Effects of ESD and Cleaning on SFP Fiber Optic Transceivers

Field Service & GSC Training

DOC1928793 MR Service Engineering

Imagination at work

Overview

Optical Modules or SFP (small form-factor pluggable) transceivers used in MR scanners are sensitive to ESD (electro static discharge). This training addresses the proper handling during installation and replacement, as well as the proper cleaning procedure to avoid intermittent signals, degraded signal power, and electrical overstress attributed to latent failures.

Learning Objectives

Upon completing this training, you will be able to:

- ❑ Define ESD
- ❑ Know SFP Module Failures, Effects, & Prevention
- ❑ Diagnose and Troubleshoot SFP Transceivers
- ❑ Use of SFP Cleaning Kit GEHC 5478006

Audience

This course is required for all GEHC employees that handle fiber optic transceivers, used in MR scanner communication links. This includes, but not limited to , Design Engineers, Manufacturing Engineers, Production Associates, and Service Engineers.

Module Length

This module takes 15-20 minutes to complete.

Course Completion

You must complete the learning module and the assessment (80% or higher) to get credit for this course.

Contents

❑ Overview

❑ Lesson 1: What is ESD?

❑ Lesson 2: SFP Failure Modes, Effects, & Prevention

❑ Lesson 3: Diagnostics and Troubleshooting

❑ Lesson 4: SFP Cleaning Procedure

GEHC Learning Module: EFFECTS OF ESD AND CLEANING ON SFP FIBER OPTIC TRANSCIEVERS

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Lesson 1: What is ESD?

Electro-Static Discharge (ESD) is defined as the rapid movement of electrical charges from one object to another. An object can become charged:

- When surfaces separate

- From friction; the movement of materials against surfaces (i.e. your shoe against the floor)

ESD voltage levels are dependent on RH (relative humidity)

Did you know?

ESD Generation by	10-25% RH	65-90% RH
Walking on Carpet	35,000	1,500
Walking on Vinyl	12,000	250
Working at Bench	8,000	100
Opening Clear Bag	20,000	1,200
Sitting on Padded Chair	18,000	1,500

Note: GEHC SFP # 5183329-2 protected to 2kV, 5183329-3 upgraded to 8kV HBM

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Sources of ESD

- Vinyl binders

- Equipment covers

- Plastic document holders/sheet protectors

- Post-It^{TM} notes

- Plastic pens

- Bubble wrap

- Plastic housings on equipment

- Paper, schematics, etc.

- Plastic spray bottles

- Personal items
    - Purses
    - Sweaters/jackets
    - Insulated lunch totes
    - Combs/brushes
    - Lotion bottles

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ESD Failures and Cost

CATASTROPHIC FAILURE

- Device circuitry is permanently damaged
- An electronic device exposed to ESD no long work

LATENT FAILURE

- Device is partially damaged, yet continues to function (i.e., pass tests)
- Product may experience a failure after it is placed into service

## COST TO GE HEALTHCARE – Up to 10% Annual Revenue

- Field Repair & Part Replacement
- Labor & Transportation
- Customer Dissatisfaction

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Lesson 2: SFP Module Failure Modes & Effects

SFP (Small Factor Pluggable) Transceivers used in GE scanners suffer from link loss mechanisms that can be controlled:

1. SFP Junction loss — 'Walkout' (Input /Output connector seating)

2. Micro-Bend loss (i.e., Cable Damage due to Inadvertent Kinking / Pinching)

3. Macro-Bend loss (i.e., Bend Radius Less than 7.0 in. (17.78 cm for Gradient Fiber Cable)

4. SFP Lens Impurities (Dirt on Fiber Cable or Transceiver)

5. ESD that Exceeds the 8kV HBM Protection
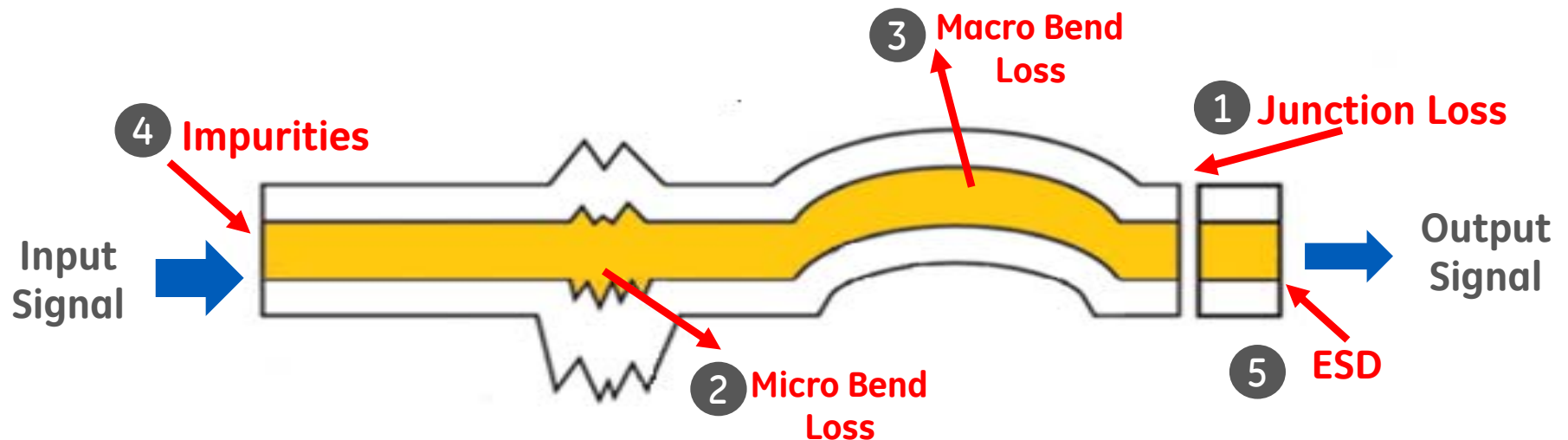
Link Loss: 'Walkout'

'Walkout' is a common condition where the cable connector backs out of the transceiver.

Prevention:
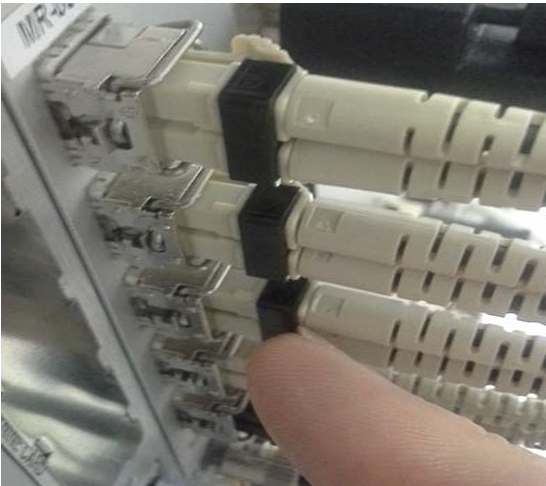
- *SFP cables must be seated properly into the SFP transceiver*

- *When replacing the SFP, clean both the cable ends and the transceiver*
  GEHC Fiber Optic Cleaning Kit 5478006

- *Insert cable by applying pressure to the black ring on the cable end using your finger nail - DOC1818501*

- *To ensure a good connection, gently pull on the cable after insertion*

A loose fiber optic cable can lead to intermittent communication faults.

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Link Loss: Micro / Macro Bend

Micro-bend link loss occurs in fiber cable that has been crimped or pinched because fiber optic signal is scattered.

Prevention:

- *Do not allow cabinet covers or doors to crimp fiber optic cables*

- *Do not walk or roll equipment over the fiber*

Macro-bend link loss occurs in fiber cable that violates its minimum bend radius because light cannot bend sharp corners.

Prevention:

- *When routing cables, keep a minimum bend radius of > 7 inches (17.78cm)*

> **If SFP cable is crimped or draped over a cabinet, the link will be lost.**

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Link Loss: Lens Impurities

Impurities left on the lens and cables limits light output, thus stressing the SFP module. Contamination accounts for significant power loss (2-6 dB) that can create a 'link down' hard system failure even though the transceiver is functional.

Dirty Optics   Clean Optics

Prevention:

- *When replacing the SFP, clean both the cable ends and the transceiver*
  Service Note: DOC1818501
  GEHC Fiber Optic Cleaning Kit (PN: 5478006)

- *Never allow the end of the fiber optic cable to make contact with any surface, including direct contact with fingers (Dirty Optics shown above is the result of finger oil and dust deposits)*

- *Never clean the transceiver by blowing into the lens—this will leave impurities (dust and moisture which will be very difficult to clean once the laser burns this into the lens*

- *Never use your shirt tail to clean the cable or transceiver—only use nonwoven material to prevent scratching the lens, resulting in scattering the light signal.*
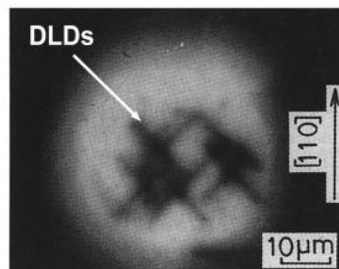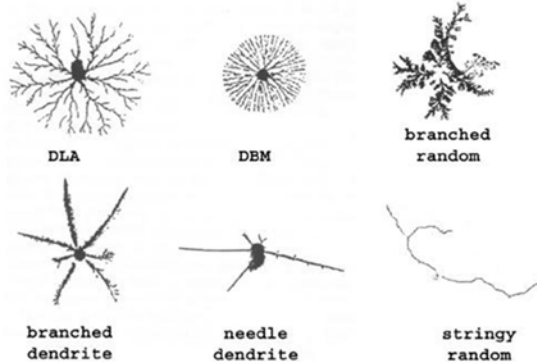
Clean fiber optic components are required for quality communication.

Link Loss: ESD

ESD induces a latent effect called DLD (Dark Line defect) that

- reduces the light aperture of the lens,
- forces the laser driver to increase its Transmit Bias (TxBias) current,
- Results in electrical over stress.

Think of this as a pebble that hits your windshield, the crack continues to grow, until your vision is impaired.

DLA   DBM   branched random

branched dendrite   needle dendrite   stringy random

DLDs

[110]

10μm

Reference: O. Ueda, Reliability and Degradation of III-V Optical Devices (Artech House, Boston, 1996)

Prevention:

- *SFP is protected to 8kV. ESD can easily surpass this level in climates with low relative humidity.*
- *SFP ESD protection is reduced in MR scan room, due to strong B0 field.*
- *ESD strap is required at all times when handling the SFP fiber optic transceiver.*
- *Use Silver 'Static Shielding' packaging when moving or transporting SFP modules*

ESD will deliver a latent effect to the SFP, not apparent at installation.

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Lesson 3: Diagnostics and Troubleshooting

DVMR Link Diagnostics displays the SFP system health parameters, indicating failure mode:

- Voltage
- Temperature
- TxBias Current
- TxPower
- RxPower

```
IXG J14
  Vendor Id : FORMERICAOE
  Vendor PN : TSD-S1KH1-A11
  Vendor rev :
  Vendor SN : 0000FR1219
  Date Code : 05-02-2013 (dd-mm-yy)
  Voltage : 3.47 v
  Temp : 45 C
  txBias : 13.800 mA
  txPwr : 0.5236 mW = -2.81 dBm
  rxPwr : 0.4339 mW = -3.63 dBm
  Sig Detect : Yes, LinkUp: Yes,
Connected to : DTX-1
  Status      : FAIL - Replace this SFP.
```

Definite internal fault
FE & PA instructed to replace unit

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Diagnostics and Troubleshooting (continues)

To troubleshoot the link, SFP can be swapped from a neighboring port.

Example: Compare the RxPwr spec on J13 with a swapped port and run DVMR Link diagnostics again. This may indicate a bad cable connection or confirm a bad transmitting SFP.

```
IXG J13
    Vendor Id : StratosLightwave
    Vendor PN : SPLC-20-F-1-D
    Vendor rev :
    Vendor SN : 74611A11111
    Date Code : 13-01-2011 (dd-mm-yy)
    Voltage : 3.29 v
    Temp : 49 C
    txBias : 10.038 mA
    txPwr : 0.3794 mW = -4.21 dBm
    rxPwr : 0.0112 mW = -19.51 dBm
    Sig Detect : No
    Status : FAIL
```

RxPwr too low - Might be fiber or remote side SFP problem

Fault indicated without a replacement instruction.

Lesson 4: SFP Cleaning Procedure

MR system utilizes a combination of **Duplex LC** (Male/Female) and **MPO** (Male/Female) connections.

Protective caps should remain on all connectors until they are mated.

Connectors left unmated for any period of time must be cleaned to minimize insertion lost.

The GEHC Fiber Optics Cleaning Kit contains appropriate cleaning tools, supplies, and instructions to clean all of the interfaces of the SPF modules

GEHC Fiber Optics Cleaning Kit
(Part Number: 5478006)

LC Duplex Cleaner

MPO Cleaner

Solvent Pen

Cleaning Cube

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SFP Cleaning Procedure

Detailed SFP Connector Cleaning Instructions are included in the GEHC Fiber Optics Cleaning Kit *(PN: 5478006).*

General Procedure:

1. Select the appropriate cleaner from the kit (LC Duplex or MPO)
2. Remove the top part of the cap on the cleaner
3. Remove the dust cap(s) on the SFP connector
4. Insert connector tips (include adapter if there is one) into cleaner; compress until it clicks
5. Remove SFP connector

If Contaminant Persists After Using the Cleaner Tool

1. Apply Solvent (from pen) to cloth on the Cleaning Cube to wet the surface
2. Place the tip of the SFP connector to the wet surface
3. Clean by swiping in the direction the cloth comes out of the Cleaning Cube

Note: Do Not Use the Cleaning Cube to Clean Male MPO Connector

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Looking Forward

GE Engineering is working on an extensive quality effort to extend the life of the optical communication of our scanners.

MR Scanner utilization of SFP transceivers is unique from the industry in that they are essential to function components: when one optical link goes down, the scanner goes down.

It's important for everyone who handles SFP transceivers to understand the failure modes and practice preventative actions to ensure customer confidence in our products.

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Summary

- Always use ESD straps and silver 'static shielding' packaging when handling SFP transceivers to avoid DLD latent effects

- Always clean the cable end and the SFP transceiver using the GEHC Optical Cleaning Kit (PN: 5478006) for every replacement

- Be careful not to pinch (micro bend) the optical fiber cable and leave a minimum of 7 inches bend radius (macro bend)

- Ensure the cable mates properly with the transceiver to prevent 'walk out' – if in doubt give the cable a little

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Revision History

Rev	Page	Description of Content Changed	Reason for Change or Change Control Number	Author Name / SSO	Revision
1	All	Initial Entry	Initial Entry	Brian Gracyalny / 212473777	See MyWorkshop
2	All	Same content, MWS update for GE Learning 2018 distribution	05Jan2018	Brian Gracyalny / 212473777	See MyWorkshop

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