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White Paper

NGBASE-T Cabling Requirements

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1.0 Introduction

NGBASE-T stands for Next Generation BASE-T, an Ethernet application beyond 10 Gb/s over twisted pair or balanced cabling. The Institute of Electrical and Electronics Engineers (IEEE) 802.3 NGBASE-T Call-for-Interest (CFI) was announced in July 2012, which led to the formation of a Study Group to investigate and possibly develop this technology. The main application for this technology is in the Data Center (DC) environment for server-to-switch connections within a row, typically referred to as end-of-row or middle-of-row architectures.

Table 1 provides the options available for Information Technology (IT) managers to choose when looking to deploy 40 and 100 Gigabit Ethernet (40GbE and 100GbE) technology today.

TABLE 1: 40GBE AND 100GBE OPTIONS

Interfaces	IEEE Standard	Supported Media
40GBASE-SR4	802.3ba	Multimode Fibre @ 850 nm (4 Lanes)
40GBASE-LR4	802.3ba	Singlemode Fibre @ 1310 nm (CWDM)
40GBASE-FR	802.3bg	Singlemode Fibre @ 1550 nm (Serial)
40GBASE-KR4	802.3ba	Backplane (4 Lanes)
40GBASE-CR4	802.3ba	Twinax Cable (4 Lanes)
100GBASE-SR10	802.3ba	Multimode Fibre @ 850 nm (10 Lanes)
100GBASE-LR4	802.3ba	Singlemode Fibre @ 1310 nm (CWDM)
100GBASE-ER4	802.3ba	Singlemode Fibre @ 1310 nm (CWDM)
100GBASE-CR10	802.3ba	Twinax Cable (10 Lanes)
SFP+ Direct Attach Cable	None	Fibre Cable

Note: CWDM – Coarse Wavelength Division Multiplexing

Table 2 provides the various 40GbE and 100GbE technologies in development by IEEE at the present moment.

TABLE 2: 40GBE AND 100GBE TECHNOLOGIES IN DEVELOPMENT

Interfaces	IEEE Standard	Supported Media
40GBASE-ER4	802.3bm	Singlemode Fibre @ 1310 nm (CWDM)
100GBASE-SR4	802.3bm	Multimode Fibre @ 850 nm (4 Lanes)
100GBASE-xxxx	802.3bm	Singlemode Fibre at 500 metres
100GBASE-KR4	802.3bj	Backplane (4 Lanes)
100GBASE-CR4	802.3bj	Twinax Cable (4 Lanes)
100GBASE-KP4	802.3bj	Legacy Backplane (4 Lanes)

Notes: CWDM – Coarse Wavelength Division Multiplexing

xxxx – Not defined yet. Depends on choice of technology

Hence the IEEE 802.3 NGBASE-T Study Group will initially focus on developing a 40GBASE-T application.

A previous white paper[1] published by the author provided a simple explanation for predicting the critical frequency for 40GBASE-T to be 1.6 GHz. Taking into account the IEEE request for 25% excess frequency for cabling specifications, the required next-generation cabling requirements would be specified to 2 GHz frequency.

This paper will provide an update on the latest IEEE development for NGBASE-T and the associated cabling specifications development in the Telecommunications Industry Association (TIA) in the United States (US) and in the International Organization for Standardization (ISO)/ International Electrotechnical Committee (IEC) in support of this application.

1 *'The Future of Balanced (Twisted Pair) Cabling' T. C. Tan, 21st August 2012*

2.0 IEEE 802.3 NGBASE-T Study Group

The NGBASE-T Study Group has adopted the following objectives:

- Support full duplex operation only
- Preserve the 802.3 Ethernet frame format utilizing the 802.3 MAC
- Preserve the minimum and maximum frame size of current 802.3 standard
- Support a BER ≤ 10^{-12} at MAC/PLS interface
- Support a data rate of 40G at the MAC/PLS service interface
- Support auto-negotiation
- Support Energy Efficient Ethernet
- Support local area networks using point-to-point links over structured cabling topologies, including directly connected link segments
- Do not preclude meeting FCC and CISPR EMC requirements
- Define a link segment based upon copper media specified by ISO/IEC SC25 WG3 and TIA TR42.7 meeting the following characteristics:
  - 4-pair, balanced twisted pair copper cabling
  - Up to 2 connectors
  - Up to at least 30 m
- Define a single 40 Gb/s PHY supporting operation on the link segment

At the January 2013 meeting, CommScope demonstrated a proof-of-concept solution for a viable 40GBASE-T channel by utilizing prototype (TIA) Category 8 RJ-45 connectors and balanced twisted pair cables. The complete cabling channels consist of the following:

- One long and one short channel
- Horizontal cable
- Two RJ-45 outlets
- Two double-ended RJ-45 plug patch cords

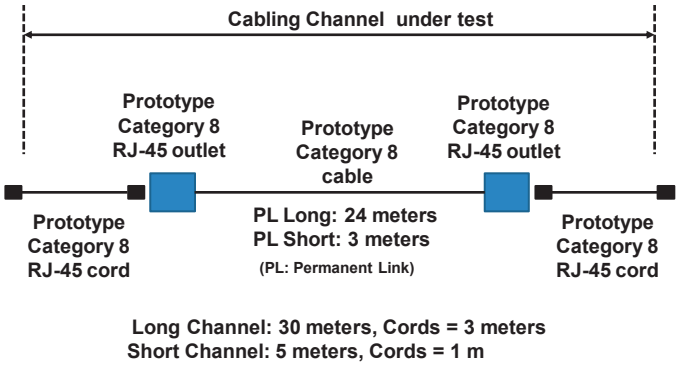

Figure 1: Proof-of-Concept Category 8 cabling channel demonstrated to IEEE NGBASE-T Study Group

The channel parameters were measured to a frequency of 2 GHz and include insertion loss (IL), return loss (RL), near-end crosstalk (NEXT) and attenuation-to-crosstalk ratio far end crosstalk (ACR-F). This parameter was formerly known as equal level far end crosstalk (ELFEXT).

This contribution[2] demonstrated the technical feasibility of the proposed TIA Category 8 cabling systems and is a step along the path toward a viable 40GBASE-T solution for DC applications. Two aspects outlined by this proof-of-concept include the widely accepted RJ-45 connectors and the bandwidth capability of proposed TIA Category 8 cabling. So far, two cabling companies have demonstrated prototype (TIA) Category 8 connectors and one has demonstrated (TIA) Category 8 cable to the NGBASE-T Study Group.

It is very likely that this Study Group will proceed to become a Task Force and standardization work on 40GBASE-T will then commence after this Task Force formation.

2 *'Category 8 Structured Cabling Channel Demonstration by CommScope' Wayne Larsen, IEEE NGBASE-T SG January 2013, Larsen_01_0113_NGBT*

3.0 TIA Copper Cabling Sub-Committee (TR-42.7)

In October 2012, the TIA TR-42.7 sub-committee selected 'Category 8' as the nomenclature for the next-generation balanced twisted-pair cabling specifications under development. This specification was first proposed by CommScope in February 2012. Although the proposal did not explicitly specify the requirement for shielding, it is clear from the alien crosstalk specification that the minimum cabling construction design will include an overall shield (F/UTP). In addition, as with current published TIA standards, the proposed draft standard requires Category 8 cabling components to be backward compatible with lower categories of cabling. A matrix of backward-compatible mated component performance is provided in the draft standard and this is shown in Figure 2.

		Category of Modular Connecting Hardware Performance				
		Cat 3	Cat 5e	Cat 6	Cat 6A	Cat 8
Category of Modular Plug and Cord Performance	Cat 3	Cat 3	Cat 3	Cat 3	Cat 3	Cat 3
	Cat 5e	Cat 3	Cat 5e	Cat 5e	Cat 5e	Cat 5e
	Cat 6	Cat 3	Cat 5e	Cat 6	Cat 6	Cat 6
	Cat 6A	Cat 3	Cat 5e	Cat 6	Cat 6A	Cat 6A
	Cat 8	Cat 3	Cat 5e	Cat 6	Cat 6A	Cat 8

Figure 2: TIA matrix of backward compatible mated component performance

4.0 ISO/IEC Joint Technical Committee 1 Sub-Committee 25 Work Group 3 (JTC1 SC25 WG3) – Cabling Committee

In November 2012, ISO/IEC JTC1 SC25 WG3 proposed a draft technical report (PDTR) ISO/IEC 11801-99-1 entitled 'Information technology – Guidance for balanced cabling in support of at least 40 Gbit/s data transmission'. This PDTR document proposed two channel classes, namely Class I and Class II, which specified to 1.6 GHz with 2 GHz under consideration. Class I minimum cabling construction design will be F/UTP and Class II will be of x/FTP design. However, at a recent meeting in Mexico, ISO/IEC JTC1 SC25 WG3 agreed to adopt 'Category 8.1 and Category 8.2' as the nomenclatures for the next-generation components respectively for Class I and Class II channels. The proposed nomenclatures are now closely harmonized with the proposed TIA Category 8.

However, there is also an identical requirement in the current published ISO/IEC IS 11801 cabling standard with regard to backward compatibility of different performance categories. The standard defines backward compatibility to mean that the mated plugs and jacks connections from different categories shall meet all of the requirements for the lower category component.

Unfortunately, this will not be the case with the newly adopted nomenclatures as shown in Figure 3. The cabling industry will eventually have to come to terms with this situation for the sake of standards harmonization.

		Category of Modular Connecting Hardware Performance						
		Cat 5e	Cat 6	Cat 6_A	Cat 7	Cat 7_A	Cat 8.1	Cat 8.2
Category of Modular Plug and Cord Performance	Cat 5e	Cat 5e	Cat 5e	Cat 5e	Cat 5e	Cat 5e	Cat 5e	Cat 5e
	Cat 6	Cat 5e	Cat 6	Cat 6	Cat 6	Cat 6	Cat 6	Cat 6
	Cat 6_A	Cat 5e	Cat 6	Cat 6_A	Cat 6_A	Cat 6_A	Cat 6_A	Cat 6_A
	Cat 7	Cat 5e	Cat 6	Cat 6_A	Cat 7	Cat 7	Cat 6_A	Cat 7
	Cat 7_A	Cat 5e	Cat 6	Cat 6_A	Cat 7	Cat 7_A	Cat 6_A	Cat 7_A
	Cat 8.1	Cat 5e	Cat 6	Cat 6_A	Cat 6_A	Cat 6_A	Cat 8.1	Cat 8.1
	Cat 8.2	Cat 5e	Cat 6	Cat 6_A	Cat 7	Cat 7_A	Cat 8.1	Cat 8.2

Figure 3: Matrix of backward-compatible mated component performance using the new Category nomenclatures from ISO/IEC JTC1 SC25 WG3

5.0 Cabling Architecture

As stated, the main application for this technology is in the DC environment for server-to-switch connections within a row, described as end-of-row or middle-of-row architecture design. In response, the NGBASE-T Study Group has adopted a 30-meter, 2-connection channel model in order to reduce the complexity and associated power consumption of 40GBASE-T transceiver. Hence, this objective suits many DC designs that are now based on modular POD (Performance Optimized DC) or portable containerized designs.

However, this objective deviates greatly from the familiar 100-meters, 4-connections cabling channel model that has been adopted by all currently published cabling standards. This will eventually be resolved in the various cabling standards committees, and it remains to be seen whether this dramatic change in architecture will be widely adopted by the cabling standards. Again, the industry will have to come to terms with this change when planning the migration to 40GBASE-T.

6.0 Conclusion

IEEE 802.3 will soon commence standardization work on 40GBASE-T. This standard is likely to be referred to as IEEE 802.3bq and may take several years to complete. The cabling standards committees are in the early stages of developing balanced twisted-pair cabling specifications to support this application. The recent CommScope proof-of-concept contribution to the IEEE NGBASE-T Study Group has demonstrated the technical feasibility of the proposed TIA Category 8 cabling systems utilizing the widely accepted RJ-45 connectors and has overcome a major challenge in developing cabling components to such a high frequency.

In addition, the recent ISO/IEC JTC1 SC25 WG3 adoption of 'Category 8.1 and Category 8.2' as the nomenclatures for the next-generation components can be seen as a major achievement in paving the way for closer harmonization with the TIA Category 8 proposal.

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WP-106703-EN (3/13)