



**NOTE**

All numerical values are in metric units [with U.S. customary units in brackets]. Dimensions are in millimeters. Unless otherwise specified, dimensions have a tolerance of  $\pm 0.13$  and angles have a tolerance of  $\pm 2^\circ$ . Figures and illustrations are for identification only and are not drawn to scale.

**1. INTRODUCTION**

This specification covers the requirements for the VMEbus International Trade Association (VITA) 66.4 Fiber-Optic Connectors with use with Multi-Mode MT Ferrules. This connector system has been designed for use as independent or stand-alone connectors in ANSI/VITA 48.1 (air-cooling applications) and ANSI/VITA 48.2 (conduction-cooling applications) applied to printed wiring boards (PWBs)/plug-in units defined in ANSI/VITA 46.0 VPX systems. Typical applications are in the aerospace and defense industry and include use in adverse environments for Embedded Computing, Processing, Avionics and Vetrronics, Radar, Secure Communications and Imaging/Targeting.

The connector system provides a high-density, blind-mate optical interconnect in a backplane/card configuration. The fiber-optic (ribbon) cable interconnect is fed through the backplane to removable systems modules using standard-grade Multi-Mode MT ferrules. The connector system consists of the backplane connector and the mating module connector which interconnects a single ferrule, accommodating up to twelve fiber paths.

When corresponding with TE Connectivity Personnel, use the terminology provided in this specification to facilitate inquiries for information. Basic terms and features of this product are provided in Figure 1.

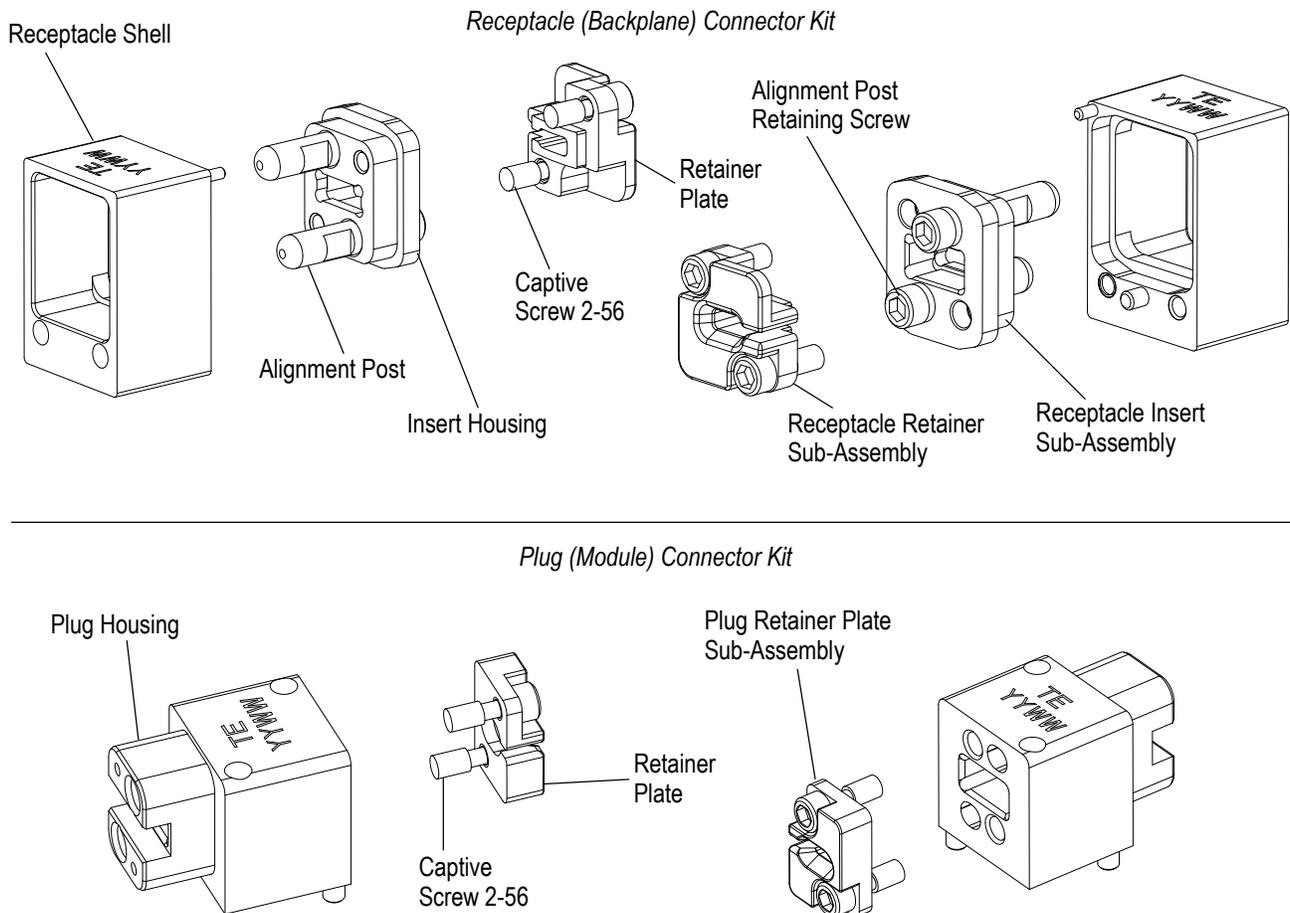


Figure 1

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## 2. REFERENCE MATERIAL

### 2.1. Revision Summary

Initial release of application specification

### 2.2. Customer Assistance

Reference Product Base Part Numbers 2226880 and 2226881, and Product Code J547 are representative of the TE VITA 66.4 Fiber-Optic Connectors. Use of these numbers will identify the product line and help you to obtain product and tooling information when visiting [www.te.com](http://www.te.com) or calling the number at the bottom of page 1.

### 2.3. Customer Drawings

Customer drawings for product part numbers are available from [www.te.com](http://www.te.com). If there is a conflict between the information contained in the Customer Drawings and this specification or with any other technical documentation supplied, the information contained in the Customer Drawings takes priority.

### 2.4. Specifications

Product Specification [108-2467-1](#) provides product performance requirements and test information for the TE VITA 66.4 Fiber-Optic Connectors installed with standard-grade, Multi-Mode, 12-position MT ferrules. Qualification Test Report [501-134012-1](#) confirms successful qualification per the information in [108-2467-1](#).

### 2.5. Instructional Material

Instruction sheets (408-series) provide product assembly instructions or tool setup and operation procedures. Instruction sheets available that pertain to this product are:

<u>Document Number</u>	<u>Document Title</u>
<a href="#">408-8922</a>	Cleaning and Inspection for Physical Contact Fiber-Optic Connectors

### 2.6. Standards and Publications

**ANSI/VITA 46.0**, “VPX Baseline Standard”, developed by the VMEbus International Trade Association (VITA) describes the VITA 46 VPX family of standards for VMEbus systems for the provision of high-speed interconnects in harsh-environment applications.

**ANSI/VITA 47**, “American National Standard for Environments, Design and Construction, Safety and Quality for Plug-In Units Standard”, developed by VITA, defines environmental, safety, and quality requirements for commercial-off-the-shelf (COTS) plug-in units (cards, modules, etc.) intended for mobile applications.

**ANSI/VITA 48.1**, “Mechanical Specification for Microcomputers Using REDI Air Cooling”, developed by VITA, defines the mechanical requirements that are needed to ensure the mechanical interchangeability of air-cooled 3U and 6U plug-in units and define the features required to achieve two level maintenance compatibility.

**ANSI/VITA 48.2**, “Mechanical Specification for Microcomputers Using REDI Conduction Cooling Applied to VITA VPX”, developed by VITA, defines the mechanical requirements that are needed to ensure the mechanical interchangeability of air-cooled 3U and 6U plug-in units and define the features required to achieve two level maintenance compatibility.

**ANSI/VITA 66.0**, “Optical Interconnect on VPX - Base Standard”, developed by VITA, defines a family of blind-mate fiber-optic interconnects for use with VPX backplanes and plug-in modules.

**ANSI/VITA 66.4**, “Optical Interconnect on VPX – Half Width MT Variant”, developed by VITA, defines the half-size fiber-optic interconnect variant for the MT style contact.

**IEC 61755-3-31**, “Fiber-Optic Connector Optical Interfaces - Part 3-31”, which defines the MT ferrule end face geometry requirements.

**IEC 61754-5**, “Fiber-Optic Connector Interfaces - Part 5: Type MT Connector Family”, which defines the standard interface dimensions for the type MT family of connectors.

### 3. REQUIREMENTS

#### 3.1. Safety Precautions



**DANGER**

Glass fiber can easily penetrate the skin and eyes. Always use extreme care and wear eye protection when stripping, cutting, and preparing the cable for use. Never look into the end of the fiber when the optical power is applied as infrared light cannot be seen, but it can severely damage the eyes. Also, never eat, drink, or smoke when working with the fibers. This could lead to ingestion of glass particles.



**DANGER**

To avoid personal injury, connectors must be handled with care; the component corners and edges may be sharp.

Do not stack product shipping containers so high that the containers buckle or deform.

#### 3.2. Limitations

This connector system is designed to operate in a temperature range of -20° to 85°C [-4° to 185°F].

#### 3.3. Material

The receptacle (backplane) connector shell, insert housing and retainer plate, and the plug (module) connector housing and retainer plate are made of aluminum and are clear chromate conversion coated. The alignment posts and screws are made of passivated stainless steel.

#### 3.4. Storage

##### A. Ultraviolet Light

Prolonged exposure to ultraviolet light could cause deterioration of the connector or the materials of the installed MT ferrules or cable assemblies.

##### B. Shelf Life

The product should remain in the shipping containers until ready for use to prevent deformation to components. The product should be used on a first in, first out basis to avoid storage contamination that could adversely affect performance.

##### C. Chemical Exposure

Do not store product near any chemical listed below as they may cause stress corrosion cracking in the material.

Alkalies	Ammonia	Citrates	Phosphates	Citrates	Sulfur Compounds
Amines	Carbonates	Nitrites	Sulfur Nitrites		Tartrates

##### D. Temperature Exposure

The storage temperature for these fiber-optic connectors is -55 to 85°C [-67° to 185°F].

#### 3.5. Special Characteristics

##### A. Receptacle (Backplane) Connector Kit (Figure 2)

- The retainer plate sub-assembly is shipped unassembled with the receptacle connector shell and insert housing. The retainer plate sub-assembly contains two captive screws which engage with the insert housing.
- The receptacle connector kit includes two mounting screws containing a pre-applied Nylok patch. The screws are used to secure the shell to the backplane board. The insert sub-assembly is secured between the connector shell and the backplane.
- The insert housing and retainer plate contain one cavity to accept an MT ferrule.
- The shell contains two locating post features that position the connector on the backplane.
- The shell and insert sub-assembly are designed with 0.51 mm minimum clearance to provide at least ±0.25 mm floating alignment in both the x- and y- directions.

Nylok is a trademark.

- The retainer plate is slotted to accept the terminated cable assemblies, and it contains surfaces supporting the MT ferrules.

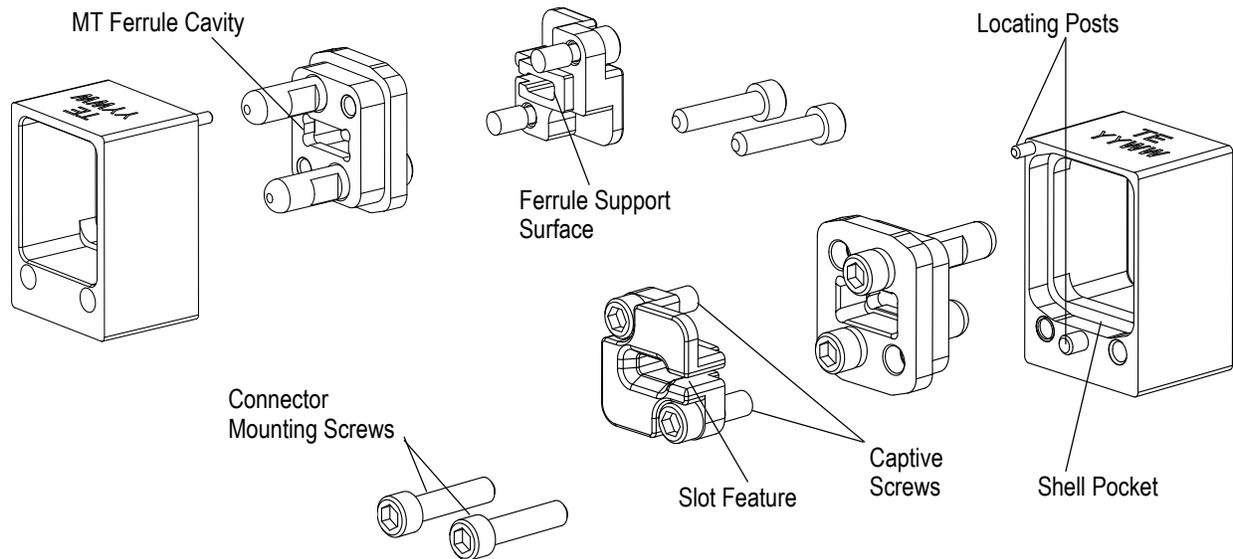


Figure 2

### B. Plug (Module) Connector Kit (Figure 3)

- The retainer plate sub-assembly is shipped unassembled with the plug connector housing. The retainer plate sub-assembly contains two captive screws which engage with the housing.
- The housing contains two locating post features that position the connector relative to the edge of the module circuit board.
- The housing and retainer plate contain one cavity to accept an MT ferrule.
- The connector kit includes two mounting screws containing a pre-applied Nylok patch. The screws are used to secure the connector housing to the module circuit board.
- The housing contains a slot feature that facilitates cleaning the MT ferrule interfaces.
- The retainer plate is slotted to accept the terminated cable assemblies, and it contains recessed pockets supporting the spring component of each fiber-optic cable assembly.

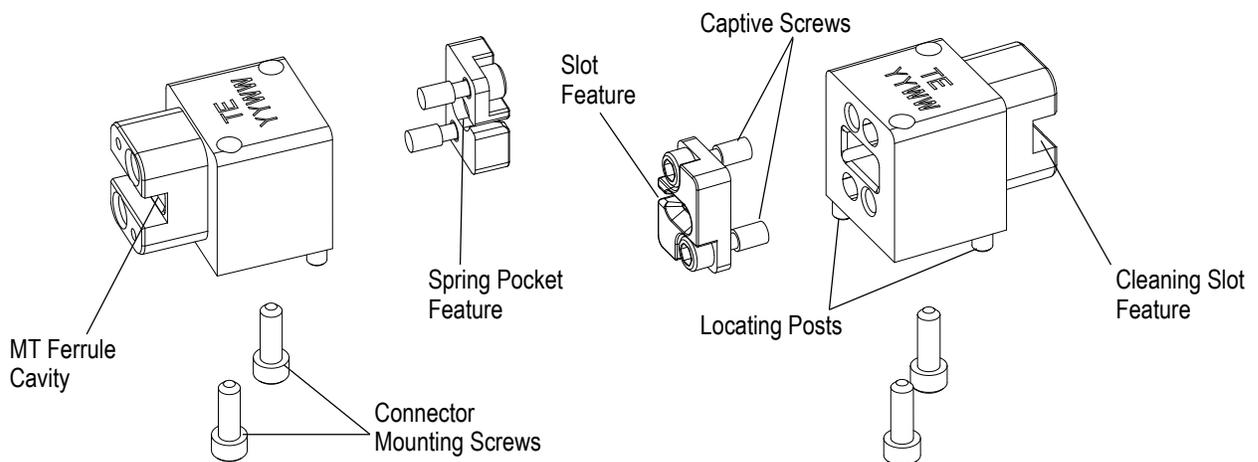


Figure 3

Nylok is a trademark.

### 3.6. Special Assembly Considerations

#### A. System Design

The system into which the VITA 66.4 connectors are installed must support the weight of the drawer when modules are engaged (for example, the drawer must bottom on a built-in stop, not on the connectors).

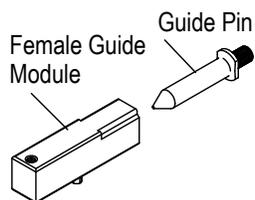
#### B. Optical Loss Budget

An optical loss budget analysis is recommended to make certain the system will work over the proposed link. Parameters such as environmental exposure and end face maintenance techniques can add variance to loss budget inputs. For the loss through the module to backplane connection interface, the budget is typically 1.2 dB at 850 nm and 1300 nm. The return loss budget should typically be better than 20 dB. More detail on optical performance is provided in Product Specification 108-2467-1.

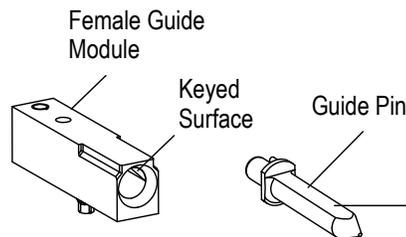
#### C. Guide Hardware (Figure 4)

The interaction of the guide pin and guide module provide error-free mating and prevents damage to the connectors. Guide hardware is recommended for multi-connector, large and heavy daughter card applications, and conditions where misalignment tolerances given in Section 3.7 cannot be met. Universal and keyed guide hardware are available for proper mating and allow up to  $\pm 3$  mm offset for blind mating. The guide hardware consist of a guide pin and guide module. The connectors require 2 guide pins (for the receptacle) and 2 guide modules (for the plug), which must be attached to the respective PWB. Refer to Figure 4.

*Universal Guide Hardware*



*Keying Guide Hardware*



*Keyed VITA 46 Type Hardware*

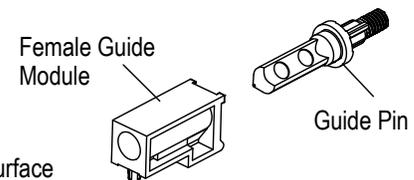


Figure 4

### 3.7. Printed Wiring Board Requirements

#### A. Material and Thickness

The recommended material for the both the backplane and module PWBs is glass epoxy (FR-4, G-10, or other TE Engineering-approved substrates). The VITA 66.4 connectors require a minimum PWB thickness of 1.47 mm [.058 in.]. The maximum PWB thickness accommodated is 5.8 mm [.228 in.].

The length of the connector mounting screws provided in the connector kits limits the maximum PWB thickness. If an application would require a thicker PWB, longer connector mounting screws would be required. In that event, call PRODUCT INFORMATION at the number at the bottom of page 1 for alternate recommended mounting hardware.

#### B. Tolerance

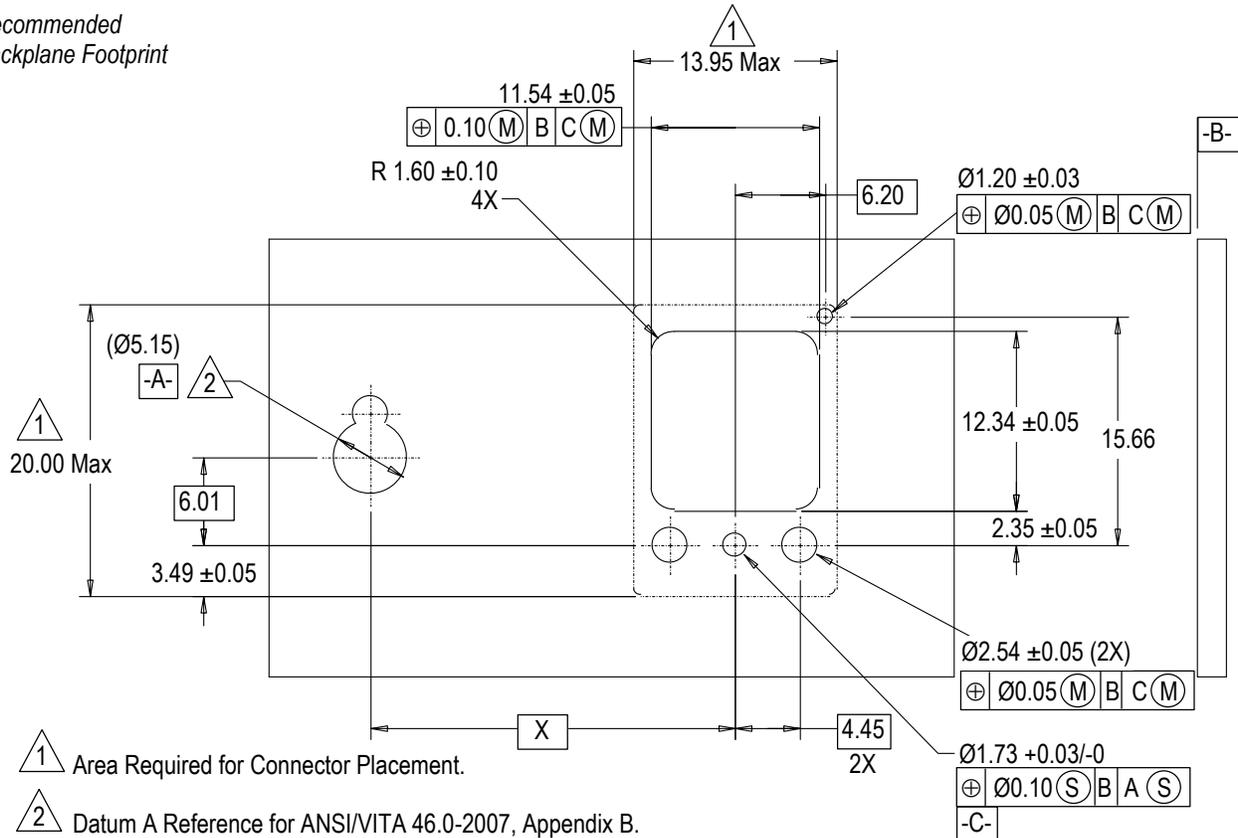
The maximum allowable bow of the PWB shall be 0.03 mm [.001 in.] over the length of the connector.

**C. Layout** (Figures 5 and 6)

**Backplane PWB Layout:**

The mounting and location holes and the rectangular cutout in the backplane PWB must be precisely located to ensure proper placement per ANSI/VITA 46.0 and optimum performance of the connector. The two PWB locating holes accept the connector alignment posts, and the two mounting holes accept the kitted machine screws required to secure the connector to the PWB. These four holes shall be unfinished. The backplane rectangular cutout provides clearance to install and remove the connector retainer plate and MT ferrule/cable assemblies.

*Recommended  
Backplane Footprint*



- 1 Area Required for Connector Placement.
- 2 Datum A Reference for ANSI/VITA 46.0-2007, Appendix B.

**CONNECTOR LOCATION ON BACKPLANE PC BOARD**

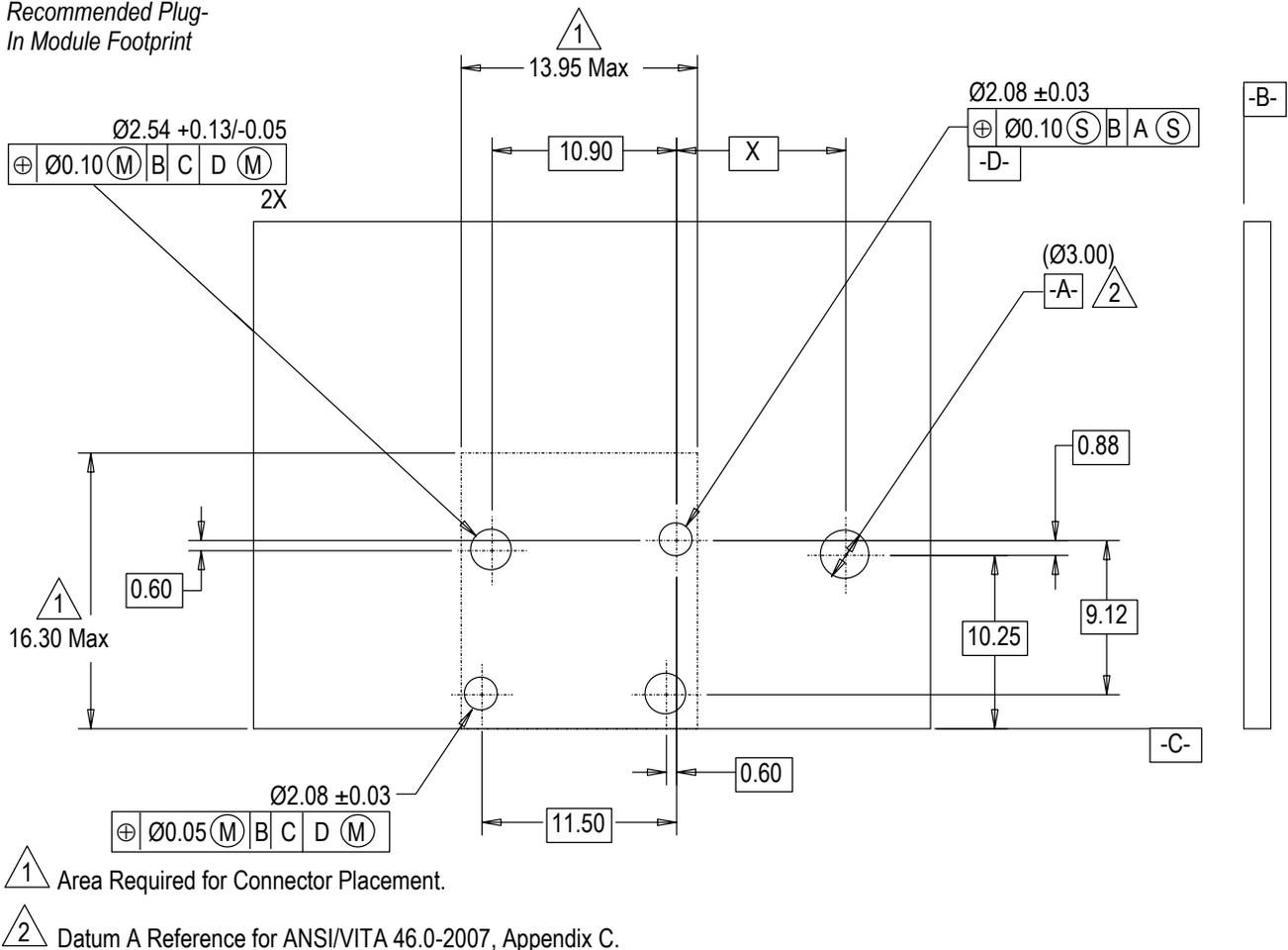
POSITION	DIMENSION "X"
J2A	58.73
J2B	72.85
J3A	101.60
J3B	115.72
J4A	130.40
J4B	144.52
J5A	159.20
J5B	173.32
J6A	188.00
J6B	202.12

Figure 5

**Module PWB Layout:**

The mounting and location holes in the module PWB must be precisely located for proper placement relative to the leading edge of the PWB and the Datum A reference per ANSI/VITA 46.0 and to ensure optimum performance of the connector. The two PWB locating holes accept the connector alignment posts, and the two mounting holes accept the kitted machine screws required to secure the connector to the PWB. These four holes shall be unfinished.

Recommended Plug-In Module Footprint



**CONNECTOR LOCATION ON MODULE PW BOARD**

POSITION	DIMENSION "X"
P2A	52.98
P2B	67.10
P3A	95.85
P3B	109.97
P4A	124.65
P4B	138.77
P5A	153.45
P5B	167.57
P6A	182.25
P6B	196.37

Figure 6

**D. Connector Spacing** (Figure 7)



**CAUTION**

Care must be taken to avoid interference between adjacent connectors and/or other components.



**NOTE**

The information provided is for manual placement of the VITA 66.4 and adjacent connectors. If robotic equipment is used, other space allowances will be required for the grippers.

To ensure proper mating, the allowable nominal distance between adjacent connectors stacked end-to-end is 14.12 mm [.556 in.] as shown in Figure 7. The allowable nominal distance between adjacent connectors stacked side-by-side is 20.32 mm [.800 in.] as shown likewise.

When using the VITA 66.4 connectors with other connectors or components, call PRODUCT INFORMATION at the number at the bottom of page 1 for recommended spacing.

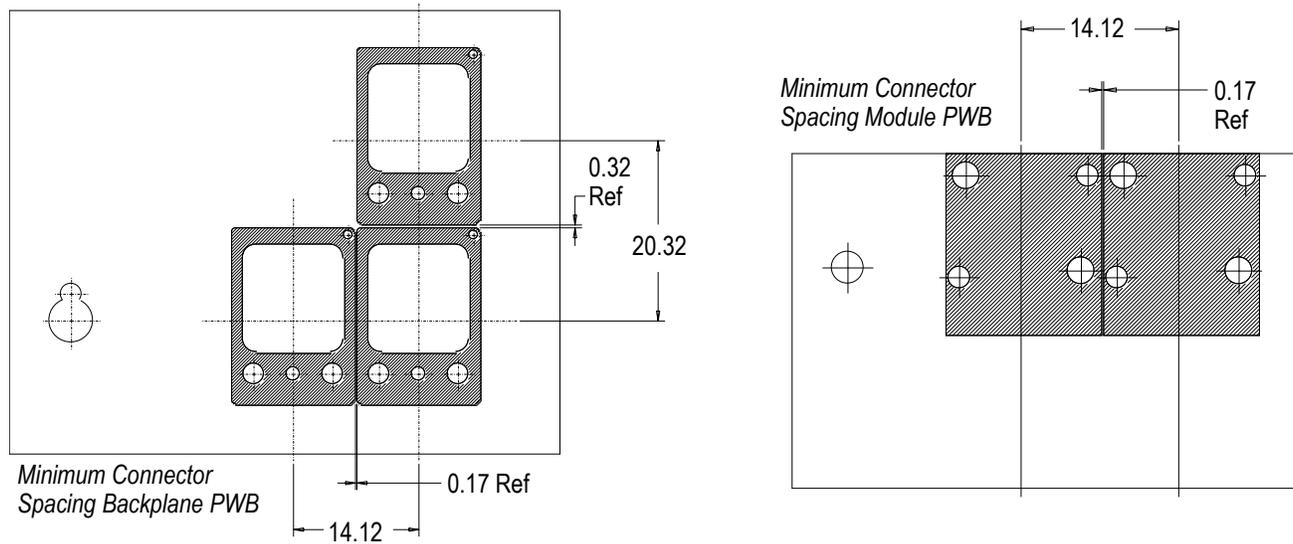
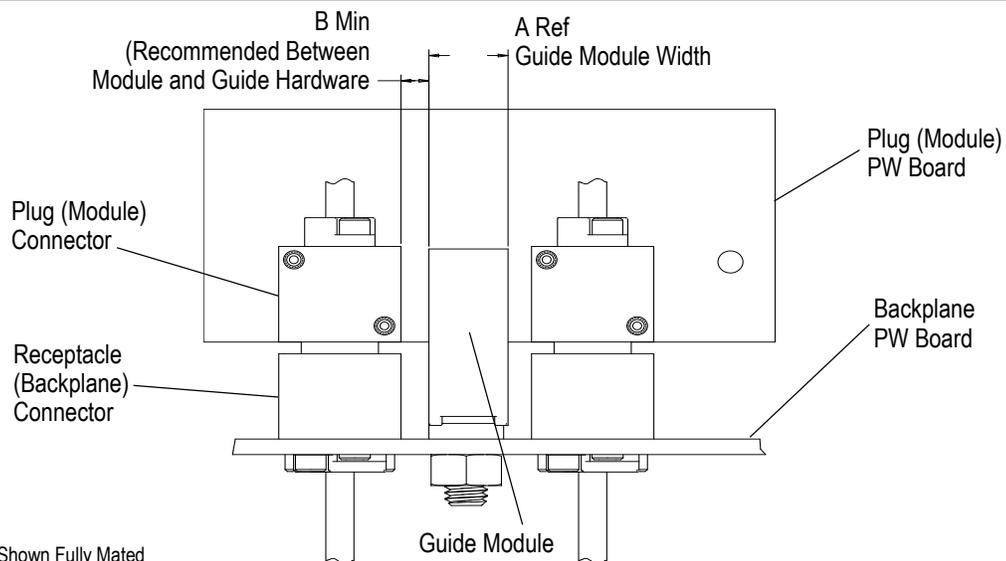


Figure 7

**E. Connectors and Guide Hardware** (Figure 8)

The recommended minimum distance between the module and guide hardware is given in Figure 8.



**NOTE:** Connectors Shown Fully Mated

Figure 8 (cont'd)

GUIDE HARDWARE	DIMENSION	
	A	B
Universal and Keyed	7.9	0.5
Keyed VITA 46 Type	9.0	0.2

Figure 8 (end)

### 3.8. Installing Connectors on the PC Boards

#### A. Soldering Exposure

TE recommends that the VITA 66.4 connectors be installed on the printed wiring boards after the soldering, cleaning and drying operations have been completed for the other components. If the printed wiring board or other components require rework involving soldering exposure, it is recommended to remove the VITA 66.4 connectors and any installed cable assemblies prior to the rework.

#### B. Plug (Module) Connector (Figure 9)



**NOTE**

When placing the plug connector on the module PWB, make sure the locating posts are aligned into the corresponding holes before securing the connector on the board.

Once the connector is seated on the module PWB, from the opposite side of the board, thread the size 2 machine screws with pre-applied Nylok patch through the respective PWB holes into the connector housing. The screws shall be installed with 0.23 - 0.34 N•m [2 - 3 in-lb] torque.

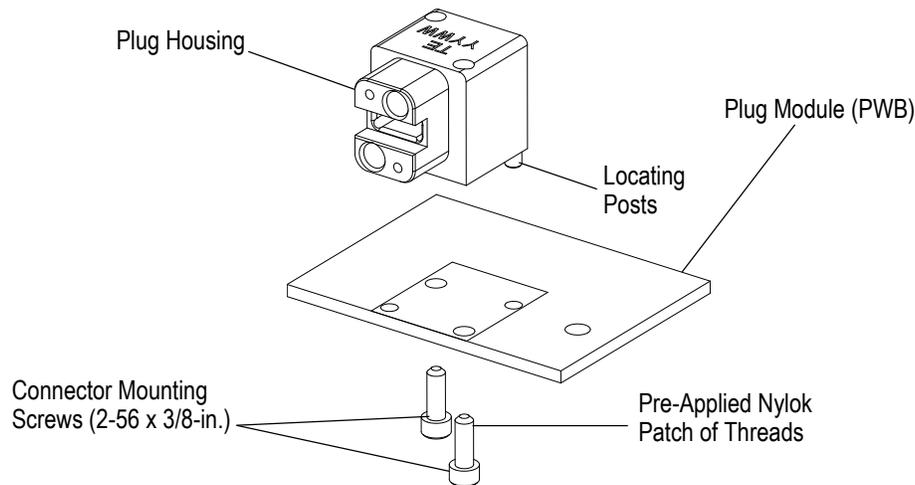


Figure 9

#### C. Receptacle (Backplane) Connector (Figure 10)



**NOTE**

Orient the insert sub-assembly and shell to the backplane PWB as shown in Figure 10. When placing them on the PWB, make sure the receptacle shell locating posts are started into the corresponding holes before securing the receptacle shell to the board.

Once the shell is seated on the backplane PWB, from the opposite side of the board, thread the size 2 machine screws with pre-applied Nylok patch through the respective PWB holes into the shell. The screws shall be installed with 0.23 - 0.34 N•m [2 - 3 in-lb] torque. Check that the insert sub-assembly floats freely between the receptacle shell and the PWB, and does not bind within the PWB cutout opening.

Nylok is a trademark.

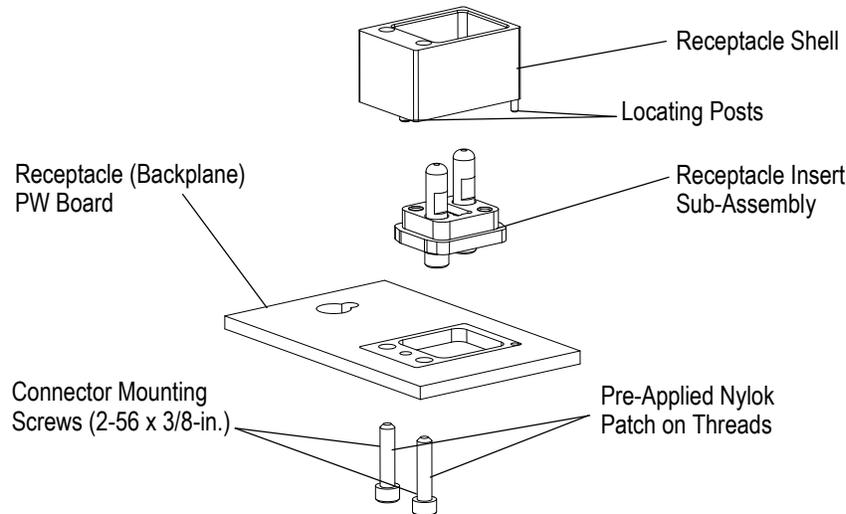


Figure 10

### 3.9. Ribbon Fiber Requirements (Figure 11)

The following commercially-available, multi-mode fiber-optic ribbon cable types are compatible with the MT ferrules and VITA 66.4 connectors.

- 12-Ribbon fiber (50/125/250  $\mu\text{m}$ , OM4) per TIA-492AAAD-XBBX
- Jacketed 12-ribbon fiber cable (50/125/250  $\mu\text{m}$ ) per TIA-492AAAB-XBAX7

Other fiber/cable types may likewise be compatible, contact your local TE Representative or contact PRODUCT INFORMATION at the number at the bottom of page 1.



**CAUTION**

When using jacketed fiber having a thickness greater than 1 mm [0.039 in.], the outer jacket layer must be removed at least 30 mm [1.181 in.] from the end of the MT-terminated end as shown in Figure 11. This is necessary to allow sufficient clearance to fit through the retainer plate slot feature and to accommodate a right-angle bend without over-stressing the ribbon fiber.



**CAUTION**

When selecting a ribbon fiber/cable, confirm the temperature rating and bend radius capabilities are compatible with the application requirements.

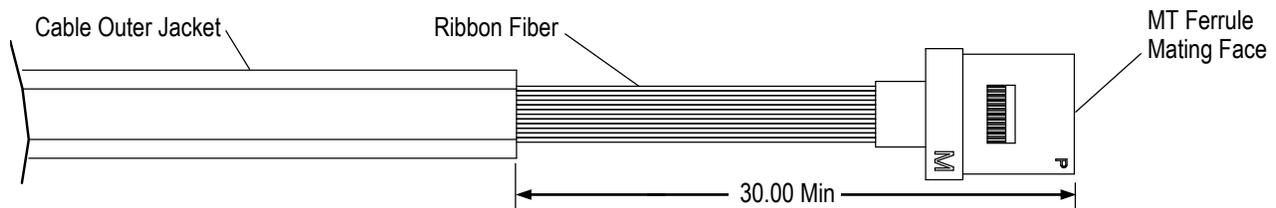


Figure 11

### 3.10. MT Ferrules

A combination of material, geometry and tolerance parameters of the MT ferrule end face control the attenuation of the MT ferrule mating interface. The TE VITA 66.4 Fiber Optic Connectors have been qualified per Product Specification 108-2467-1 using Standard-grade, multi-mode, 12-position MT ferrules.

#### A. Ferrule Requirements

MT ferrules shall be of polyphenylene sulfide (PPS) material having a Young's modulus of less than 20 GPa [2.90E6 psi]. The MT ferrules shall comply with the mechanical characteristics defined in IEC 61754-5 for 6.4 mm [0.252 in] x 2.5 mm [0.098 in] ferrules.

Multi-mode MT ferrules accepting two thru twelve fibers are allowed. Commercially available ferrules and accessories are identified in Section 3.14. For other ferrule types, contact your local TE Representative or call PRODUCT INFORMATION at the number at the bottom of page 1.

**B. MT Ferrule End Face Characteristics**

The end face geometry shall comply with the characteristics defined by IEC 61755-3-31, except that parameter GY shall be -0.2° minimum to 0.2° maximum.

**3.11. Installation and Removal of MT Ferrule Cable Assemblies**

**A. Plug (Module) Connectors** (Figure 12)

The plug connector housing contains one cavity accepting an MT ferrule. Manually place the MT ferrule / cable assembly (with pins/holder and spring) into the respective cavity until the shoulder feature of the MT ferrule bottoms within the connector cavity. Slip the ribbon cable into the respective slot of the plug retainer plate sub-assembly, fitting the spring in the pocket feature of the retainer plate. Then, position the retainer plate behind the insert housing and engage the two captive screws, compressing the spring, until the retainer plate sub-assembly bottoms against the insert housing. Torque the screws to 0.23 – 0.34 N•m [2-3 in-lb.]. Do NOT over-torque the screws.

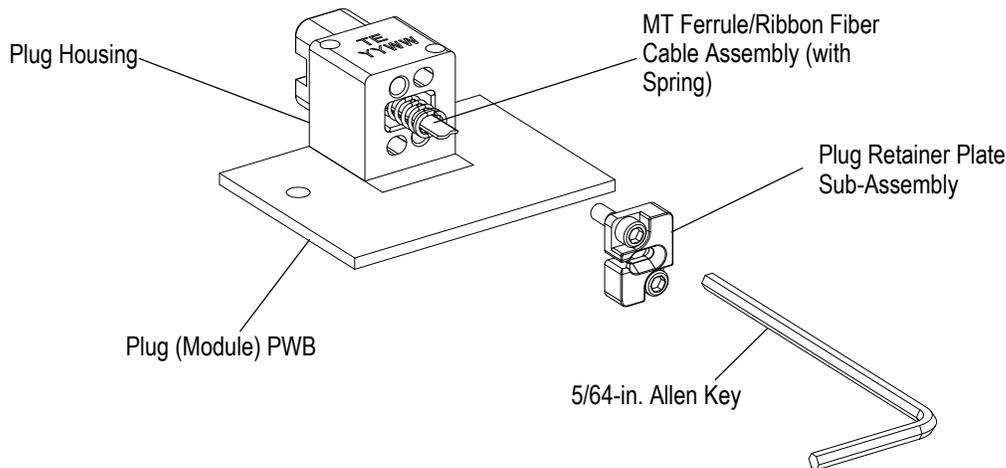


Figure 12

**B. Receptacle (Backplane) Connectors** (Figure 13)

The receptacle connector insert housing likewise contains a single ferrule cavity. Manually place the MT ferrule / cable assembly into the respective cavity until the shoulder feature of the MT ferrule bottoms within the connector cavity. Slip the ribbon cable into the respective slot of the receptacle retainer plate subassembly, positioning the support surfaces of the retainer plate directly behind the MT ferrule, with the mini-boot seal extending into the slot feature of the retainer plate. Then, position the retainer plate behind the insert housing and engage the two captive screws into the housing until the retainer plate subassembly is bottomed against the insert housing. Torque the screws to 0.23 - 0.34 N•m [2-3 in-lb.]. Do NOT over torque the screws.

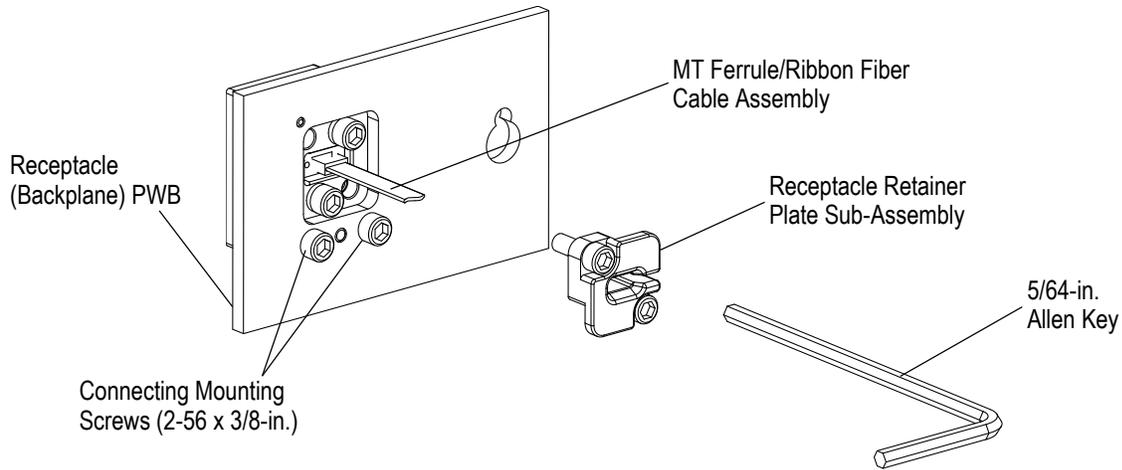


Figure 13

### 3.12. Cleaning the MT Ferrules

The MT ferrules may be cleaned following the recommended instructions per Instruction Sheet 408-8922, Cleaning and Inspection for Physical Contact Fiber Optic Connectors.

Additionally, the following commercial tooling is available from US Conec to facilitate cleaning of the connectors installed in typical ANSI/VITA 46.0 system applications.

- MPX Cleaner Assembly, 7.5-in Length, IBC Brand Cleaner: C12050
- MPO Cleaner Assembly, HBMT Extended Nozzle Tip (14-in Length), IBC Tool: C9959

### 3.13. Connector Mating and Unmating

#### A. Mating Dimension/Range of Engagement (Figure 14)

To ensure proper optical coupling between the mating MT ferrules, the following distances must be within the limits specified in Figure 14:

- On the module board, the distance from the centers of the post holes and that of the tooling hole.
- The distance from the center of the tooling hole on the module board and the front face of the backplane.



**NOTE**

The MT ferrule interface is spring-loaded, by design, in the axial direction of connector mating and unmating. As a result, the connectors do not secure themselves in a fully-mated state. The exterior system design shall engage the connectors to the proper mating depth.

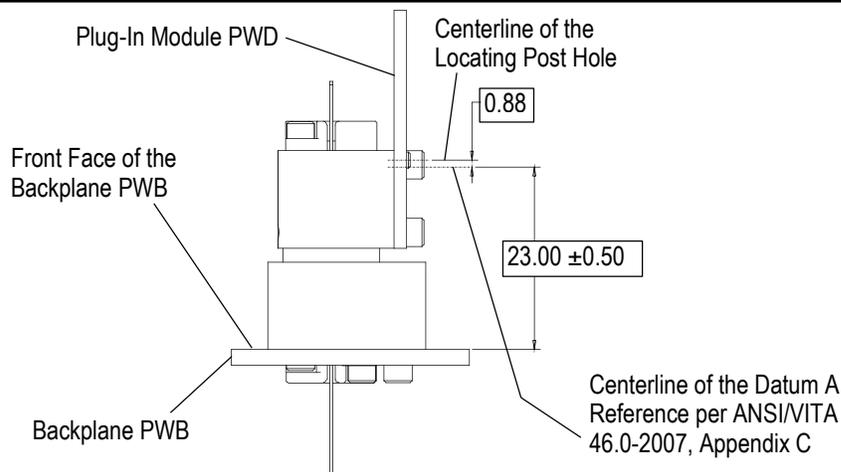


Figure 14

### B. Mating Force

A retained mating force between the module and backplane MT ferrules is necessary for reliable optical performance during operational conditions. A spring within the plug (module) connector generates this mating force. The mating force varies as the module and backplane connectors mate through a module insertion range.

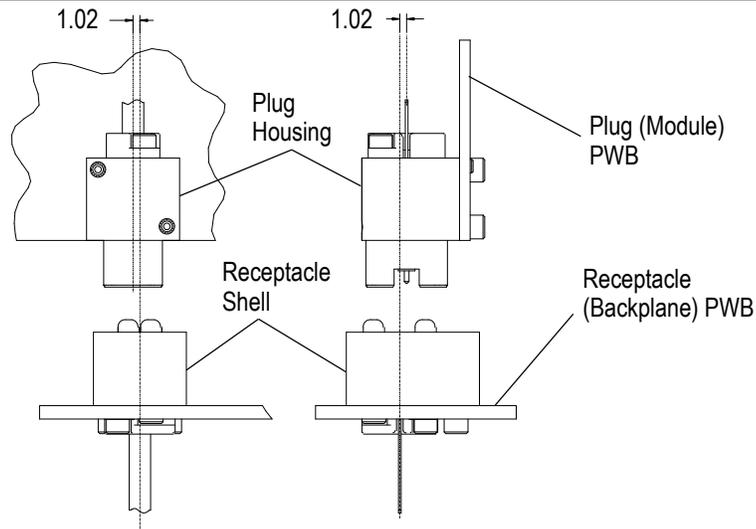
The optical interconnect requires a minimum mated force of 7.8 N [1.75 lb.] for each MT ferrule. The maximum mated force required at maximum connector engagement is 11.8 N [2.65 lb.] per MT ferrule.

### C. Connector Alignment (Figure 15)

Proper alignment is essential to ensure full engagement of the mating connectors and to ensure the MT ferrules are not damaged during mating. Due to the manufacturing tolerances typical of VITA 46 plug-in modules and backplanes, the VITA 66.4 connector system incorporates float to enable aligning the mating interfaces of the MT ferrules.

The lateral clearance existing between the shell and insert housing of the backplane connector provides a minimum of  $\pm 0.25$  mm [.010 in.] float in both the x- and y- directions. The backplane connector guide pins and plug cavities accommodate a maximum misalignment of 1.02 mm [.040 in] in. The exterior system design shall ensure the connectors are located relative to each other within that range. Also, the system shall axially align the connectors within a  $2^\circ$  angle.

Lateral Misalignment



Axial Misalignment

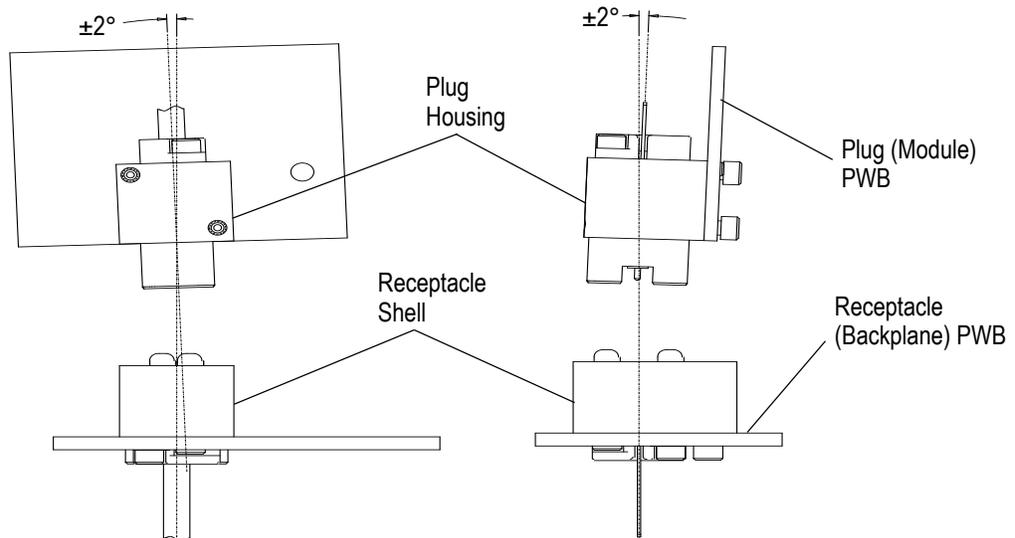


Figure 15

The guide hardware described in Paragraph 3.13.C provides lateral alignment to within 1.02 mm [.040 in.] to enable the connector guide pins. These guide hardware are typical of VITA 46 applications. Varieties are available that accommodate up to 3.5 mm [.137 in.] of lateral misalignment. Contact your local TE Representative or call PRODUCT INFORMATION at the number at the bottom of page 1.

**D. Ferrule and Circuit Identification** (Figures 16 and 17)

Each MT ferrule (MT#) and fiber path (F#) shall be identified by the notation and convention shown below. The fiber path number applies as viewed from the receptacle (backplane) and plug (module) connector mating faces.

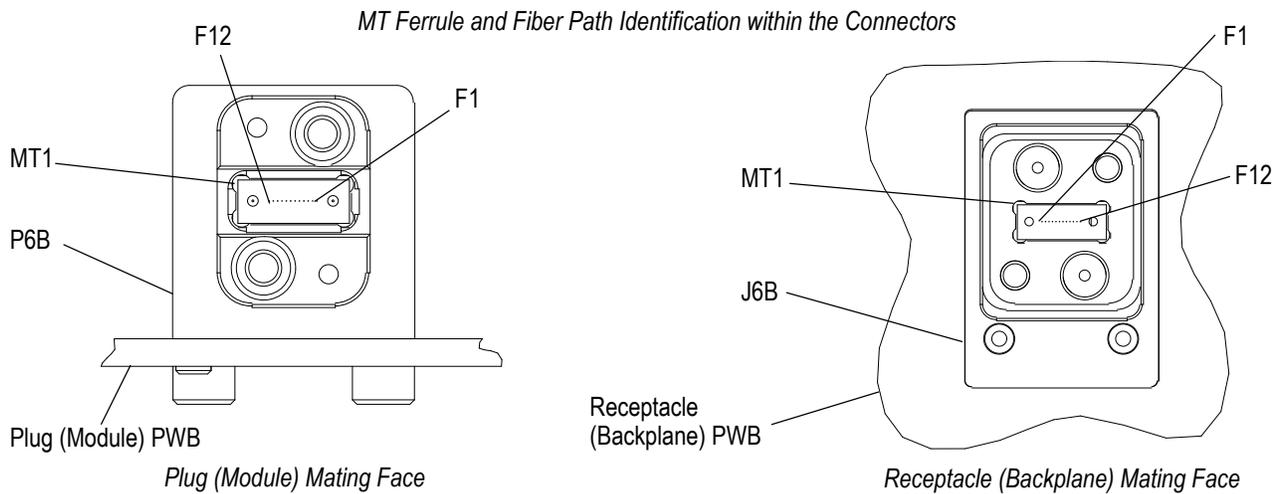


Figure 16

**i** **NOTE**  
The connector locations “P6B” and “J6B” identified in Figure 16 are shown as examples and are variable for the module and backplane position within the card slot in accordance with VITA 66.0.

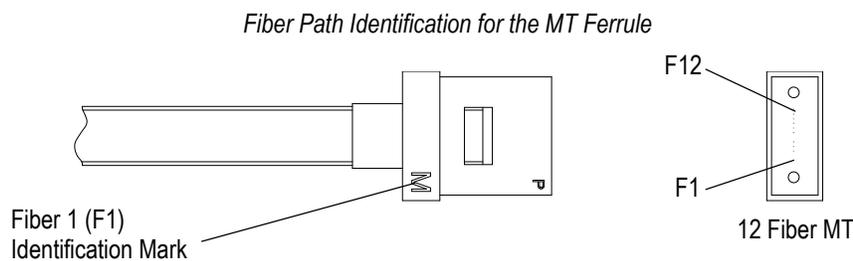


Figure 17

**i** **NOTE**  
The F1 designator “M” shown in Figure 17 applies for the multi-mode version MT ferrule.

**E. MT Ferrule Support**

The VITA 66.4 Fiber Optic Connectors support a single 12-fiber, Multi-Mode MT ferrule.

### 3.14. Ancillary Items

#### A. Fiber Optic Cable Assemblies

Fiber-optic cable assemblies are likewise available for purchase, or custom assemblies may be requested, through your local TE Representative or by calling PRODUCT INFORMATION at the number at the bottom of page 1.

#### B. MT Ferrule Kits

To terminate custom fiber optic cable assemblies, MT ferrule kits are available for purchase through your local TE Representative or by calling PRODUCT INFORMATION at the number at the bottom of page 1. For the receptacle (backplane) connector, the ferrule kit includes an MT ferrule (multi-mode, 12-position, standard grade), a ferrule cover and a mini-boot seal. For the plug (module) connector, the ferrule kit includes an MT ferrule (multi-mode, 12-position, standard grade), a pin holder (for multi-mode ferrules), a spring, a ferrule cover and a mini-boot seal.

#### C. MT Ferrules and Accessories

The following MT ferrule and accessory items are commercially-available from US Conec:

- Spring, for a 12-position MT ferrule: MTP-A12-03
- Pin holder, for use with multi-mode MT ferrules: 6042
- MT ferrule (multi-mode, standard-grade, 12-position) and mini-boot seal: MTF-12MM7-02

#### D. FO Ribbon Cable

Commercially-available fiber-optic ribbon cable types are compatible with the MT ferrules and VITA 66.4 connectors as listed in Paragraph 3.9.

#### E. Strain Relief/Fiber Management

The VITA 66.4 Fiber-Optic Connectors do not provide strain relief for the ribbon fiber optic cable assemblies. It is the responsibility of the user to provide proper strain relief and management of the optical fibers/cable. Consult your local TE Representative or contact PRODUCT INFORMATION at the number at the bottom of page 1 for fiber-management products specially designed to the application.

### 3.15. Repair/Replacement

#### A. Replacement of MT Ferrules

Damage may occasionally occur to the MT ferrule end faces. A damaged MT ferrule (and the attached cable assembly) may be removed from the plug or receptacle connector accordingly by disengaging the respective connector retainer plate. Turn the Allen key counter-clock-wise to disengage both captive screws securing the retainer plate to the connector. Slide the retainer plate backward along the fiber-optic cable, then remove the cable through the slot feature in the retainer plate. A replacement MT ferrule/cable assembly may then be re-installed per the installation procedure.

#### B. Damaged Components



##### **CAUTION**

*Damaged components must not be used. If a damaged component is evident, it must be removed and replaced with a new one. If this requires removing the connector from the PWB, disengage the connector mounting screws.*

## 4. QUALIFICATION

No commercial or agency qualifications for the VITA 66.4 Fiber-Optic Connectors have been defined at the time of publication of this document.

## 5. TOOLING

The connector mounting screws and the captive screws securing the retainer plate to the connector are installed and removed using a commercially-available 5/64-in Allen key.

## 6. VISUAL AID

The illustration below shows a typical application of this product. This illustration should be used by production personnel to ensure a correctly applied product. Applications which do not appear correct should be inspected using the information in the preceding pages of this specification and in the instructional material shipped with the product or tooling.

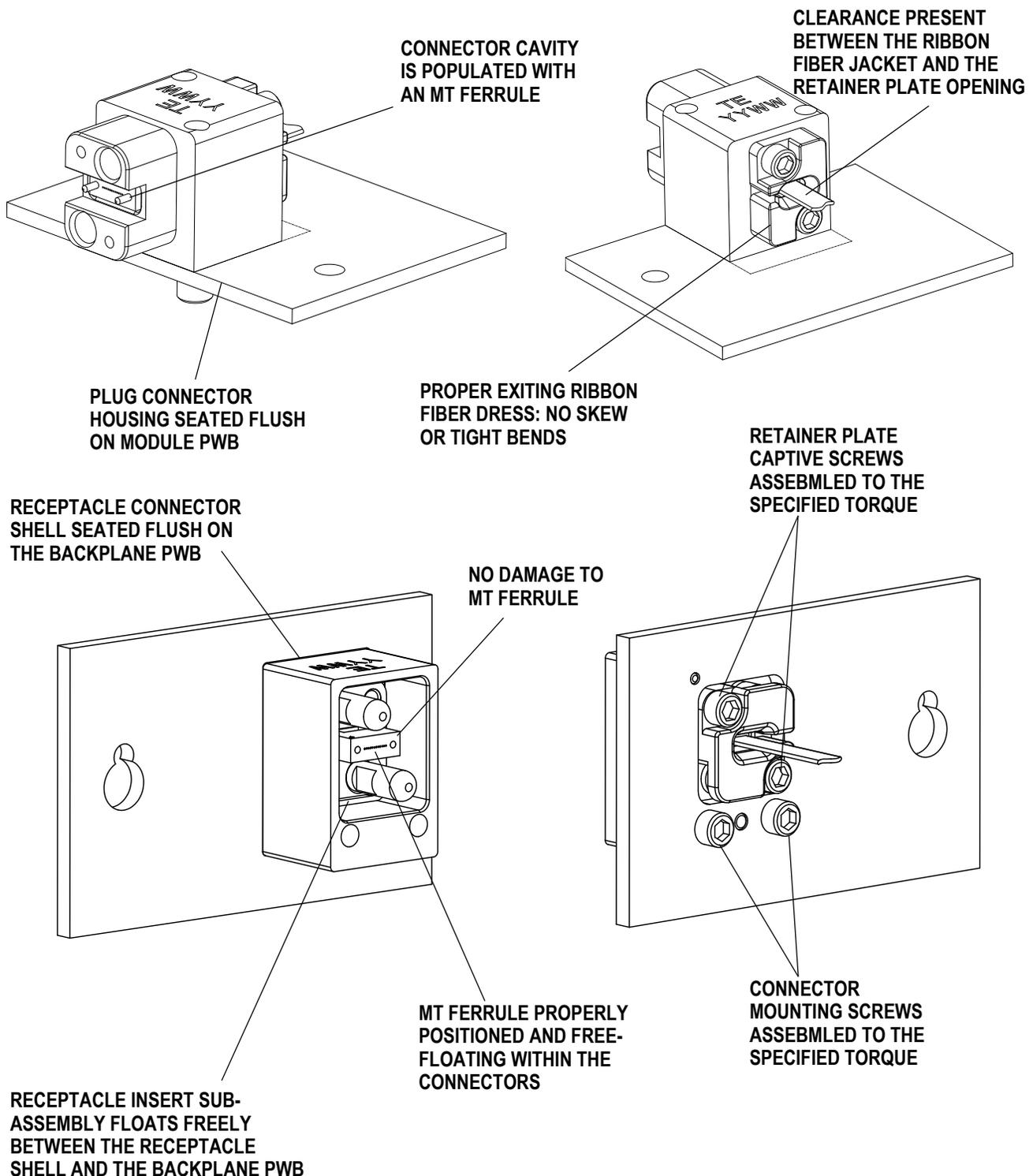


FIGURE 18. VISUAL AID