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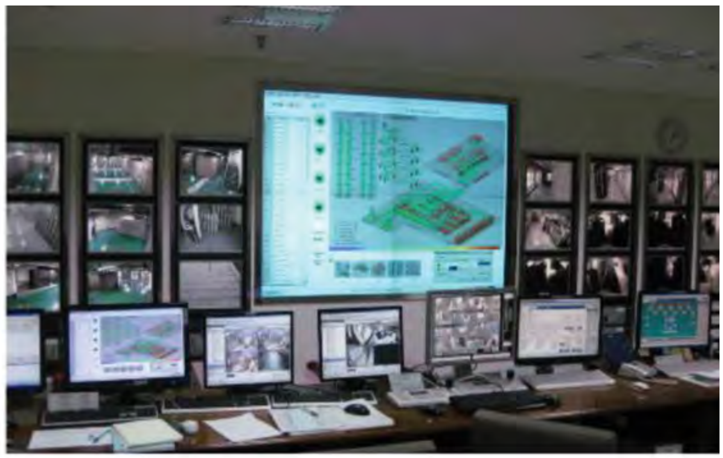
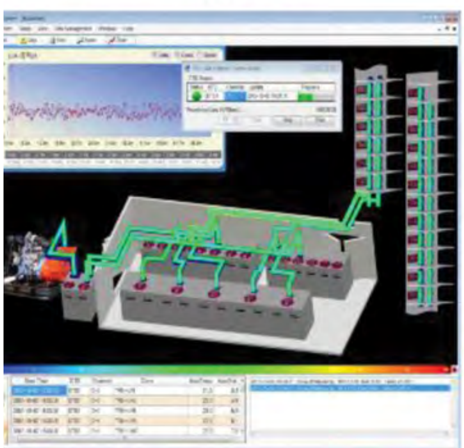
Linear Heat Detection – Fiber Optic Sensing Cable Installation Guide


Continuous Bus Duct Temperature Monitoring (CBTM)

MADE IN THE USA

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Contents

1 Preface

This document has been prepared for local partners to implement the FiberStrike Continuous Bus Duct Temperature Monitoring (CBTM) solution according to an approved design. The document takes into consideration the commonly used busbar and develops a planning framework for the local partner to make decisions while adhering to recommended guidelines.

A non-exhaustive list provides the reader with an overview of busbars used for different applications and should not be regarded as final, since product technology may evolve and more data can become available.
The requirement for development and local manufacturing of cable clips are introduced. In the future, FiberStrike may introduce a selection of suitable cable clips into our product line.

Installation planning considerations combine our recommendation for fiber optic (FO) cable routing design with examples for practical fitting of FO cable. Suggested installation accessories, consumable requirements and a general workflow checklist are provided to assist the local partner to develop a detailed installation plan.

Lastly, a concise reference list captures the most common busbar characteristics of the 4000A Compact Sandwich Bus duct available on the market. This document is typically read in conjunction with other published FiberStrike materials as required.

2 Common Abbreviations

Table 1 shows commonly used abbreviations.

Common Abbreviations	
BMS	Building Management System
BOM	Bill of Materials
DCS	Distributed Control System
DTS	Distributed Temperature Sensing
FAT	Factory Acceptance Test
FO	Fiber Optic
HMI	Human Machine Interface
MM	Multimode
OTDR	Optical Time Domain Reflectometry
PO	Purchase Order
SAT	Site Acceptance Test
SCADA	Supervisory Control and Data Acquisition
SM	Singlemode
SR	Spatial Resolution
Vac	Volts Alternating Current
VDC	Volts Direct Current

Table 1 Abbreviations

3 Introduction to Fiber Optic Cable Installation

This document outlines installation planning and essential tasks with emphasis on handling FO sensing cable for the CBTM application.

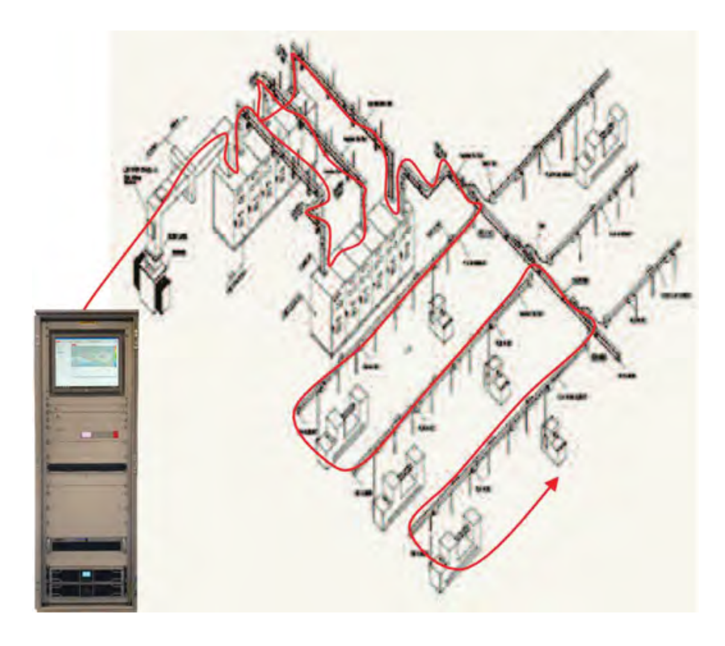
CBTM is a solution for monitoring hotspots on the busbar (or bus duct or busway), it can replace traditional thermography services. The operational challenge is knowing that a busbar does not develop a serious fault during its life, such a fault typically originates from accumulative overheating. Busbar manufacturers may certify their product with IEC 61439 temperature rise testing.

Throughout the life of a busbar, CBTM provides advanced information and identifies the location of a possible busbar hotspot. Distributed Temperature Sensing (DTS) technology uses a length of passive FO sensor cable fitted along the length of the busbar. The DTS unit terminates the sensor cable and performs real-time analysis to generate an alarm when a hotspot is detected.

Line-of-sight is a requirement for the classic thermography technique, modern data centers are densely populated with busbars in switch rooms and possibly concealed within false ceilings or raised access flooring. Hence, line-of-sight is not easily achievable.

CBTM adds value to modern busbar infrastructure at large factories, high rise buildings and data centers – achieving peace of mind every minute, and automatically alerting the Building Facility Management (BFM) of the location of a potential hotspot.

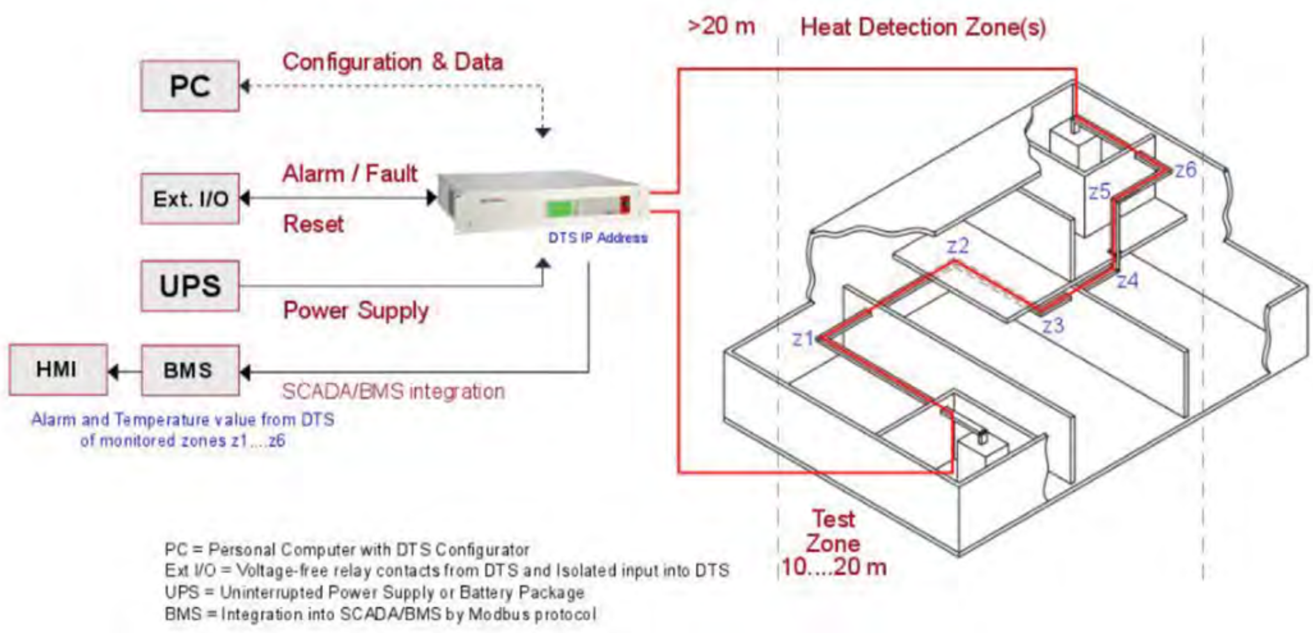
The red colored line shown on the next page denotes the possible path a FO Cable can follow for a busbar installation; this document describes the start-to-end fitting considerations of the FO cable.



The complete system identifies the presence of a hotspot (typically at busbar joints) and this information is translated (as a busbar zone) to the site-specific layout (seen within busbar layout CAD drawing) for the human operator to be alerted (human-machine interface (HMI)) of a hotspot. The complete system comprises of the DTS unit and the FO sensing cable attached to the busbar.

The drawing on the next page represents the system-level schematic connection for CBTM with the FO sensing cable fitted to the busbar, forming the monitored busbar infrastructure. The DTS performs the temperature measurements and translates the zone information that resolves the location of a hotspot. DTS usually communicates directly to BMS/SCADA to enable notification of the operator through the operator's familiar Network Operation Centre (NOC) interface and workflow.

CBTM Setup Overview



FiberStrike Documentation Scope	
Document Type	**Document Name**
FO cable installation planning	This document
FO cable handling	Sensor Cable Handling and Project Setup_2015-05-05
FO cable splicing	Splicing Procedure S2002A Cable
Splice enclosure handling	Splice Box Handling_2015-01-05
DTS enclosure mounting	Linear Heat Series User's Guide (B-Version Ed.06-February-2018)
DTS wiring	DTS Instrument Installation and Wiring_2015-09-22
SmartVision database and application software installation	Full SQL Database - Installation Guide - 06.03.2019

Typical roles at site:

- **Local partner –** Develop and arrange local manufacturing of cable clip, fit FO cable, mount DTS unit and arrange splicing.
- **FiberStrike –** Site work for DTS commissioning, standby BMS integration support, SmartVision setup and documentation

FO cable installation tasks are mostly carried out at indoor locations, but some occasional outdoor work may be required.

3.1 Warning

At times, a technician may be placed in close working proximity amongst electrical busbars in an industrial environment. In some situations, the technician may require touching the earthed housing of busbars. This document has been developed specifically for “Compact Sandwiched Bus Ducts” construction in mind and is simply abbreviated as “busbar”. Such busbars are designed to operate at up to 600 Vac phase and have a current handling capacity of up to 6000 A.

While the individual electrical phase conductors are housed inside an earthed busbar housing, it is important to know the task of fitting the FO cable may be carried out to an energized busbar. If in doubt, follow customer health, safety and environment (HSE) procedures.

In the context of this document, busbars are typically mounted at a height between 3 m and 4 m from the floor level. If required, safe practices for working at heights should be observed.

General personal protective equipment (PPE) requirements may be found in the customer’s HSE procedure.

3.2 CBTM Objective

Busbar monitoring is becoming a preferable technique using a FO sensor and DTS equipment. The FO sensing cable is fitted along the length of the busbar to its external surface. This document describes the installation planning tasks for field installation of a FO cable to the housing of a busbar of “Compact Sandwiched Bus Duct” construction. Given that several brands of busbars are available in the market with manufacturers offering different physical sizes to match the voltage and ampacity handling requirements, this produces several busbar designs and opportunities for a single FO sensing cable to monitor the full busbar installation.

International standards such as IEC 61439 state a maximum indoor ambient temperature of 40 °C, a maximum daily average of 35 °C and a minimum ambient temperature of -5 °C.

The sources of heat within the low voltage AC infrastructure will be:

1. Heat liberated by the copperwork and cabling.
2. Heat liberated by the devices.
3. Heat liberated by eddy currents and magnetic losses.

Temperature rise at any points on the external metal surface of bus duct housing will not exceed 55 °C above ambient temperature. The temperature rise at any points of external insulated conductors will not exceed 70 °C above ambient temperature when operating at rated load current. Fitting of FO cable to almost all busbar brands is achieved using a customized cable clip. Some busbar manufacturers have already engineered their product line to embed FO cable to be used as a temperature sensor, other busbar manufacturers have no provision, but by using third-party cable clips, suitable fitting of FO sensing cable can be achieved. Most of the busbar products today have no provisions for FO sensing cable and it is a simple task of developing a cable clip.

Due to the business nature, such cable clips are neither available from busbar manufacturers nor FiberStrike. However, it is normal practice for FiberStrike to propose a general design of the cable clip and follow through with the local partner to achieve manufacturing of the required quantity by a simple sheet-metal stamping process.

4 Busbar Overview

4.1 Busbar Overview

A quick survey of publications reveals various names for busbars such “busway”, “Bus duct”, “trunking” etc. All these terms represent the technique of electrical power distribution, the emphasis of <0.6 kV and <6000 A indicate “local power distribution”, physically each circuit is short (to <5 km) and hence there could be several circuits locally.

The concept of local power distribution is different from power cable transmission. The term “transmission” of electricity involves significantly higher voltages in order to reduce transmission losses over a much longer distance. Typical transmission could be achieved by one or two circuits of direct-buried underground cable with a typical circuit length from 10 km upwards. Power cable monitoring is addressed as a separate application.

Generally, a power cable is flexible and of longer circuit lengths between electrical substations, and a busbar is a fixed arrangement of several shorter systems of different circuits within a small area (inside a building).

In this context, a power transmission cable requires a point-to-point topology implementation, whereas a busbar could utilize point-to-multipoint or mesh topology. For simplicity, this document adopts the term “busbar” throughout the duration in order to encapsulate the similar items and to encompass different types of electrical power distribution busbars found in the market, this section visually describes each of them.

Busbar Type	Item	Nots
Busbar system		• Usually found within naturally ventilated • <0.6 kV electrical switch gear. • Could be bare metal or insulated.
Busbar		High voltage application (15 kV) usually found separated by phase inside positive air pressure ventilated trenches. Could be bare metal or insulated
Bus duct		Bus duct with provision for temperature sensor along entire length.
Bus duct		Typical bus duct without provision for temperature sensor.

Bus duct	"Ventilated" bus duct with fins without provision for temperature sensor.
Non-segregated phase	Air insulated construction for high voltage application (to 38 kV)
Segregated phase	Air insulated construction for high voltage application (to 38 kV)
Cast resin	Epoxy resin construction for outdoor application (to 1 kV)
Open channel	Indoor distribution bus duct system (<400 A)
Shrouded	Outdoor distribution bus duct system for physically moving load
Solid insulated busbar	Indoor or outdoor locations to for 33 kV (and higher)
GIS isolated phase	Use with switch gear application. Compressed SF6 gas used from 33 kV upwards.

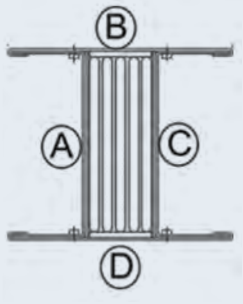
In general, busbars are manufactured to either metric or imperial dimensions, depending on the market they serve. For example, the typical length of a “straight feeder section” is available in either 3 m or 12 ft lengths. Busbar manufacturers can further offer busbar conductors constructed with either copper or aluminum materials that meet the electrical design requirements for local power distribution. Housing of Compact Sandwiched Bus Duct is commonly constructed from extruded aluminum and form an electrical earth.

The challenge of achieving CBTM for Compact Sandwiched Bus Ducts is addressed as a combination of a high performance DTS system, project-specific customized cable clip design, and local engineering support.

4.2 Fitting FO Cable to Compact Sandwich Bus Ducts

This section explains the mounting position of the FO sensing cable with reference to the cross-section profile of a busbar. A customized cable clip offers the ability to rapidly position the FO sensing cable against the busbar housing and achieve the desired consistent fitting of FO sensing cable across its length. The cable clip design proposed by FiberStrike takes into consideration on which specific “side” of the “busbar housing” the clip should be applied.

Experience from previous project suggests it is desirable for FO sensing cable to be fitted closer to the larger face of the internal busbar conductor, because busbar heating could contribute to total harmonic current on the neutral conductor within the busbar. The desired fitting position is illustrated as position “A” or “C” shown in cross-section drawing below. With some past projects, position “B” or “D” has been considered and implemented, both arrangements have also been considered for double-stacked busbar construction. Our recommendation is for the FO sensor cable fitting to remain on the same housing side of the busbar throughout its length, and to derive a neat and tidy installation.



On a case-by-case basis, FiberStrike is able to develop the cable clip together with a local partner. While each cable clip design is similar, it differs in physical dimension to match the brand and model of the busbar used in each project. Other methods to ensure the FO cable is correctly and securely fitted to the busbar are known and some methods have been implemented. If required, please consult us for details.

During the normal busbar operation state, the nominal temperature fluctuation is small (around 1 ºC to 2 ºC) – a requirement to ensure the FO sensing cable can effectively detect this temperature fluctuation. The cable sheathing material of S2000A cable is sensitive to infrared energy. It is also a requirement that the FO sensing cable sheathing is fitted in direct contact to the busbar housing and achieves a neat and consistent appearance.

A cable clip addresses the issue of busbars being subject to constant vibration from the building structure and of the electromagnetic (EM) forces at the 50/60 Hz modal frequency of the electrical voltage. A cable clip ensures a secure FO sensing cable fitting and eliminates FO sensing loosening over time.

A cable clip is a preferred method for quick and effective installation of the FO cable. It also permits future “un-clipping” along the busbar location where cable slack may be required.

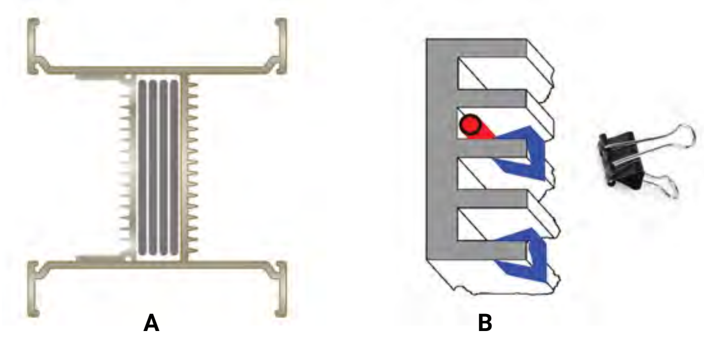
4.3 Commercial Off the Shelf (COTS) Cable Clip

A suitable Commercial Off the Shelf (COTS) clip may be used, provided that it holds the FO cable in the desired position.

The type of busbar that may be applicable is those with fins of appropriate configuration. Such fins offer enhanced ventilation of the busbar, it may be acceptable for FO cable to be fitted and secure within the fins of the busbar.

The diagrams show a busbar housing profile with fins for ventilation.

Provided that the depth and width of the fin can accommodate the FO cable, it shall be possible to use an appropriate spring-loaded clip to achieve a secure pushed-on fitting.



A. Cross section profile of ventilated busbar.
B. Detailed view of FO cable held within fins using office clip.

4.4 Customized Cable Clip Development

Usually fitted by a single technician, the custom-designed cable clip achieves a neat and tidy fitting of the FO cable. As per our recommendations, the following is the design consideration:

To quantify cable clip requirements for a project, a rough rule-of-thumb is adopted: the standard recommendation is one cable-clip per meter of FO Sensing cable plus 10 % more.

The outer diameter of "S2000A" (safety cable) is 4 mm. To facilitate local development of the cable clip, feel free to contact us for samples of the S2000A cable.

Photo of a prototype cable clip.

- The small "V" is required to ensure the FO cable is correctly positioned. The FO sensing cable is required to touch the housing of the busbar.
- The "white part" is just tape, it may be optional – it depends on the width of the clip and the consideration of feedback from installation technicians who assemble the cable clip onto the busbar.

4.5 Cable Clips by Busbar Manufacturers

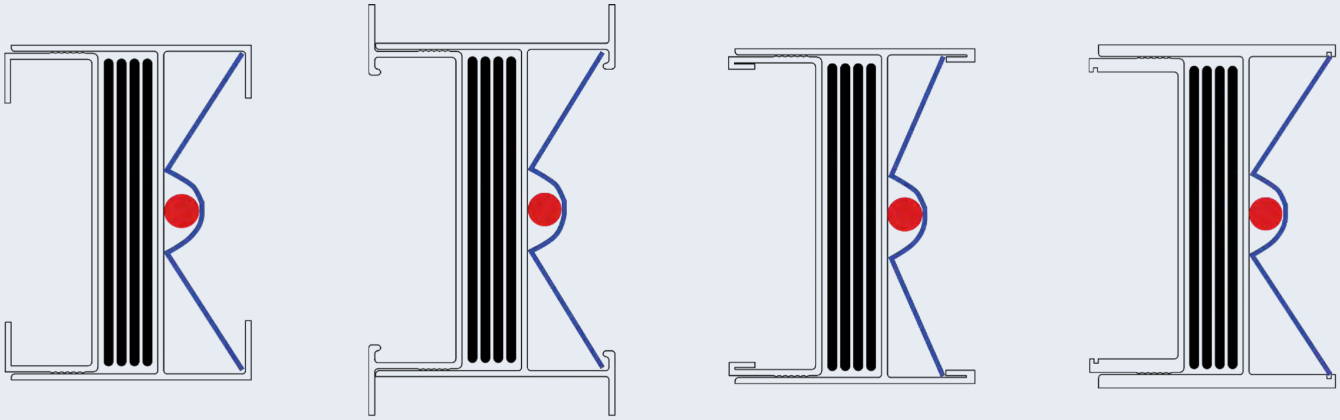
At present, only a few busbar manufacturers enable their commercial busbar product to accommodate FO sensing cable, as well as having the cable clip engineered for their busbar product line.

- A busbar design is seen to have provisions for FO cable with a channel engineered into the design of the housing.
- The metal item is for fitting to holes on the busbar housing
- The plastic item is a snap-on cover
- The FO sensing is lightly pressed against the busbar housing.

Follow the busbar manufacturers' instructions and recommendations for the use of such a clip.

4.6 Cable Clip Design Development

Upon a review of busbar products available from major busbar manufacturers, the following diagrams represent the basic busbar housing profiles, from which the basic customized cable clip design is developed for local production using the facilities of a sheet metal workshop (i.e., punching, rolling and stamping process)



Cross-section of different busbar housing illustrating FO cable assembled with cable clip

The red item line shown above denotes the cross-section of the FO cable, with the blue item denoting the customized cable clip.

4.7 Cable Clip Design Cut-Sheet

For each busbar monitoring project, in order to initiate the development of a customized cable clip, a “cut-sheet” may be introduced. The term W-clip is now introduced to denote the customized cable clip.

W-clip is a simple clip made from a trip of sheet metal. The material and shape of the W-clip enable the FO sensing cable to be securely attached to the busbar housing by the simple bending tension of the material.

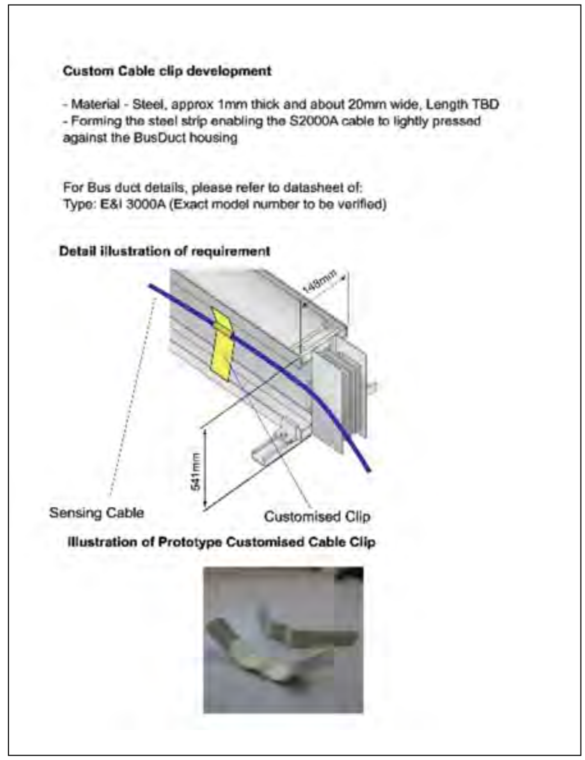
The dimension of the W-clip is a function of the busbar being deployed. Since it forms a triangle, the mathematics to derive the length are straightforward:

Identify the internal busbar width and internal busbar depth from the inside of the side lips. Apply the Pythagorean theorem to get a bent length. For the cut-sheet, an approximate dimension is shown in order to derive a prototype design.

- $(Width/2)^2$ x depth2 = C^2
- Total length is 2C. Exaggerated W bend allows the capture of the outer diameter of the cable in the small center bend area of the W.
- For the curve length at the center bend area, allocate a width of about 20 mm (i.e. 5x cable diameter), allowing the S2000A cable sheathing to become lightly pressed to the busbar housing.

In order to develop the W-clip, specific dimensions of the housing are required. With detailed dimensions of busbar housing being known only to the busbar manufacturer and only general dimension shown within marketing materials, it may be a requirement to derive the necessary dimensions from a CAD drawing, or to take measurements of the key dimensions from the actual busbar. Even with known dimensions available, the prototype requires further possible optimizations with consideration of the actual fitting experience by technicians.

It is possible for the local partner to propose an alternative design of the W-clip, FiberStrike shall be pleased to discuss the details further.



W-clip cut-sheet of project with E&I brand busbar

Cut-sheet objectives:

- Communicate the engineering development to local partner
- Busbar Brand and model number
- Suggested material
- Indicative width
- Indicative length
- Suggested shape and profile
- Illustration of expected fitting to bus bar

W-clip cut-sheet of project with E&I brand busbar

4.8 W-Clip Fitting

Fitting the W-clip is like turning a door key:

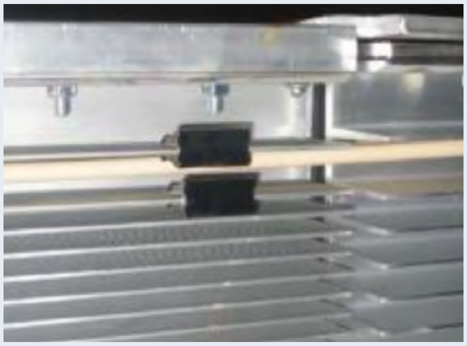
1. The W-clip is inserted into the designated housing-side from a slight angle.
2. Position the FO sensing cable at the small "V".
3. Latch the W-clip to both inner edges of the busbar.
4. Finish by straightening the W-clip assembly.

Result = The spring tension of the clip will secure the FO sensing cable.

Allocate one W-clip per meter length of FO cable, where applicable, apply additional W-clip if the FO cable requires additional support.

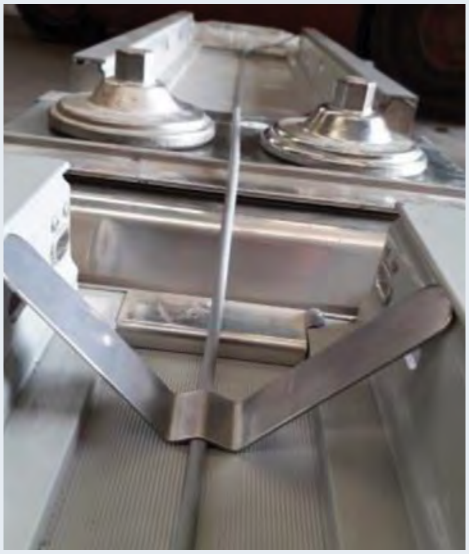
4.9 Examples of FO Cable Fitted to Busbars

FO sensor cable fixed in place using busbar manufacturer-supplied clip.

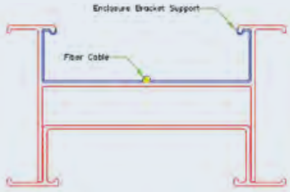


FO sensing cable secured into the fins of ventilated busbar using ordinary spring-loaded clip (i.e. office clip).

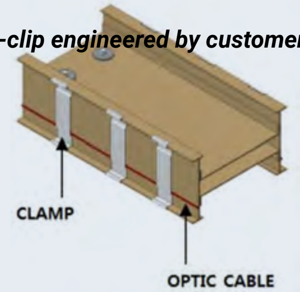
W-clip engineered by customer



W-clip engineered by customer



W-clip engineered by customer



Offset W-clip engineered by customer

Other known methods to achieve the correct fitting of the FO cable to the busbar exist, and some have been implemented. In most cases this became a compromise between the end-user, consultancy firm, busbar manufacturer and FiberStrike – please consult us for suggestions.

5 Installation Planning

5.1 System Installation Planning Tasks

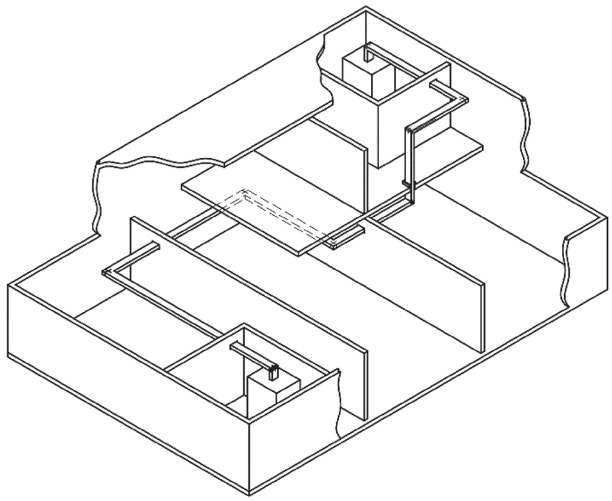
Installation planning of the DTS unit is documented in "Linear Heat Series User's Guide (B-Version Ed. 06-February-2018)"

The site-specific planning tasks associated with the DTS unit are outlined below:

- For wall-mounted housing, identify the suitable wall; the enclosure is hinged on the left.
- For rack-mounting, 2U is reserved for the DTS unit.
- Electricity is supplied to the DTS via an AD/DC adapter. Ensure a main power socket is available near the DTS unit.
- For connection to BMS/SCADA, arrange for an Ethernet data socket to be near the DTS unit.
- Joint boxes are to be arranged near the DTS as required.

5.2 FO Sensing Cable Routing Plan

Commence planning by collecting busbar layout information in advance. This information is usually found within the project-specific Building Information Modeling (BIM) model or the CAD drawings that represent the designated busbar layout and provide a detailed view of the busbar infrastructure. A simplified example is shown below.



Busbar start and end points

- Denoting feeder, elbows, flanges, and other busbar components
- Quantifying and identifying busbar joints
- Length and dimension of each busbar component
- Partition wall (i.e. fire barrier) and vertical riser (spring hanger and expansion joints)

Basic planning for FO cable routing is possible with this limited formation; the objective is to arrange for the longest continuous length of FO cable from start to finish. Further considerations for detailed routing planning include the partition wall, floors of the building and detail of FO cable arrangement at busbar joints, placement of each W-clip, splicing of FO cable, placement of joint-boxes, location where the FO cable run is in transit and also DTS connectivity.

It is adequate for the FO sensor cable to pass through each busbar joint just once. Furthermore, it is recommended to implement a “fold-back” arrangement of the FO sensing cable at busbar joints. This means the FO sensor cable passes through the busbar joint three times, serving the following purposes:

- It further enhances resolving the busbar joint to improve upon the best spatial resolution (SR) available from the DTS unit (N4387B SR is 0.5 m at best).
- It implements a “buffer” of FO cable length along the busbar, providing cable-slacks to facilitate future busbar component swap-out.

FO cable routing design is usually developed by a local partner who has local knowledge of the site as well as busbar working experience. This shall become the project-specific installation design for each site, at its simplest, the original busbar layout drawing is further developed with the following details inserted:

- Fully showing the arrangement of FO cable on the busbar at joints, elbow, tee, flange and observing minimum bending radius requirement (MBR) of the FO sensing cable being >80 mm.
- Arrangement of FO cable in transit, between DTS unit to the busbar, across floors, partition wall and possibly between different busbars.
- Intended placement of joint-box and possible FO cable splicing works
- Desirable placement position for each W-clip

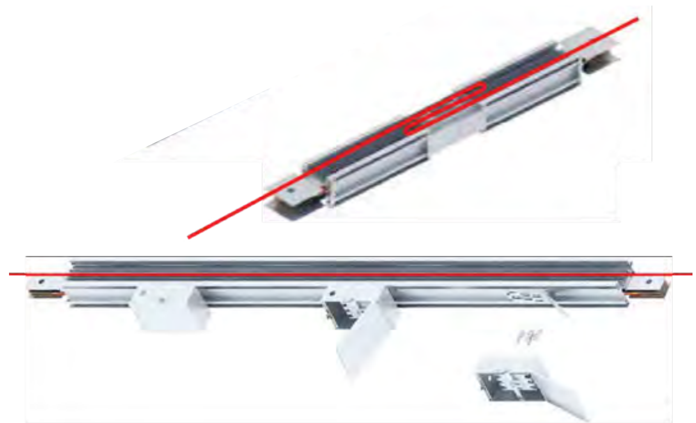
Detailed planning ensures the FO cable sheathing is in direct contact with the busbar housing and optimally crossing each busbar joint to ensure effective temperature measurement. Planning documents generated facilitate future trouble shooting if required.

5.3 General Sensing Cable Routing Requirements

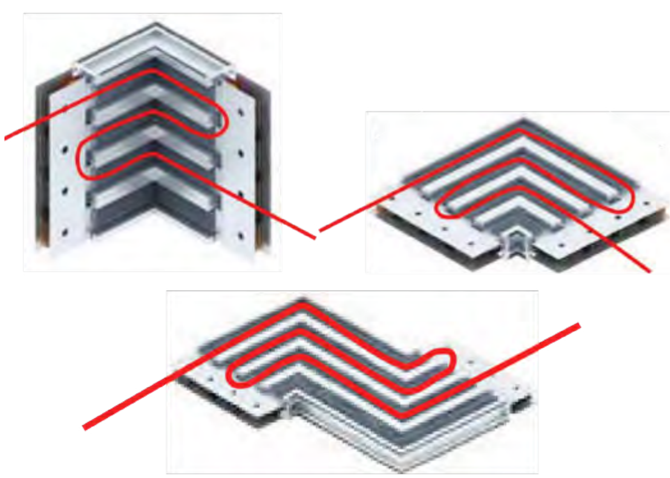
This section is a discretionary recommendation for routing the FO sensing cable onto common busbar components to achieve enhanced resolution to busbar joints and provide a buffer for the future option of easily slackening the FO cable.

The FO cable is arranged into a “loop back” or “fold back” upon crossing the busbar joint.

Feeder

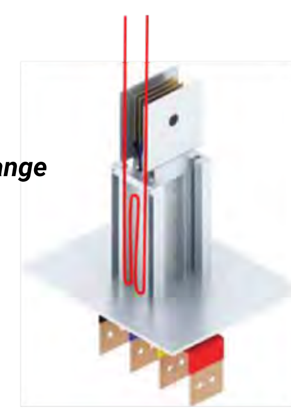


Tap-Off



Elbow

Tee



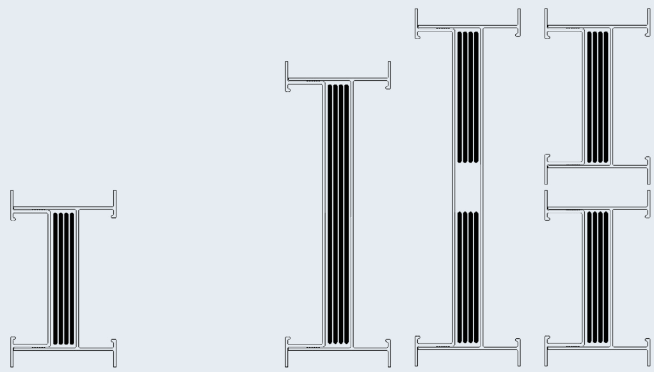
Flange

5.4 Busbar Profile Consideration

From a review of available busbar products from major busbar manufacturers, the following diagrams represent the basic busbar design and constructions, typically known as “single stack” and “double stack”. Some busbar manufacturers offer multiple stack design. The different approach by different busbar manufacturers represents their innovation.

To put this into perspective, for busbar manufacturers to achieve higher ampacity (>2000 A) of busbars, they may offer double-stack busbars for a project. The drawings below illustrate the different approaches used by busbar manufacturers to cater for single stack and double stack designs.

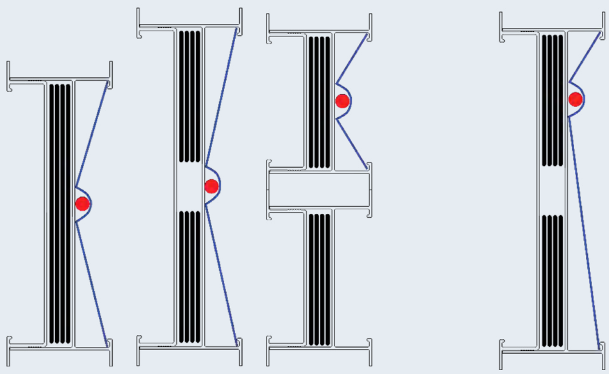
Depending on the profile of double stack (or multiple stack), the W-clip can take this into consideration. The next illustration shows prototype designs of the W-clip for different profiles of double-stack busbar.



Single stack busbar profile

Double stack busbar profile (>2000 A Ampacity)

Acceptance of the final design of the W-clip for use with double stack busbars is usually a joint effort between the local partner and FiberStrike.



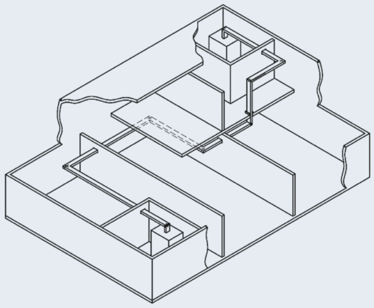
Symmetric W-clip design

Asymmetric W-clip design

5.5 Busbar Joints

Individual electrical carrying busbars are connected using a mechanical coupler known as a “joint pack” (or “joint package” or “splice” etc.). This is a critical item to achieve rapid and secure mechanical mounting as well as resulting in low electrical loss.

Common perceptions suggest the busbar joint may be a weak point of any busbar system. CBTM is a method to effectively and efficiently monitor the temperature throughout busbar installations. An inspection of busbar layout drawings or the bill of materials (BOM) reveals the location and quantity of joints for each project.

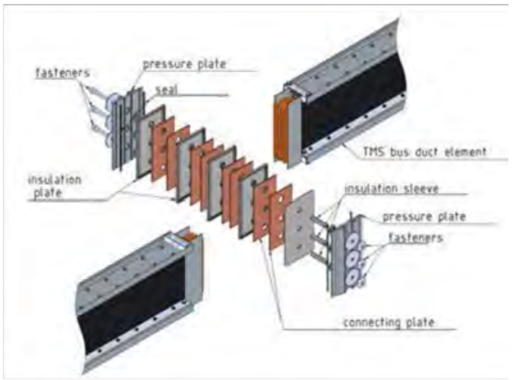


Busbar joints quantity and location

- At straight feeder sections
- For elbow/tee/flange

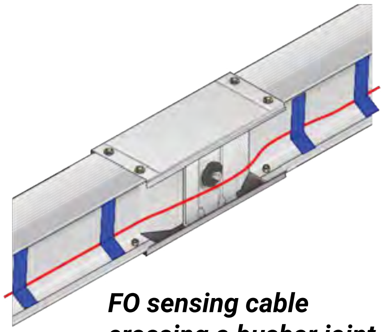
Shown below is a typical arrangement of a busbar joint, this provides the required mechanical compression for busbar conductor mating surfaces.

Joint package by Schneider



Exploded view of typical joint pack

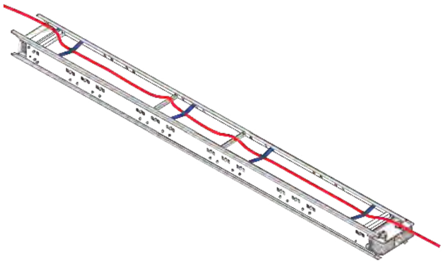
At the joint pack, the FO cable is arranged to simply follow its profile in direct contact; FO cable is secured using W-clips located on the feeder adjacent to the joint. The fold-back arrangement across the joint pack may be implemented as required.



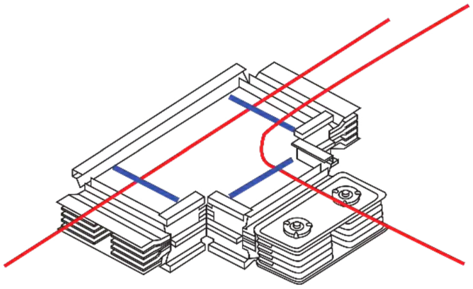
FO sensing cable crossing a busbar joint

5.6 Examples of FO Cable Fitted to Busbar Components

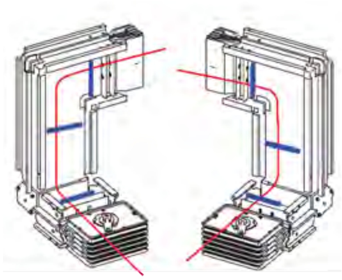
Shown below is a selection of illustrations for FO cable and W-clip on different busbar components of a leading brand:



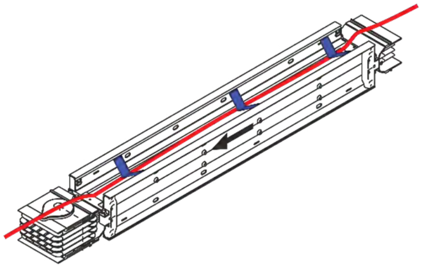
Schneider Square D feeder



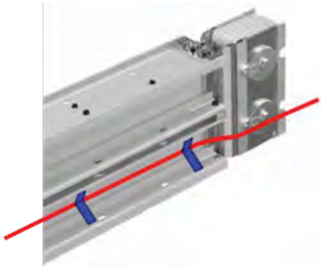
Schneider Square D tee (double stack)



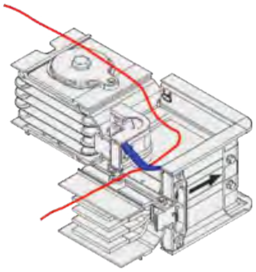
Schneider Square D elbow (double stack)



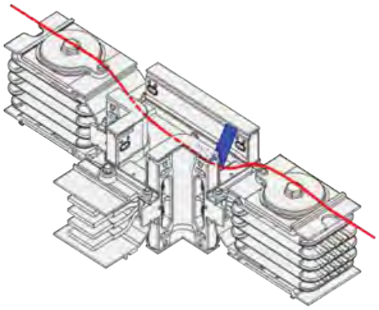
EAE brand feeder



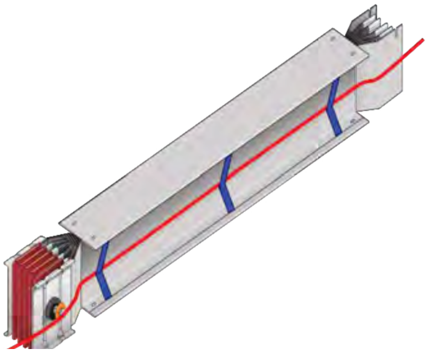
EAE brand feeder (double stack)



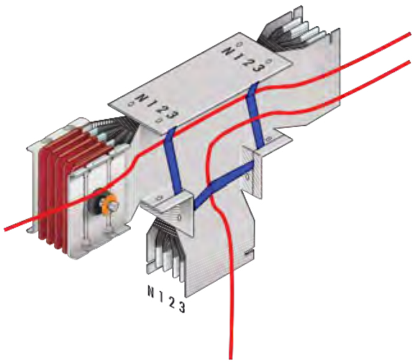
EAE brand elbow



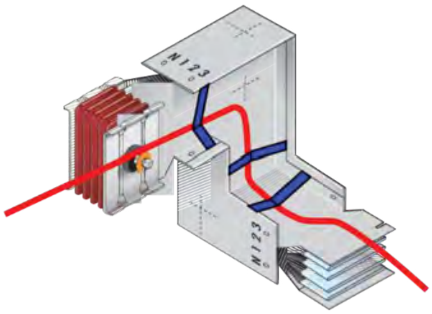
EAE brand tee



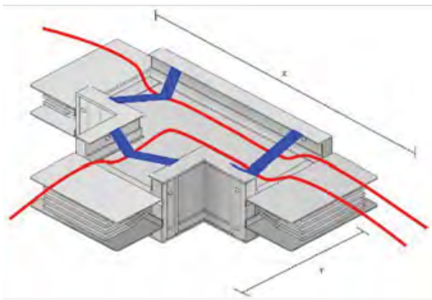
Legrand Zucchini brand feeder



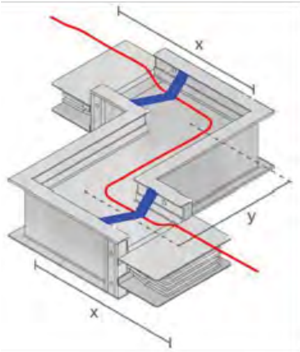
Legrand Zucchini brand tee



Legrand Zucchini brand elbow



E+I brand tees



E+I brand offset

Please consult us for any specific FO cable fitting requirements. Guidelines for fitting FO cable to expansion joints and the arrangement of fire barriers are documented in a separate section of this document.

5.7 Consumable Installation

For each CBTM project, the requirement is to deploy the longest possible continuous length of FO cable using the minimal number of DTS channels. In some cases, the CAD drawing of a busbar layout reveals the transition of the FO cable beyond the busbar infrastructure. At such locations, cable trays may be used to support and protect the FO cable. At other locations, it may be a requirement to arrange for the FO cable to "jump" across adjacent busbars.

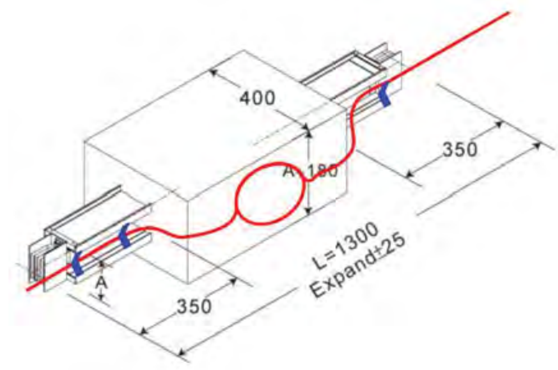
Cable ties and flexible plastic conduit (Typ. Ø 20 mm) may be required for installation. Such items may be known as "consumables" or "accessories" that are easily available locally. These materials shall become part of the installation plan that identifies and sources the required quantity of installation consumables for each project.

Flexible conduit protecting FO sensing cable

5.8 Expansion Joints

Where specified for a project, special conditions may require busbar joints to achieve longitudinal expansion by amounts between 20 mm and 40 mm. These shall be identified from the busbar layout CAD drawing or the BOM. Such items may be specific busbar components implementing the expansion or available as a feature of certain busbar components. These can be recognized by the presence of a “bellow”.

Take the W-clip and attach the FO cable at locations adjacent to the bellow, with a “loop” of FO cable on the bellow being gently supported by cable tie. This “loop” provides room for the FO cable to remain flexible as longitudinal expansion of the busbar is experienced.



Typical busbar expansion joint

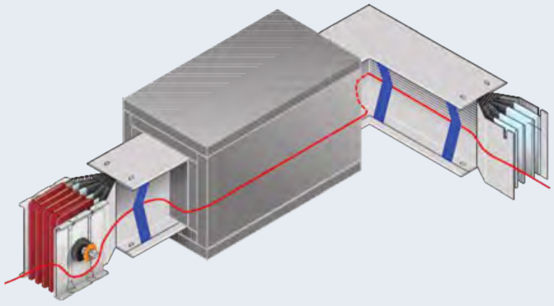
5.9 Busbar Fire Barrier and Partition Wall

For modern buildings, busbar installations are required to prevent the propagation of fire and limit the propagation of heat through building divisions (walls and floors), for a specified time under fire conditions. On some busbars, the linear seal is provided by “fire barriers” or “fire stop”.

Take the W-clip and attach the FO cable at locations adjacent to the barrier as illustrated below.

Within a building, busbars are designed to cross into another location, such physical separations may be the partition wall or flooring. There is a requirement to implement fire stopping and penetration seals.

Since the FO cable is fitted to the busbar, any penetration seals shall be implemented as the final step. The necessary penetration seal is usually implemented as a mastic/ sealant.

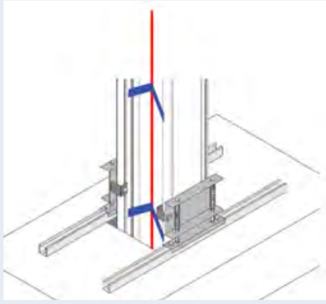


Fitting FO cable over fire barrier (Legrand Zucchini brand)

Busbar with fire barrier crossing partition wall (without penetration seal)

5.10 Vertical Riser

At a vertical riser, the spring hanger is specified for the busbar. Where required, FO cable may be fitted to the busbar using a W-clip. At this location, it is important to ensure the FO cable is fitted without being in contact with static surfaces along the vertical riser.



Vertical Spring Hangar, E&I Brand

5.11 Outdoor Busbars

It may be a requirement for the busbar to be fitted at outdoor locations, these may be found on the roof or spanning between buildings. Whilst these retain a similar construction to Compact Sandwiched Bus Ducts, unlike its indoor variant, there is no busbar housing, with the insulation material being Epoxy Resin and hence also known as Cast Resin busbar (CR).

It may be required that the FO cable is fitted to the CR busbar. Due to the cross-section profile of the CR busbar, the W-clip is no longer applicable, however nylon cable-ties of appropriate length could be used instead.

General guideline for FO cable fitting to CR busbar:

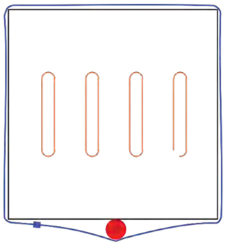
- Ensure Epoxy Resin to all required busbar joints are fully cured.
- To avoid accumulation of surface water, arrange for the FO cable to be fitted along the bottom of the busbar.

This arrangement is acceptable for CBTM, the epoxy material permits the CR busbar to operate at a higher rated voltage and higher permissable temperature. Compared to indoor busbars, the Epoxy Resin material of CR busbars has increased thermal inertia. Also, with the CR located outdoors, the FO cable shall experience temperature fluctuations from the environment.

The illustration to the right shows the acceptable arrangement of FO cable fitted to a CR busbar, secured by a cable-tie and utilizing drip loop where required.

Cast Resin busbar shown with joint pack

Fully prepared joint on Cast Resin busbar



Cross section view: General placement of FO cable on CR busbar, secured using cable-tie

Illustration of FO cable routing onto CR busbar (Schneider brand)

6 Workflow

Shown below is a general workflow of the key tasks for FO cable installation.

General Tasks and Ownership	Ownership	
	Local Partner	FiberStrike
Before Fitting FO Cable		
✔ Identify the correct busbar that shall be fitted with FO cable	Yes	
✔ Ensure the location of DTS placement is known	Yes	
✔ Ensure FO sensing cable is available on-site	Yes	
✔ Ensure the project-specific W-clip are on-site		
✔ HSE procedure is satisfied	Yes	Yes
After Fitting FO Cable		
✔ Verify against busbar layout drawing to ensure FO cable is fitted to the correct busbar	Yes	
✔ Verify where fusion splicing is required	Yes	
✔ Verify FO cable integrity using handheld Optical Time Domain Reflectometer (ODTR)	Yes	
✔ Implement fusion splice as required	Yes	
✔ Prepare calibration, mapping, and commissioning task	Yes	Yes
✔ Complete documentation tasks	Yes	Yes

6.1 Verifying and Achieving FO Cable Integrity

This is achieved using a handheld OTDR to quickly ascertain the FO cable has been fitted without breakage. When the FO cable has been found with breaks and requires repairs, follow the fusion splicing process, and arrange for FO cable repair and re-testing by OTDR.

For some projects that require the FO cable to be fitted to all busbars in segments, each segment shall be joined, forming a continuous optical circuit from start to end. The same fusion splicing technique applies.

The handheld OTDR is enough to identify a bad splice with lossy or reflective characteristics, it is a simple task to reject and repeat the repair of the specific splice.

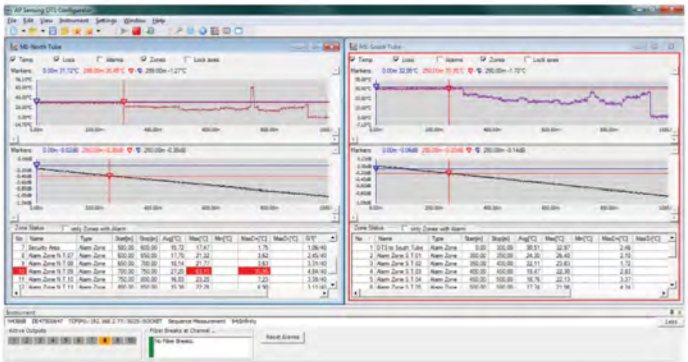
Final verification of FO cable integrity is required prior to DTS commissioning and operating the DTS unit using the DTS configurator tool.

The S2000A FO cable is comprised of multimode fiber, most commercial handheld OTDR test the FO cable by operating at a wavelength of either λ= 850 nm or λ= 1330 nm. The N4387B DTS operates at λ= 1064 nm, hence the different instruments shall show a slight difference of loss characteristics for the same FO cable.

Maintain good housekeeping by creating a document capturing all FO cable splices. SAT documentation guidelines apply.

Fusion splicer equipment

Managing fiber on a splice tray



DTS configurator showing loss profile and temperature profile of the FO sensing cable.

7 Quick Reference

7.1 Handy Information for 4000A Compact Sandwich Bus Duct

This document contains almost entirely information for the “Compact Sandwich Bus Duct”, available with an electricity-carrying conductor using copper or aluminum to handle an ampacity up to 6000 A. The earthed housing is usually made from extruded aluminum that encases all internal busbars.

The key data for this most common busbar product for 4000 A ampacity is listed below:

	European	American
General standard	IEC 61439-1 and IEC 61439-6	UL 857 listed
Temperature rise limit	10.10	UL Sub-Clause 8.2.1
Common feeder length	0.6 m to 3 m	2" to 12"
Feeder overall dimension (H x W)	Approx.: Cu: 400 mm x 150 mm Al: 540 mm x 150 mm	Approx.: Cu: 19" x 6" Al: 24" x 6"
Feeder overall weight	Approx.: Cu: 65 kg/m Al: 40 kg/m	Approx.: Cu: 55 lbs/ft Al: 32 lbs/ft
Dimension of 4000 A elbow	Approx.: 500 mm to 750 mm per leg	Approx.: 20" to 30" per leg
Resistance	Approx.: Cu: 0.01 mΩ/m Al: 0.015 mΩ/m	Approx.: Cu: 0.2 mΩ/100 ft Al: 0.45 mΩ/100 ft
Ambient operating temperature	-5 °C to +40 °C	-22 °F to +131 °F

Consult the busbar manufacturer datasheet for specific parameters and values.