OTN and Ethernet services.

X40 is based on a XENPAK MSA-like mechanical form-factor and host board electrical edge connector and cage. The module integrates four transmit and four receive channels (CWDM wavelengths around 1310 nm operating at 10 Gb/s) with industry standard optical connectors (SC/LC). X40's electrical interface is based on four lanes of XFI, the high speed 10 Gb/s serial electrical interface from the XFP MSA.

10 Gb/s Modules - Technology and Economics

The confluence of huge investment in 10 Gb/s module technology and the rapid uptake in enterprise and carrier markets has enabled superior economics for 10 Gb/s modules. The factors that enabled the success of 10 Gb/s modules are -

(a) Cheap Silicon CMOS electronics - The use of mature 0.13 um CMOS processes enabled cheap electronic components

(b) Hot-pluggable modules - Pluggable optics enabled flexibility and facilitated a pay-as-you-grow business model. The success of 10 Gb/s pluggable modules was despite the presence of multiple form-factors (X2, XENPAK, XFP and SFP+ in the future). The multiple form-factors emerged as improvements in chip density and power dissipation made successively smaller form-factors feasible.

(c) Flexibility in optical technologies - The use of either serial (IEEE 802.3 10GBASE-LR) or CWDM (IEEE 802.3 10GBASE-LX4) enabled the lowest cost technology for a specific application.

(d) MSAs and standardization - The presence of MSAs and easy interoperability facilitated rapid customer adoption.

X40 MSA leverages the following key technologies that were developed for 10 Gb/s pluggable modules to realize low-cost 40 Gb/s transceivers.

- Electrical Interfaces
  - XAUI - 4 x 3.125 Gb/s 10 GbE electrical interface
  - XFI - Serial 10 Gb/s electrical interface
  - Integrated 0.13 um Si CMOS SerDes

- Optical interfaces
  - 10GBASE-LR - Serial 10 GbE optical interface
  - 10GBASE-LX4 - 4 x 3.125 Gb/s CWDM 10 GbE optical interface

- Transceiver MSAs
  - XENPAK - Optical transceiver with XAUI interface
  - X2/XPAK - Second-generation XENPAK
  - XFP - Optical transceiver with XFI interface

X40 combines the functionality of 4 XFPs in the mechanical form-factor of a XENPAK MSA.

X40 - Technology and Benefits

The initial version of X40 can be visualized as the functionality of 4 XFPs in the mechanical form-factor of a XENPAK MSA. The optical interface is based on the Coarse Wavelength Division Multiplexing (CWDM) with 4 transmitters with wavelengths around 1310 nm. The wavelengths from the four lasers are multiplexed using an on-module optical multiplexer. Similarly, in the Rx direction, the optical demultiplexer separates the four wavelengths and directs them to the four receivers. Each transmitter and receiver operates at 10 Gb/s to create an aggregate data rate of 40 Gb/s.

X40 supports a reach of 10 km, which is superior to the 2 km reach of the current VSR2000-3R2 300-pin MSA transponder. X40 uses 4 lanes of XFI serial interfaces as defined by SFF-INF-8077i. The physical dimensions of the X40 transceiver are 3.6 cm (W) x 12.1 cm (D) x 1.8 cm (H). In comparison, the current 300-pin MSA transponder has dimensions of 12.7 cm (W) x 17.7 cm (D) x 1.8cm (H), which is 5x larger.

The optical and electrical signal flow and interfaces for the X40 optical transceiver are shown schematically in Figure 1. The mechanical form-factor of the X40 MSA is similar to the XENPAK MSA form-factor, and is illustrated in Figure 2.

X40 is designed to support SONET/SDH (STS-768/STM-64), OTN (ODU-3) payloads and Ethernet (4x 10 GbE). The optical module is agnostic to the underlying protocols and lower rate structures like 9.953G (OC-192/STM-64), 10.3125G (10GBASE-R), 10.7G (OTU2) and 11.1G (OTU2 overclocked to support a 10GBASE-R payload)

40 GbE PHY can be realized by combining 4x 10GBASE-LR and CWDM concepts (leveraging 10GBASE-LX4) and using the 64B66B PCS layer (10GBASE-R) and a Aggregation at the Physical Layer (APL) technique such as the one being discussed by the IEEE Higher Speed Study Group (HSSG). STS-768/STM-256 can be realized by combining 4x OC-192 SR1 with CWDM and using a STS-192c-4v Virtual Concatenation scheme. OTN G.709 ODU3 can be carried by combining 4x OTU2 with CWDM and using ODU2-4v Virtual Concatenation.

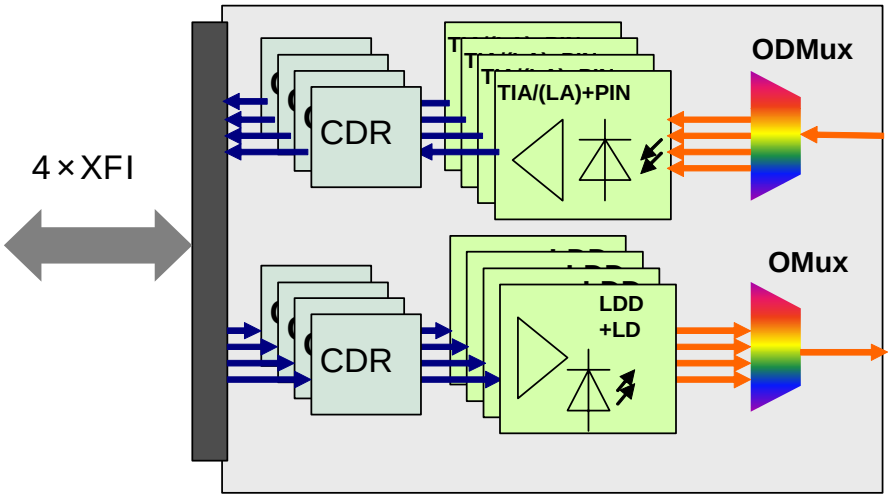
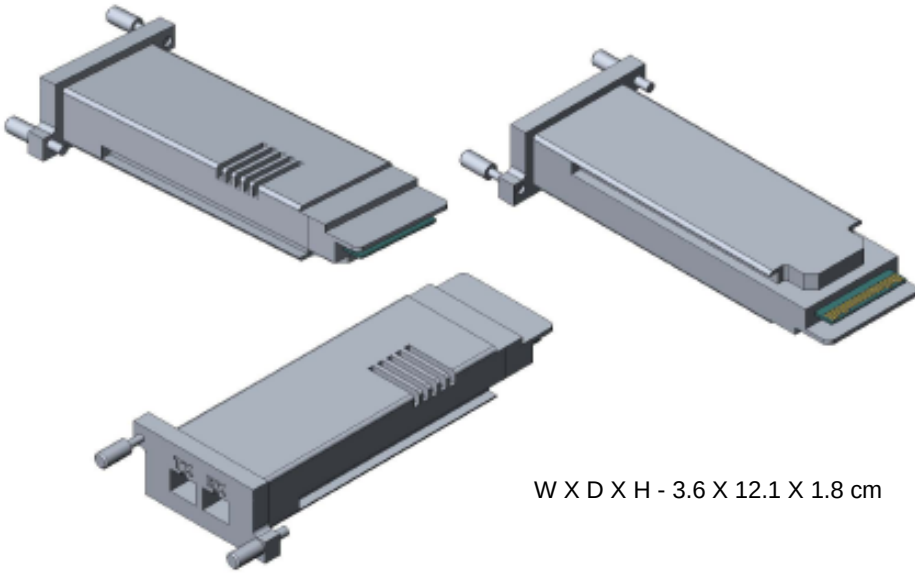


Figure 1 Schematic of X40 Transceiver

X40 form-factor is about 5 times smaller than current 300-pin 40 Gb/s transponders.



W X D X H - 3.6 X 12.1 X 1.8 cm

Figure 2 Mechanical form factor of X40 is same as XENPAK

The benefits of X40 compared to current 40G serial 300-pin MSA modules are summarized below :

- Lower total system costs as X40 leverages existing high-volume 10 Gb/s technologies
- Longer reach of 10 km compared to 2 km for current 300-pin 40G serial MSA
- Higher line card and port density as X40 is nearly 5x smaller
- Lower power consumption - X40 is targeting a 2X reduction to help realize higher

density
- Hot Pluggability which provides flexibility, pay-as-you-grow capability, and operational ease

X40 - Future Direction

X40 is a versatile platform that can evolve beyond the initial application of 40 Gb/s short-reach transceivers. Some potential future directions are -

- Reach and interface type
  - The use of 4 x 15xx nm wavelengths (instead of 13xx nm) may allow increasing the reach to 40 km and beyond to enable longer-reach applications.
  - Electrical interfaces can enable ultra-low cost connections within the same rack or to nearby racks using, for example, Infiniband QDR-style coax cables.
  - Parallel optical interfaces using MTP/MPO connectors (instead of on-module mux/demux) can enable the use of low-cost VCSEL technology over MMF.
  - Serial 40G VSR2000-3R2 interface may be realizable with future low-power CMOS and OEO conversion technologies.

X40 is a versatile platform that can evolve beyond the initial application of 40 Gb/s short-reach transceivers

- Form-factor enhancements (X40 version 2)
  - Next-generation SFP+ technology or 4x10G chips may offer required power reduction to fit into X2 or QSFP MSA packages.

Industry Coalition

X40 has been developed by a coalition of leading networking, system, optical module, semiconductor, and connector companies, including Aeluros, Inc., Broadcom Corporation, Emcore Corporation., Finisar Corporation, Infinera Corporation, Juniper Networks, Inc., MergeOptics GmbH, Tyco Electronics and Vitesse Semiconductor, Inc.. The X40 partners invite companies from all sectors of the industry to express interest and submit views on the requirements for this innovative technology.

www.x40msa.com