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SFF Committee

SFF-8461 Specifications for

SFP+ Active Cable Specifications and Alternate Test Methods

Revision 0.1

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Secretariat: SFF Committee

Abstract: This specification defines SFP+ active cabling for SFF-8431 linear and limiting host. This specifications also defines alternate cable test method based on S-parameters.

This specification provides a common reference for system manufacturers, system integrators, and suppliers. This is an internal working specification of the SFF Committee, an industry ad hoc group.

This specification is made available for public review, and written comments are solicited from readers. Comments received by the members will be considered for inclusion in future revisions of this specification.

Support: This specification is supported by the identified member companies of the SFF Committee.

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EXPRESSION OF SUPPORT BY MANUFACTURERS

The following member companies of the SFF Committee voted in favor of this industry specification:

tbd

The following member companies of the SFF Committee voted against this industry specification:

tbd

The following member companies of the SFF Committee voted to abstain on this industry specification:

tbd

The user's attention is called to the possibility that implementation to this Specification may require use of an invention covered by patent rights. By distribution of this specification, no position is taken with respect to the validity of a claim or claims of any patent rights in connection therewith. Members of the SFF Committee which advise that a patent exists are required to provide a statement of willingness to grant a license under these rights on reasonable and non-discriminatory terms and conditions to applicants desiring to obtain such a license.

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Foreword

The development work on this specification was done by the SFF Committee, an industry group. The membership of the committee since its formation in August 1990 has included a mix of companies which are leaders across the industry.

When 2 1/2" diameter disk drives were introduced, there was no commonality on external dimensions e.g. physical size, mounting locations, connector type, connector location, between vendors.

The first use of these disk drives was in specific applications such as laptop portable computers and system integrators worked individually with vendors to develop the packaging. The result was wide diversity, and incompatibility.

The problems faced by integrators, device suppliers, and component suppliers led to the formation of the SFF Committee as an industry ad hoc group to address the marketing and engineering considerations of the emerging new technology.

During the development of the form factor definitions, other activities were suggested because participants in the SFF Committee faced more problems than the physical form factors of disk drives. In November 1992, the charter was expanded to address any issues of general interest and concern to the storage industry. The SFF Committee became a forum for resolving industry issues that are either not addressed by the standards process or need an immediate solution.

Those companies which have agreed to support a specification are identified in the first pages of each SFF Specification. Industry consensus is not an essential requirement to publish an SFF Specification because it is recognized that in an emerging product area, there is room for more than one approach. By making the documentation on competing proposals available, an integrator can examine the alternatives available and select the product that is felt to be most suitable.

SFF Committee meetings are held during T10 weeks (see www.t10.org), and Specific Subject Working Groups are held at the convenience of the participants. Material presented at SFF Committee meetings becomes public domain, and there are no restrictions on the open mailing of material presented at committee meetings.

Most of the specifications developed by the SFF Committee have either been incorporated into standards or adopted as standards by EIA (Electronic Industries Association), ANSI (American National Standards Institute) and IEC (International Electrotechnical Commission).

The SFF Committee activities support the requirements of the storage industry, and it is involved with several standards.

If you are interested in participating or wish to follow the activities of the SFF Committee, the sign up for membership and/or documentation can be found at:

www.sffcommittee.com/ie/join.html

The complete list of SFF Specifications which have been completed or are currently being worked on by the SFF Committee can be found at:

<ftp://ftp.seagate.com/sff/SFF-8000.TXT>

If you wish to know more about the SFF Committee, the principles which guide the activities can be found at:

<ftp://ftp.seagate.com/sff/SFF-8032.TXT>

Suggestions for improvement of this specification will be welcome. They should be sent to the SFF Committee, 14426 Black Walnut Ct, Saratoga, CA 95070.

Industry Documents

The following interface standards are relevant to SFP+ Specifications.

SFF-8431 - Specifications for Enhanced Small Form Factor Pluggable Module SFP+

SFF-8432 - Improved Pluggable Formfactor (<ftp://ftp.seagate.com/sff/>)

SFF-8083 - Improved 0.8mm Card Edge Connector (<ftp://ftp.seagate.com/sff/>)

SFF-8089 - SFP Rate and Application codes (<ftp://ftp.seagate.com/sff/>)

SFF-8079 - SFP Rate and Application Selection (<ftp://ftp.seagate.com/sff/>)

SFF-8472 - Diagnostic Monitoring Interface for Optical Transceivers (<ftp://ftp.seagate.com/sff/>)

INF-8074i - SFP (Small Form Factor) Transceiver (<ftp://ftp.seagate.com/sff/>)

INF-8077i - 10 Gigabit Small Form Factor Pluggable Module (XFP MSA) (<ftp://ftp.seagate.com/sff/>)

FC-PI-4 - Fibre Channel - Physical Interface-4

10GFC - Fibre Channel - 10 Gigabit

FC-MJSQ - Methodologies for Jitter and Signal Quality Specifications FC INCITS Project 1316-DT Rev 14.1, June 5, 2005

IEEE 802.3 - IEEE Standard 802.3, Relevant 10 Gigabit Ethernet clauses are 49, 10GBASE-R LAN PHY; 50, 10GBASE-W WAN PHY; 52, 10 Gigabit Ethernet serial PMDs; and 68, 10GBASE-LRM)

OIF CEI - Optical Internetworking Forum - Implementation Agreement # OIF-CEI-02.0 Common Electrical I/O (CEI)

(<http://www.oiforum.com/public/impagreements.html>)

Acronyms and other abbreviations

| | |
|---------|--|
| 64B/66B | Data encoded with 64B/66B encoder as defined by the IEEE Std. 802.3 CL 49. |
| BER | bit error ratio |
| CDR | clock and data recovery |
| CRU | clock recovery unit |
| dB | decibel. $10 \cdot \log_{10}(\text{ratio of power quantities})$. Powers can be electrical or optical. Conventional usage. See also dBe and dBo. |
| dBe | Specific case of dB where signals are electrical. $10 \cdot \log_{10}(\text{ratio of electrical power quantities})$. $20 \cdot \log_{10}(\text{ratio of voltage quantities})$ can be used if reference impedances are equal. |
| dBm | decibel (relative to 1 mW) |
| dBo | decibel optical (1 time dBo= 2 time dBe). Specific case of dB where the signals are in optical power. $10 \cdot \log_{10}(\text{ratio of optical power quantities})$. Also, in certain cases with electrical signals relating to linear optical modules, where it is expected that electrical voltage is in proportion to optical power, $10 \cdot \log_{10}(\text{ratio of voltage quantities})$. |
| DCD | Duty cycle distortion |
| DDPWS | Data Dependent Pulse Width Shrinkage |
| DDJ | Data Dependent Jitter |
| dRN | Difference of Relative noise see Appendix D |
| DUT | device under test |
| dWDP | Difference of the waveform distortion penalty of an optical receiver |
| dWDPc | Difference of the waveform distortion penalty of an electrical cable assembly |
| EMC | electromagnetic compatibility |
| EMI | electromagnetic Interference |
| FC | Fibre Channel |
| h | hexadecimal notation |
| HCB | Host Compliance Board |
| IEEE | Institute of Electrical and Electronics Engineers |
| ITU-T | ITU Telecommunication Standardization Sector |
| Gbit | gigabit = 10^9 bits |
| GBd | Gigabaud |
| J2 | 99% Jitter |

| | | |
|--------|--|----|
| LRM | IEEE 802.3 CL68 Physical Layer Specifications for 10Gb/s using 10GBASE-R encoding and long wavelength optics for multimode fiber | 1 |
| MCB | Module Compliance Board | 2 |
| OMA | optical modulation amplitude | 3 |
| PCB | printed circuit board | 4 |
| PRBS9 | Pseudo-Random Bit Sequence 2^9-1 , see SFF-8431 D1.1.1 | 5 |
| PRBS31 | Pseudo-Random Bit Sequence $2^{31}-1$, see SFF-8431 D1.1.1 | 6 |
| Qsq | Qsq a measure of SNR, see SFF-8431 D1.1.1 and IEEE 802.3.68.6.7 | 7 |
| RI | random interference | 8 |
| RMS | root mean square | 9 |
| RN | relative noise | 10 |
| Rx | receiver | 11 |
| Rx_LOS | Loss of signal same as defined in FC PI-4 and the inverse of signal detect (SD) in 802.3 | 12 |
| RSS | "Root Sum of Squares" | 13 |
| SD | Signal Detect | 14 |
| SerDes | Serializer/Deserializer | 15 |
| SFI | SFP+ high speed serial electrical interface | 16 |
| SNR | signal-to-noise ratio | 17 |
| VccT | Module positive power supply rail for the transmitter | 18 |
| VccR | Module positive power supply rail for the receiver | 19 |
| VMA | voltage modulation amplitude | 20 |
| Tx | transmitter | 21 |
| TWDP | Transmitter Waveform Distortion Penalty for an optical transmitter | 22 |
| TWDPc | Transmitter Waveform Distortion Penalty of a host transmitter supporting an electrical cable assembly | 23 |
| UI | unit interval = 1 symbol period | 24 |
| UJ | Uncorrelated Jitter | 25 |
| WDP | Waveform distortion penalty | 26 |
| WDPC | Waveform distortion penalty for an electrical cable assembly | 27 |

SFF Specifications

There are several projects active within the SFF Committee. The complete list of specifications which have been completed or are still being worked on are listed in the specification at <ftp://ftp.seagate.com/sff/SFF-8000.TXT>

Document Sources

Those who join the SFF Committee as an Observer or Member receive electronic copies of the minutes and SFF specifications (<http://www.sffcommittee.com/ie/join.html>).

Copies of ANSI standards may be purchased from the InterNational Committee for Information Technology Standards (<http://tinyurl.com/c4psg>).

Copies of SFF, T10 (SCSI), T11 (Fibre Channel) and T13 (ATA) standards, and standards still in development are available on the HPE version of CD_Access (<http://tinyurl.com/85fts>).

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CHAPTER 1 SCOPE OF THIS SPECIFICATION

1.1 INTRODUCTION

This specification defines cabling solutions compatible with SFP+ linear or limiting host for 10.3125 GBd operation based on “SFI”. For detailed SFI specifications and test methodology, see SFF-8431.

This specifications also defines an alternative passive cable test method based on cable S-parameters. The S-parameters method provides parameters for cable VMA loss, VCR, dWDP, and Vcm.

SFP+ active and passive cable assemblies are hot pluggable and are powered by individual power connections for the transmitter (VccT) and the receiver (VccR). Multiple modules can share a single 3.3 V power supply with individual filtering for each VccT and VccR. Detailed power supply specifications are given in SFF-8431 Chapter 2.

The SFP+ cable assemblies compatible with SFI (SFF-8431) could be active-active, active-passive, passive-active, or passive-passive implementations and may support one or more of the applications listed in [Table 1](#).

SFP+ cable assemblies are either compatible with host supporting linear modules or a host supporting limiting module as defined in SFF-8431 Chapter 3.5.

1.2 THE SFP+ SUPPORTED STANDARDS

SFF-8461 cable assembly may comply with any combination of the standards shown in [Table 1](#), and may be suitable for other or future standards. This specification does not preclude operation at other signalling rates that are not listed in this table, such as 2.125 GBd for 2GFC, or 4.25 GBd for 4GFC.

Table 1 SFP+ Standard Compliance

| <i>Standard</i> | <i>Signalling Rate (GBd)</i> | <i>High Speed Serial Interface</i> | <i>High Speed Serial Test Method</i> | <i>Low Speed Electrical Definitions</i> | <i>Low Speed Test Methods</i> | <i>Management</i> | <i>Mechanical/ Connector</i> |
|--|------------------------------|--|--------------------------------------|---|-------------------------------|---|------------------------------|
| IEEE 802.3 Clause 38 or Clause 59 (1 Gb/s Ethernet) | 1.25 | SFF-8431 Appendix-F | | SFF-8431 Chapter 2 | SFF-8431 Chapter 2 | SFF-8431 Chap 4 SFF-8472, SFF-8079, SFF-8089 | SFF-8432 SFF-8083 |
| 8 GFC | 8.5 | FC-PI-4 | FC-PI-4 | | | | |
| 10GSFP+Cu | 10.3125 | SFF-8431 Chap 3 Appendix E | SFF-8431 Appendix D and E | | | | |
| 10GSFP+Ac | 10.3125 | Chapter 2 and SFF-8431 Chap 3 Appendix E | SFF-8431 Appendix D and E | | | | |
| IEEE 802.3 CL 52 (10 Gb/s Ethernet LAN PHY) | 10.3125 | SFF-8431 Chap 3 | Appendix D | | | | |
| IEEE 802.3 CL 52 (10 Gb/s Ethernet WAN PHY) | 9.95328 | | | | | | |
| IEEE 802.3 CL 68 (LRM) | 10.3125 | | | | | | |
| 10 GFC | 10.51875 | | | | | | |
| 10GBASE-R (IEEE 802.3 CL 49) Encapsulated in G.709 ODU-2 Frame (FEC) | 11.10 | | | | | | |

1.3 ESD

The active and passive cable assemblies SFI contacts (High Speed Contacts) shall withstand 1000 V electrostatic discharge based on Human Body Model per JEDEC JESD22-A114-B.

The active and passive cable assemblies contacts with exception of the SFI contacts (High Speed Contacts) shall withstand 2 kV electrostatic discharge based on Human Body Model per JEDEC JESD22-A114-B.

The active and passive cable assemblies shall meet ESD requirements given in EN61000-4-2, criterion B test specification such that units are subjected to 15 kV air discharges during operation and 8 kV direct contact discharges to the case.

CHAPTER 2 ACTIVE CABLING SPECIFICATIONS

2.1 INTRODUCTION

High speed cabling specifications are based on SFI signalling as defined in SFF-8431 supporting either a limiting or linear host. Active cable assemblies may be used to provide operation over longer or thinner cables than achievable with direct attach copper assemblies. This section defines electrical specification and compliance testing methodology for such assemblies.

2.2 CABLE APPLICATIONS REFERENCE MODEL

A compliant active cable assembly is designated as 10GSFP+ACA and it can be identified by reading the memory map of SFF-8472.

The compliance points for SFP+ Active Cables(10GSFP+ACA) are the same as host compliance test points in 3.3.1 and the module compliance test points in 3.3.2 of SFF-8431.

All SFI test equipment must have 50 Ohms single ended impedance on all test ports.

Tx_Disable contacts in the module for cable assembly with active transmitter shall enable or disable the transmitter. For a passive assembly it shall be pulled to VccT with a 4.7 kΩ to 10 kΩ. The RX_LOS contact in the module for a cable assembly with active receiver shall be connected to the receiver IC loss of signal. A passive cable assembly RX_LOS contact shall be pulled low in the module. Direct connection of RX_LOS to VeeR is allowed for a cable assembly with passive receiver.

This specification does not assume transmit pre-emphasis beyond the level defined in SFF-8431.

Warning: 10GSFP+Cu can only be used on systems with common grounds. Connecting systems with different ground potential with SFP+ direct attach cable results in a short and may cause damage.

2.3 10GSFP+Ac DIRECT ATTACH CONSTRUCTION

10GSFP+ACA SFP+ active cable assemblies could be copper or optical, providing either a linear or a limiting output. While particular implementations

are not specified by this standard, it is expected that SFP+ Active Cables operate with either linear or limiting hosts as defined in section X.2.

An example of active cable assembly with active transmitter is shown in [Figure 1](#). The cable assembly shown has an active transmitter and active receiver. Other implementation possible are active-passive and passive-active. The cable assembly shall incorporate DC blocking capacitors with at least 4.3 V rating between any signal commissioning IC and the SFP+ edge card connector¹. The DC blocking capacitor shall have high pass pole of between 20 kHz and 100 kHz. For a copper cable assembly, the drain wire is connected to VeeT and to VeeR and the cable shield directly connects the module A and B cases.

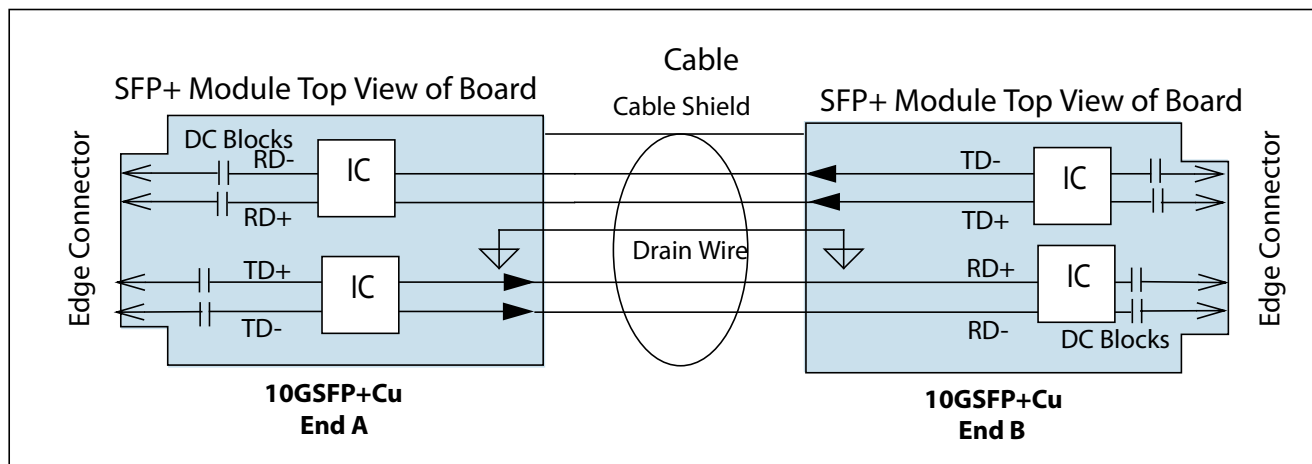


Figure 1 10GSFP+ACA Direct Attach Block Diagram

2.4 SFP+ ACTIVE CABLE HIGH-SPEED ELECTRICAL SPECIFICATION

This section defines the high-speed electrical specification for implementations with limiting or linear outputs. Active Cables designed to operate with limiting hosts are broadly defined as Type I, while Active Cables designed to

1. SFP+ edge card connector contacts are defined in SFF-8431.

operate with linear Hosts are broadly defined as Type II. The test setup for both Type I and Type II Active Cables is shown in [Figure 2](#).

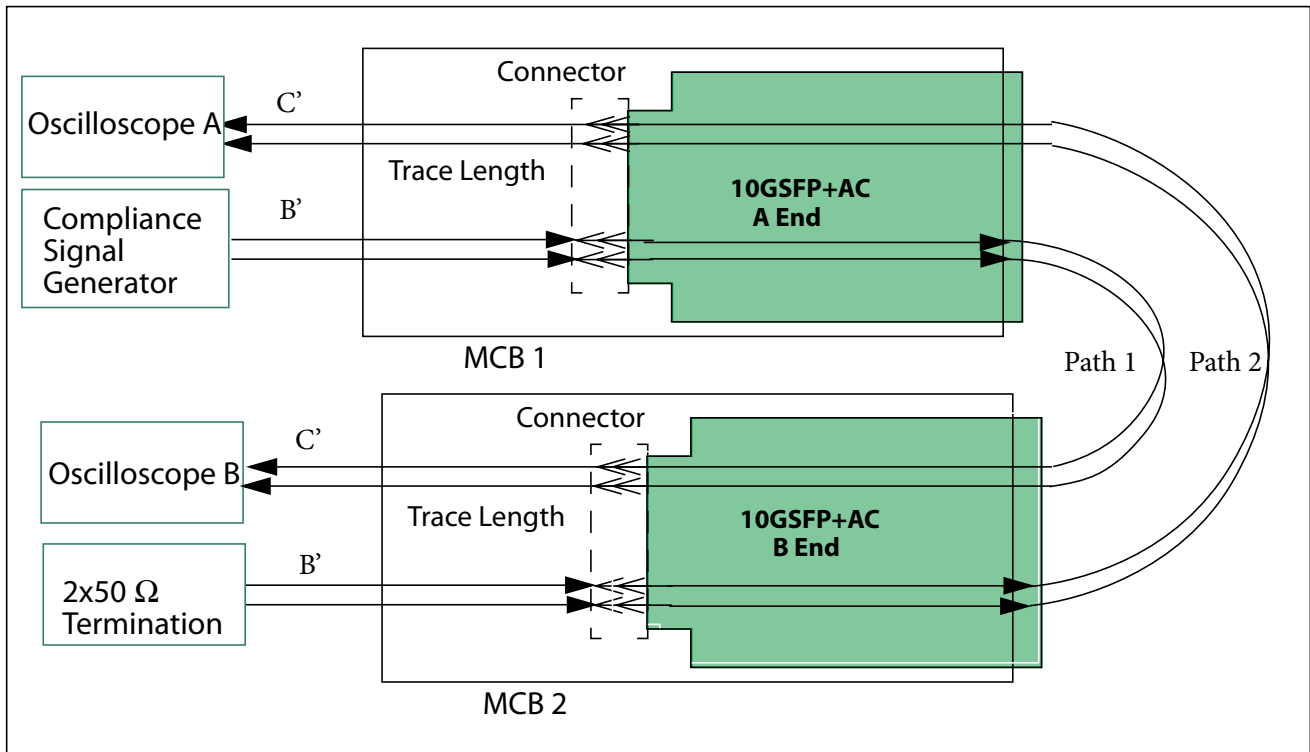


Figure 2 Active Cable Assembly Test Setup

2.5 SFP+ ACTIVE CABLES TYPE I (FOR OPERATION WITH A LIMITING HOST)

SFP+ Active Cable's Type I are assemblies that operate with the SFP+ limiting hosts defined in Chapter 3 of SFF-8431. Specifically, the active cable input must satisfy the SFP+ module transmitter input specifications at B' in Table 16 of SFF-8431 and tolerance specifications at B'' in Table 17 of SFF-8431. The active cable output must satisfy the *SFP+ Limiting Module Receiver Output Electrical Specifications at C'* in Table 18 of SFF-8431 and the *SFP+ Limiting Module Receiver Output Jitter and Eye Mask Specifications* Table 19 of SFF-8431. These output specifications must be met with worst case input allowed by Table 16 and Table 17 of SFF-8431.

2.6 SFP+ ACTIVE CABLES TYPE II

SFP+ Active Cables Type II are cables that operate with the linear hosts defined in Chapter 3 of SFF-8431. To ensure this, SFP+ Active Cables Type II must comply with the following specifications. The active cable input must satisfy the SFP+ module transmitter input specifications at B' in Table 16 of SFF-8431

and tolerance specifications at B'' in Table 17 of SFF-8431. The output at C' of Active Cables Type II must satisfy the requirements of Table 18 of SFF-8431. In addition, it must meet the specifications in [Table 2](#).

Table 2 Active Cable Type II Output Specifications at C'

| <i>Parameters - C'</i> | <i>Symbol</i> | <i>Conditions</i> | <i>RN</i> | | <i>RNmax</i> |
|---|---------------|-----------------------------|------------|------------|--------------|
| | | | <i>m</i> | <i>b</i> | |
| Relative Noise with post-cursor stressor | RN | See 1 and D14.1 in SFF-8431 | -0.01 | 0.12 | 0.083 |
| <i>Parameters - C'</i> | <i>Symbol</i> | <i>Conditions</i> | <i>Min</i> | <i>Max</i> | <i>Unit</i> |
| Waveform Distortion Penalty | WDP | See 2 and 3 | | 10 | dBe |
| Differential Voltage Modulation Amplitude For LRM | VMA | See D.7 in SFF-8431 | 180 | 600 | mV |
| Differential peak to peak voltage | Vpk-pk | See D.14.3 in SFF-8431 | | 600 | mV |
| 1. Maximum rms RN values are given by the following equation: $RN \leq \min[(m \cdot WDP + b), RN_{max}]$. 2. Defined with reference receiver with 14 T/2 spaced FFE taps and 5 T spaced DFE taps. 3. Worst-case input allowed by the specifications in Table 16 and Table 17 of SFF-8431. | | | | | |

CHAPTER 3 S-PARAMETERS TEST METHOD FOR 10GSFP+CU

S-Parameters test method is an alternate method of calculating 10GSFP+Cu cable parameters for passive cable assembly. The advantage of the S-parameters method is that it can give consistent results without requiring extensive adjustment to the SerDes driver. This method gives equivalent result to direct measurement of cable dWDP, VMA loss, and VCR per definition of SFF-8431 Appendix E.4.

3.1 S-PARAMETERS TEST METHOD PROCEDURE

In order to calculate the cable parameters as defined in SFF-8431 table 37, following test procedure is required:

- Measure S-parameters for MCB-HCB from point B" to B, see [3.1.1](#)
- Measure the s4p for through S-parameters for cable end 1 to cable end 2, see [3.1.2](#)
- Measure the s4p for crosstalk S-parameters for cable end under test, see [3.1.3](#)

S-Parameter Test Method Matlab code, [Appendix A](#), reads the three S-parameters s4p files in order to calculate the cable parameters dWDP, VMA loss, and VCR.

3.1.1 MCB-HCB S-PARAMETERS MEASUREMENT

The 4-ports S-parameters for the MCB-HCB response from B" to B is measured with a Vector Network Analyzer, see [Figure 3](#). The MCB-HCB 4-ports S-parameters

ters are used for S-Parameter Test Method Matlab code calibration, see [Appendix A](#).

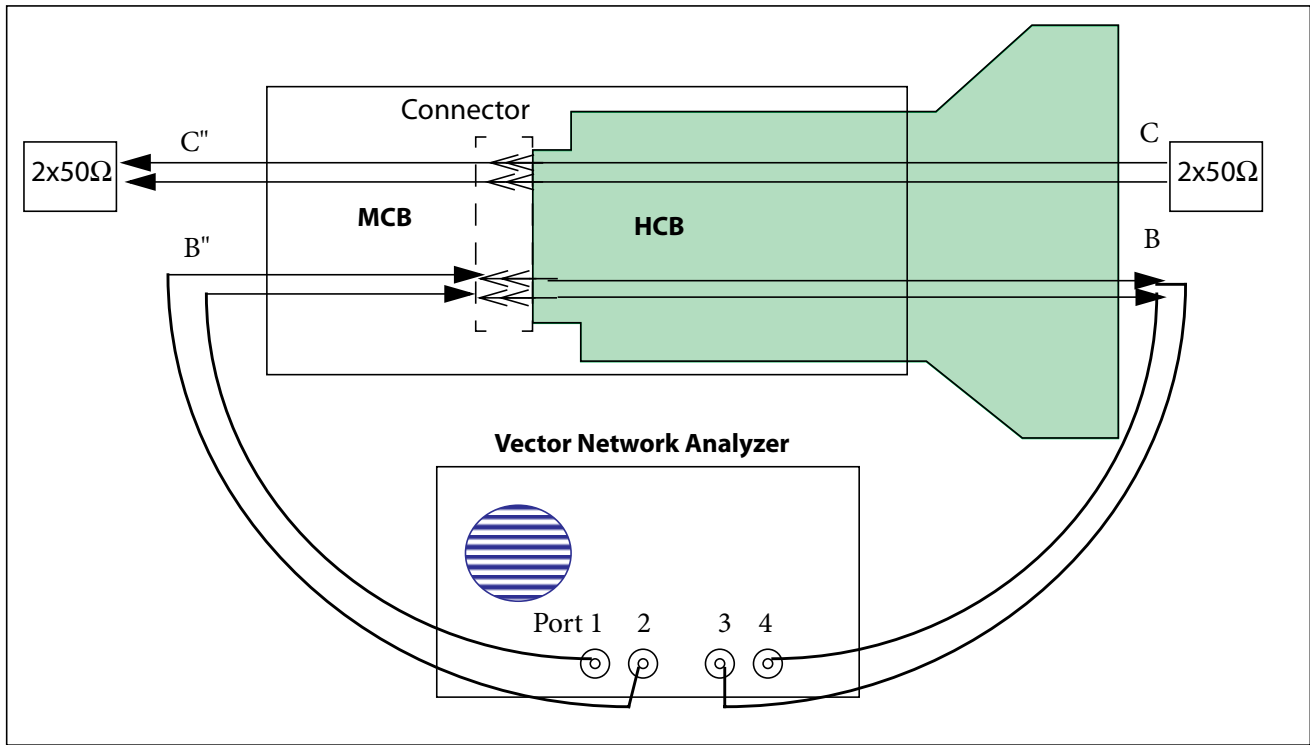


Figure 3 MCB-HCB S-parameters Test Setup

3.1.2 CABLE S-PARAMETERS THROUGH MEASUREMENT

Cable S-Parameters through Measurement setup is shown in [Figure 4](#). The through measurement setup shown is for cable end B to cable end A with the response measured B' to C'. The procedure is then repeated to measure cable through response from end A to end B.

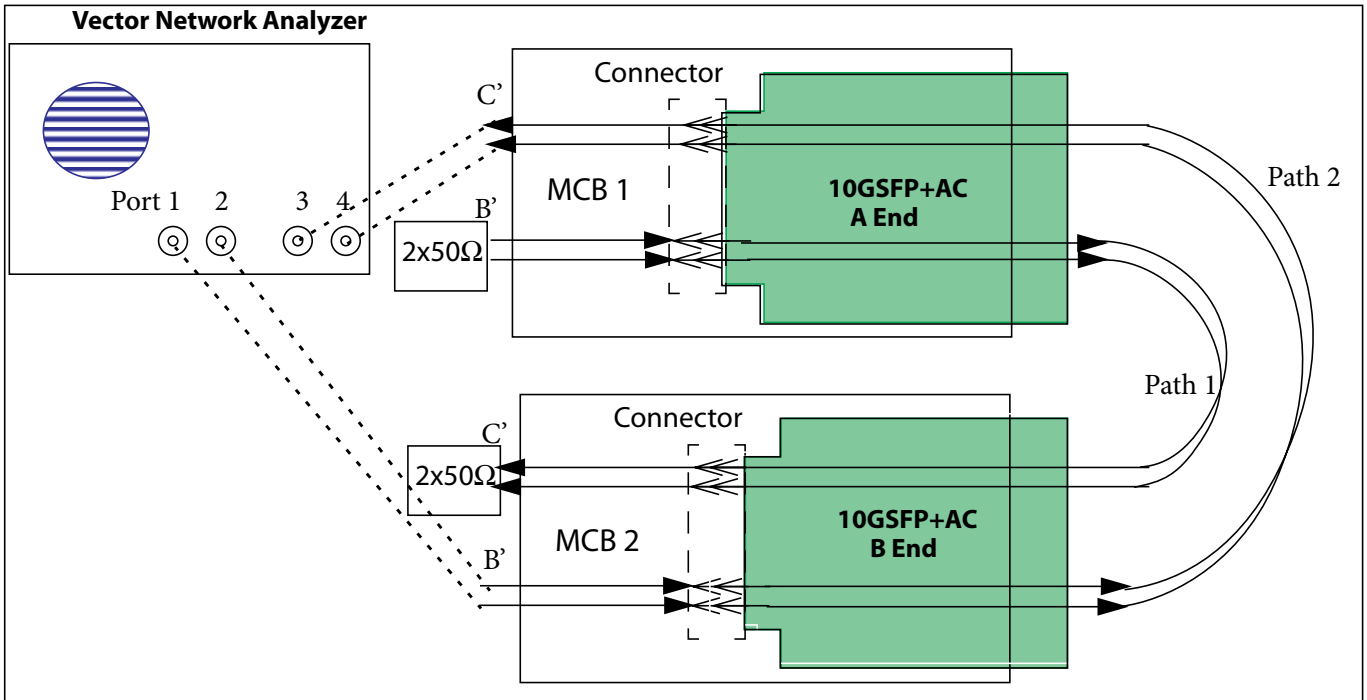


Figure 4 Cable S-Parameters Through Test Setup

3.1.3 CABLE S-PARAMETERS CROSSTALK MEASUREMENT

Cable S-parameters crosstalk measurements setup is shown in Figure 5. The crosstalk measurement setup shown is for the cable end B measured from B' to C'. The procedure is then repeated to measure cable crosstalk for the other end.

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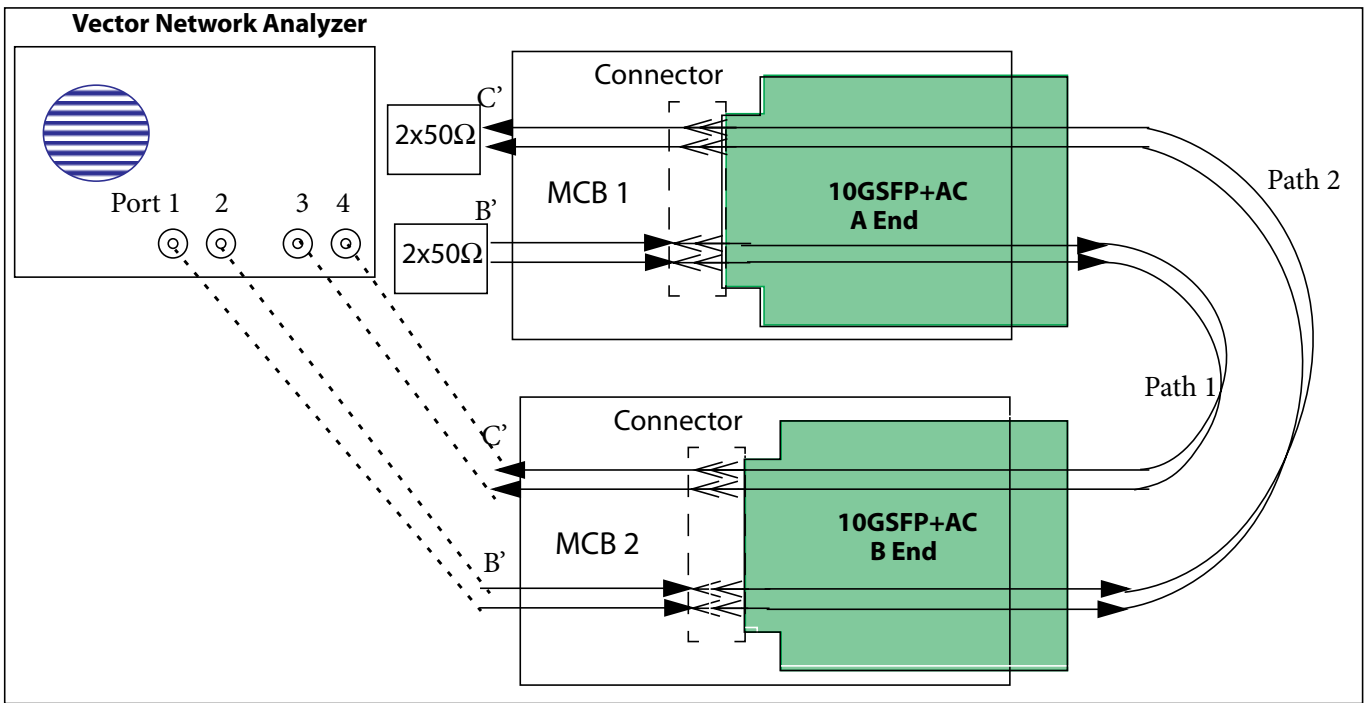


Figure 5 Cable S-Parameters Crosstalk Measurement

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APPENDIX A MATLAB CODE FOR S-PARAMETERS METHOD

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