REA Arc Protection System
Sensor Fiber Installation and Testing

Instruction Book 1VAD266601-MB

REA Arc Protection System

The REA Arc Protection System is designed to give fast trip commands to all circuit breakers that may feed an arc fault in low voltage or medium voltage air-insulated, metal-clad switchgear. The system optically senses arc flashes very quickly (2.5 ms). It stands alone, installs easily, and requires minimal maintenance. Combined with a 3-cycle breaker, circuit interruption is typically achieved in less than 60 ms. This reduces arc energy significantly, reducing risk of personal injury and property damage.

The system is made up of 4 relays—the REA101 central unit, the REA103 fiber extender extension unit, the REA105 high-speed tripping extension unit, and the REA107 lens sensor extension unit. The REA101 is required for all installations. The extension units and additional REA101s are added as required for the particular application.

The system uses both Sensor Fiber, a non-jacketed, transparent fiber optic strand that detects light along its entire length, and a Lens Fiber, a jacketed fiber optic strand that only detects light at its remote end.

This document provides guidelines for installing the Sensor Fiber and testing the installed system. For specific product information, refer to the "Arc Protection Relay Buyer's Guide."

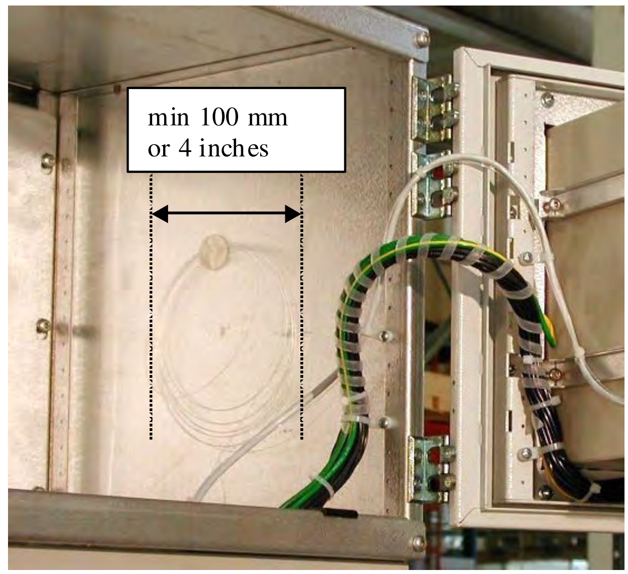
Sensor Fiber Installation Guidelines

Proper installation and routing of the Sensor Fiber is important for the correct operation of the REA arc protection system. Below are installation guidelines. Some are more applicable to new installations, others for retrofit installations.

1. **Non-terminated, "bulk" Sensor Fiber is generally recommended over pre-terminated Sensor Fiber.** The advantages to using bulk fiber are: 1) More precise length which avoids extra, unnecessary loops and decreases signal loss. 2) Smaller transition holes between switchgear cells. A termination kit, shown on page 6, will be required with the use of bulk fiber.
2. **Each Sensor Fiber should be routed with the appropriate protection zone in mind.** When exposed to an arc flash, the Sensor Fiber will cause a trip operation of the connected REA101 or REA105 units. Consider which upstream breaker(s) should be tripped for an arc flash in each compartment and route the fiber through the compartments where a similar tripping action is desired.
3. **Minimize exposure to moving parts to avoid snagging the fiber.** For circuit breaker compartments, the best location is usually near the top and rear of breaker cell and away from the breaker. For bus compartments, the best location is usually along the back wall, centrally located with respect to the busbars.
4. **Avoid high temperature surfaces.** High temperatures (above 80 °C or 176 °F) can decrease the performance of the fiber over time. Do not secure the fiber directly to the bus.
5. **Avoid obstructions that would shield the fiber from the light of an arc flash.** The fiber should not be installed in conduit or in raceways that would limit or prevent exposure to the arc flash. However, a protective tubing (innerduct tubing or corrugated tubing) or conduit impervious to light is necessary if sections of the Sensor Fiber have to be routed via areas where light detection is not wanted.

6. **Secure the fiber using nylon ratchet clamps or similar "loose" cable management products. (Non-conductive wire ties can also be used, but care must be used to avoid over tightening and breaking fiber.)** The purpose of these clamps is simply to keep the fiber away from moving parts and to avoid snagging the fiber when racking breakers in or out of the cell. Self-adhesive attached products are **not** recommended because they may lose their adhesive properties over time.

7. **Use protective rubber grommets when routing the Sensor Fiber through metal walls.** When installing bulk fiber, a very small grommet can be used. For pre-terminated fiber—with a ST connector on each end—a minimum hole size of 10 mm or 3/8 inch diameter is required.



8. **Avoid sharp bends.** The minimum permanent bending radius of the Sensor Fiber is 50 mm or 2 inches (that's a 4-inch diameter). (During installation, a temporary bending radius down to 25 mm or 1 inch is acceptable.) The fiber will be damaged or broken if this minimum bending radius is not maintained. When coiling fiber, make a loose coil of the excess fiber and attach it to the compartment wall (see photo). Do not pull the fiber tight.

9. **Loop layout of the Sensor Fiber is preferred but not absolutely necessary.** A radial layout will work, however in radial configurations the connected unit cannot detect fiber breaks. *Warning: If a radial Sensor Fiber installation is used, the end of the fiber has to be carefully protected from light (for example with a piece of heat shrink tube plug) as the end of the fiber is far more receptive to light than the normal external cylindrical surface, and could cause a spurious trip if exposed to light. Having the end of the fiber covered with such a blind plug also protects your eyes from the sharp end during installation.*

10. **Protection of line-ups with air-magnetic breakers requires special routing consideration.** If the Sensor Fiber is being installed on a line-up with air-magnetic breakers (where normal opening operation has visible arcs), special care must be used in routing the fiber. Please contact your ABB technical representative for help with your specific installation.

11. **If possible, in factory installations:**

    a. **Install the Sensor Fiber last (after all other switchgear work is done).** This avoids unnecessary exposure to damage during the installation of other wiring.

    b. **Tie fluorescent non-adhesive tape bows along fiber at regular intervals in cable compartments.** This will help the commissioning crews see the fiber during field construction.

    c. **Avoid installing where commissioning crews may damage.** Since the fiber can be hard to see, even with fluorescent tape, avoid installing fiber where it would be easily damaged during commissioning. For example, this would include on top of a busbar brace (great place for trouble light).

12. And finally a few "experience has taught" suggestions:

a. Use the right tools.

b. Use the right connectors.

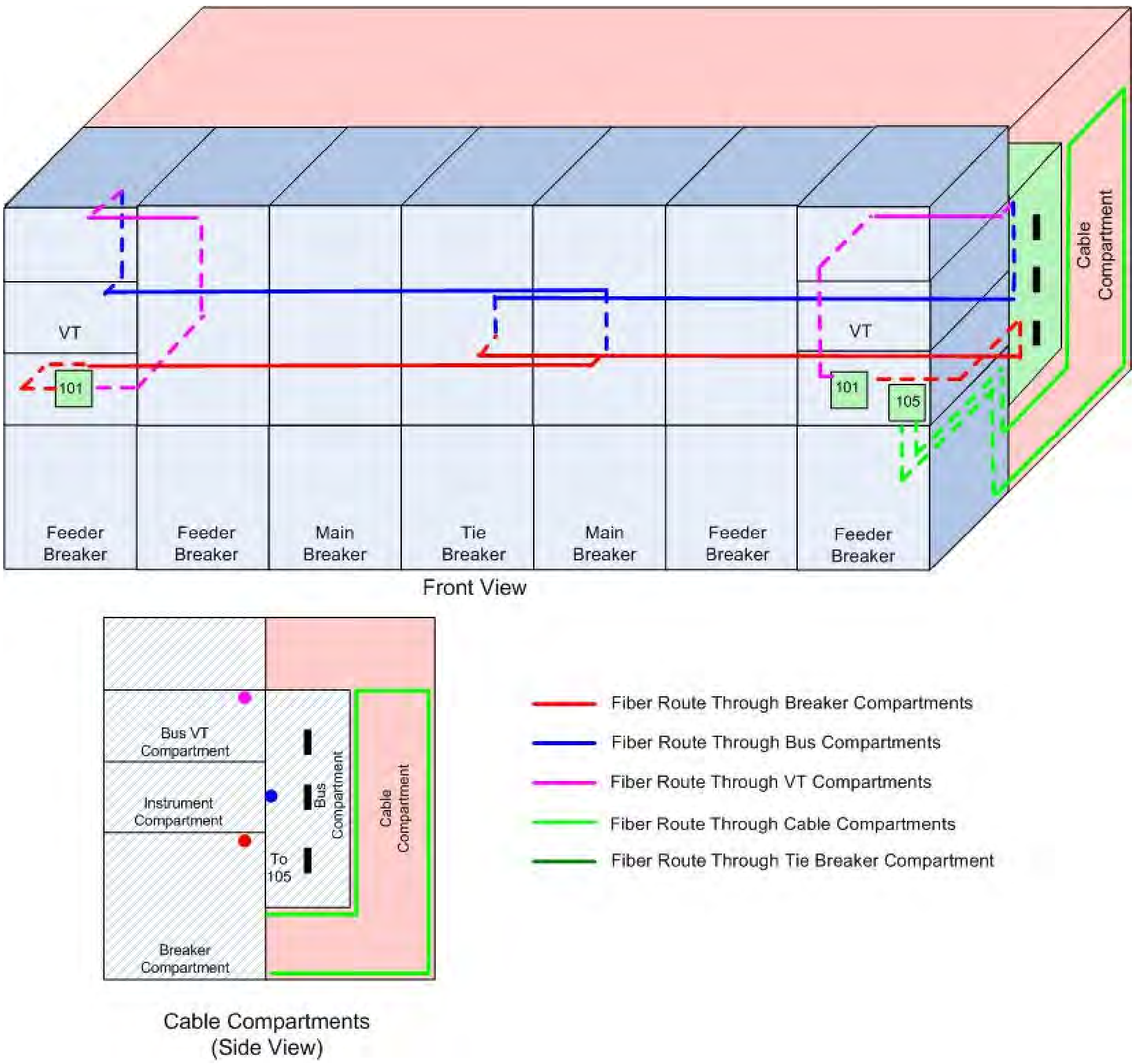
c. Treat Sensor Fiber like fiber optic cable, not wire.

d. Don't be a neatnik (e.g., squared corners), but also don't be sloppy.

e. Don't leave loops without properly securing.

f. Don't casually try to pull out loops.

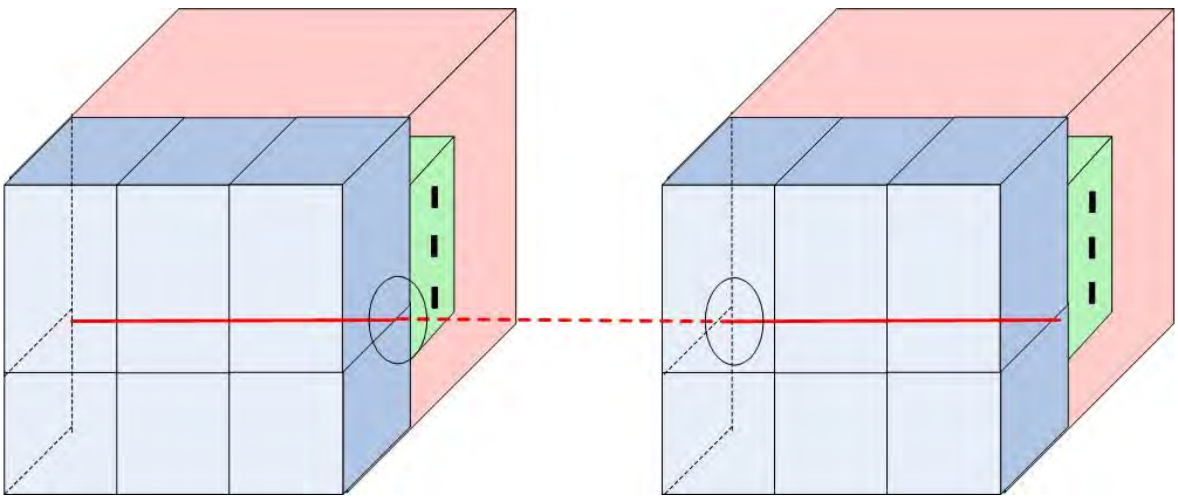
Sensor Fiber Routing Example for One-High MV Switchgear



This lineup consists of a single-high, main-tie-main layout with two feeder breakers on each side of the tie breaker. Three Sensor Fiber loops are shown. They are routed as follows:

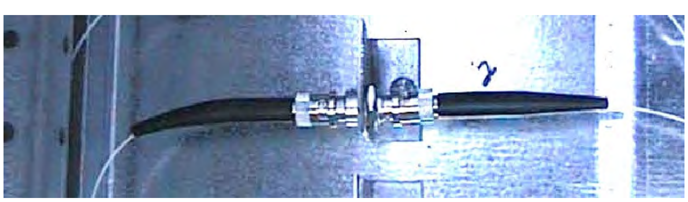
1. One Sensor Fiber is routed from the left REA101 through the lower main and feeder breakers (red) and the tie breaker (dark green). From this point, it returns back through the bus compartments (blue), then through the bus VT (magenta) where it completes the loop back to the REA101. The fiber runs are along the top and back of the breaker and VT cells and approximately centrally located along the inside wall of the bus compartments. This REA101 will trip the main breaker on the left and the tie breaker.
2. A second Sensor Fiber is similarly routed from the REA101 on the right side. This REA101 will trip the main breaker on the right and the tie breaker. The two fibers overlap in the tie breaker compartment.
3. A third fiber is an example of a fiber protecting the cable compartment. This fiber is routed from an REA105 unit around the cable compartment (light green) along one wall and back. The REA105 has its own trip contacts and will trip the corresponding feeder breaker for an arc flash in the downstream cable compartment. *One REA105 per breaker compartment is used. Only one is shown.*

Shipping Split Applications



When shipping splits are necessary for shipping switchgear, there are two options to consider. The preferred method is to cover each shipping split with its own Sensor Fiber loop. In most applications this means mounting a REA103 near one end of the shipping split such that the REA103 can accommodate two shipping split sections. Then, the REA103 can be interconnected to upstream and downstream units with the REA communications cables. This option costs a bit more up front, but will be easier to install in the field and provides a better final installation.

The other option is to use shipping split splice adapters. The splice adapter is a female/female ST fiber optic connector (see photos). It is used to terminate the fiber at each relay unit and also to repair the fiber, if ever necessary, when broken.



The ST connector of the first section of the fiber loop may be terminated at a splice adapter near one end of the switchgear section. The ST connector for the adjacent fiber loop section should be temporarily secured in place with a wire tie during shipment. During final assembly in the field, the two fibers are joined together at the splice adapter.

Each time the female/female ST connector is used it counts as a splice. For all practical purposes, you can only join a maximum of shipping split sections together using 2 such connectors creating an overall fiber loop consisting of 3 sections since the maximum number of splices allowed is 3. Hence the reason for the preferred shipping split option suggested earlier.

Terminating the Sensor Fiber with Splice Adapters

Terminating the Sensor Fiber with Splice Adapters is straightforward. The process requires a termination kit, splice adapters, and Sensor Fiber. This termination process is used for terminating bulk fiber during installation, splicing the fiber for shipping splits, or to repair a broken fiber.

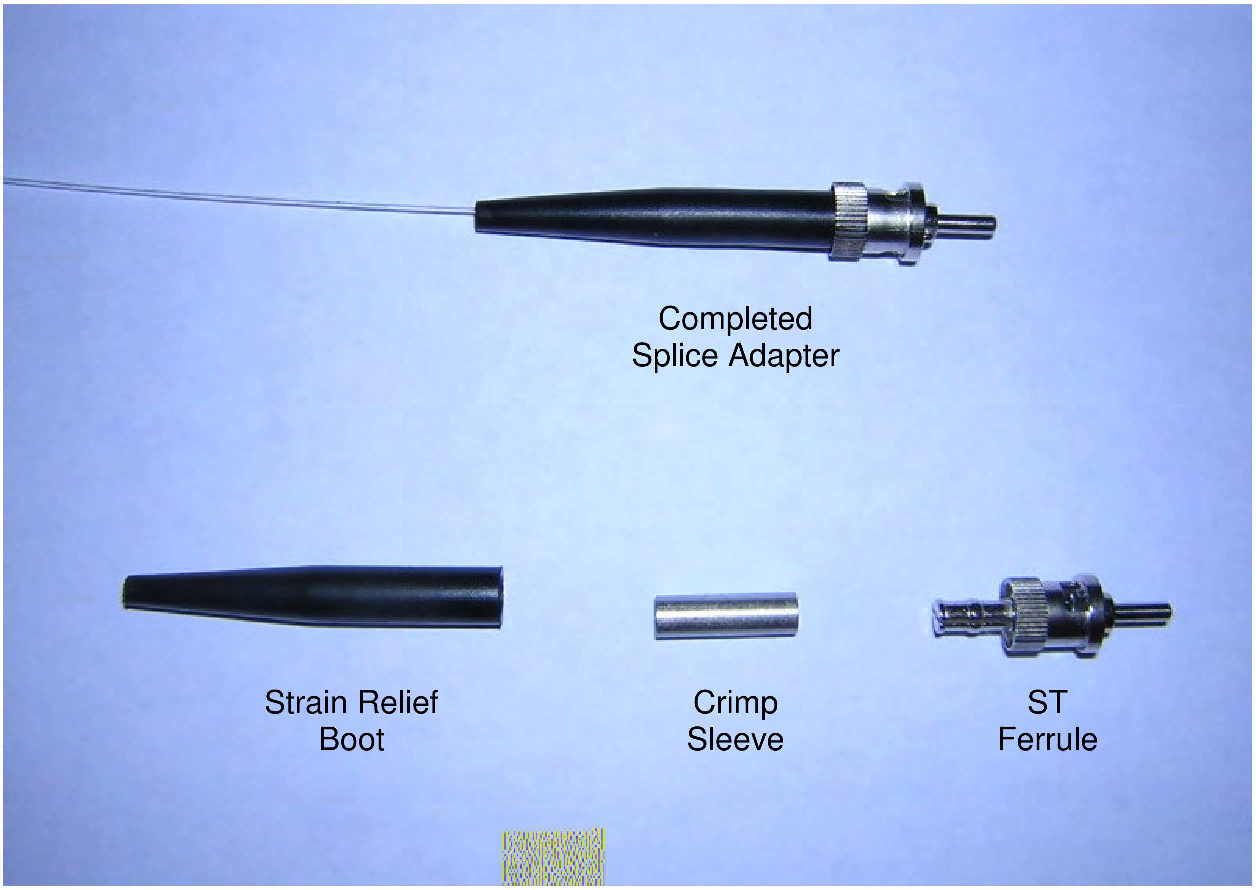
As mentioned above, there is a limit to the number of splices that can be installed in a given length of Sensor Fiber to maintain reliable operation. When using splice adapters, the following overall fiber loop length limits must be followed:

Maximum total length without splices or with one splice………..60 meters or 196 feet
Maximum total length with two splices…………………………..50 meters or 164 feet
Maximum total length with three splices…………………………40 meters or 131 feet

Termination Kit

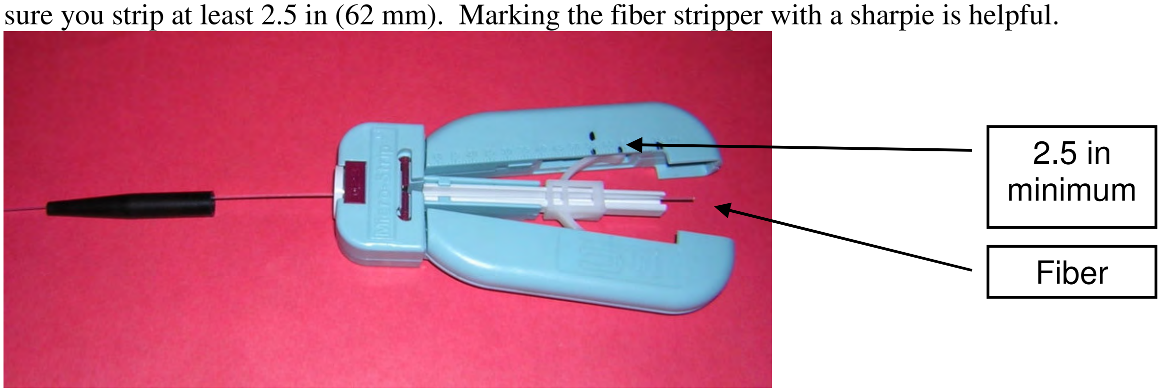
The termination kit is shown in the photo below. As noted, the Cable Stripper comes with the kit, but is not used with the Sensor Fiber since the fiber is not jacketed. Instructions for using the kit are included with each kit. An overview is shown in the next section.

Termination Steps

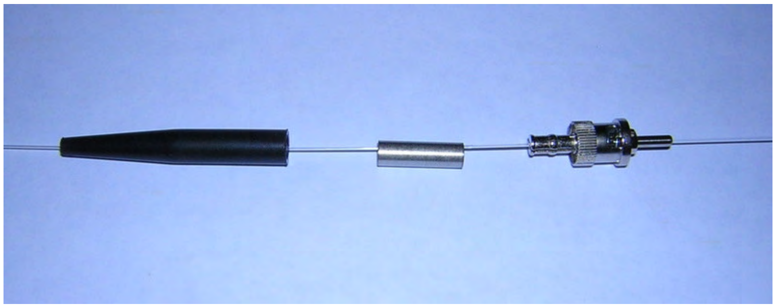


1) **Install Strain Relief Boot.**
   Just slip it onto the fiber, tapered end away from the end.

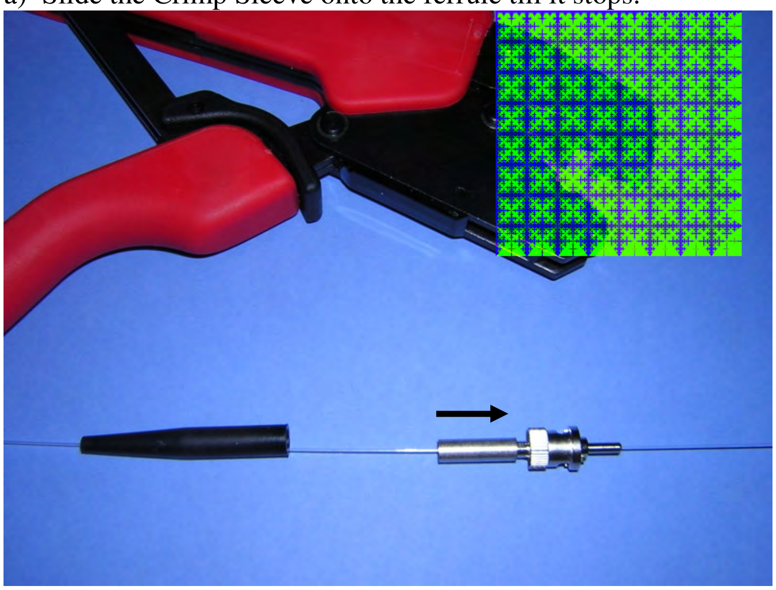
2) **Strip Fiber Buffer.**
   Don't be surprised by how hard you will need to pull on the fiber to strip it. This is normal. Gloves are recommended. Extra fiber length is not a problem (the cleaving step below removes), but make sure you strip at least 2.5 in (62 mm). Marking the fiber stripper with a sharpie is helpful.



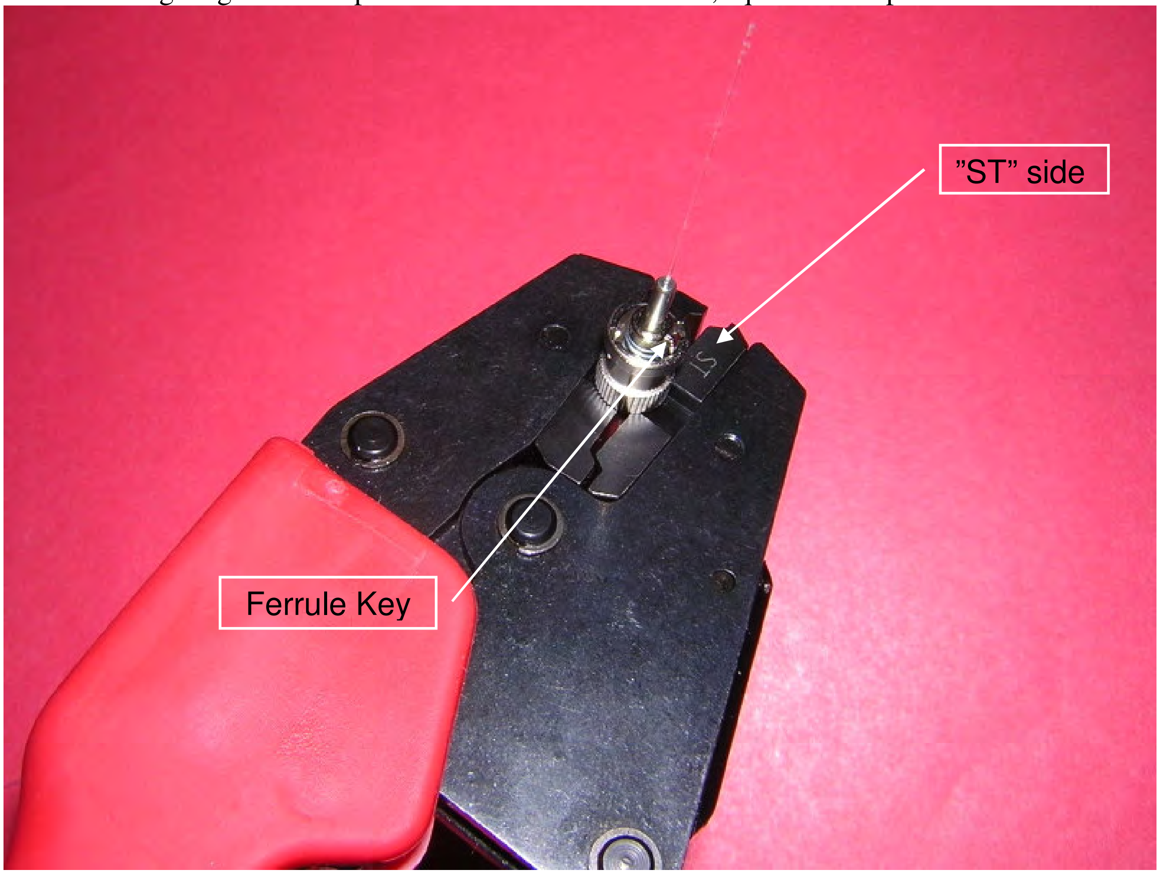
3) Install Crimp Sleeve and Ferrule.
Slide the Crimp Sleeve on to the stripped fiber. Then push the ferrule till it stops at end of stripped section.



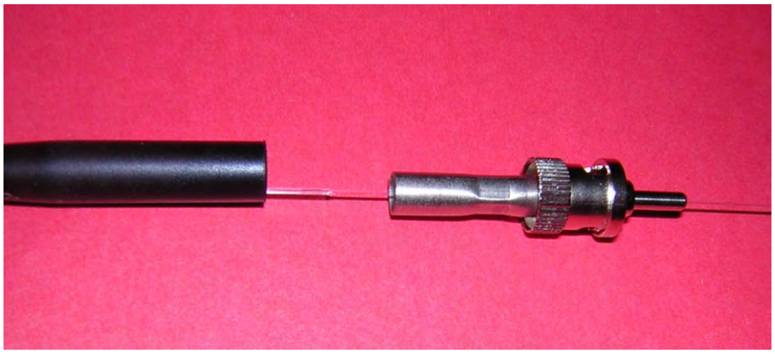
4) Crimp Sleeve/Ferrule.
a) Slide the Crimp Sleeve onto the ferrule till it stops.



b) Place the Ferrule in the Crimp Tool. Ensure Ferrule is on the ST side. Finally, make sure Ferrule Key points up—towards top of Crimp tool—as shown (this ensures crimp is perpendicular to slit in Ferrule). It usually works best to slightly close Crimp Tool on Crimp Sleeve, then—before finalizing crimp—check that fiber is pushed into Ferrule till it stops at end of stripped section, and to check that Ferrule sits tight against Crimp Sleeve. Once this is assured, squeeze Crimp Tool until it releases.

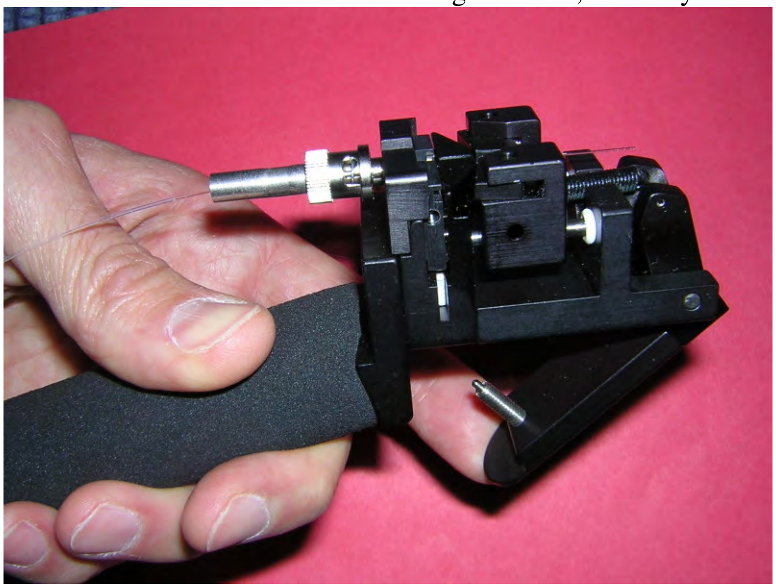


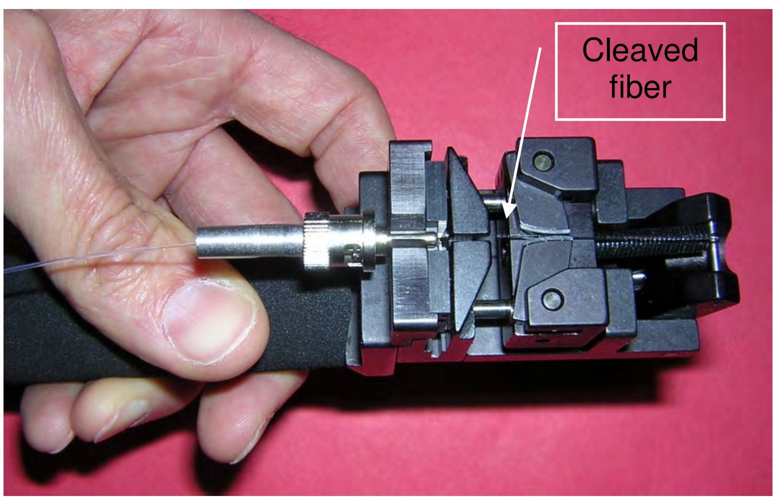
c) Completed crimp should look as shown below. Pull on fiber to make sure it won't slide out of Ferrule.



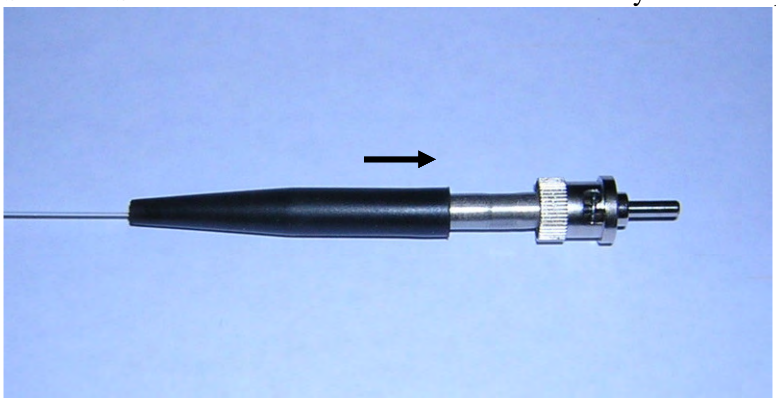
5) Cleave Fiber.

Place Ferrule assembly in Cleave Tool as shown. [Be aware, the Cleave Tool is a precision tool and should be treated carefully.] Using index finger slowly, but in continuous motion, squeeze lever. Fiber will be cleaved. Before releasing the lever, carefully remove excess fiber from Cleave Tool.



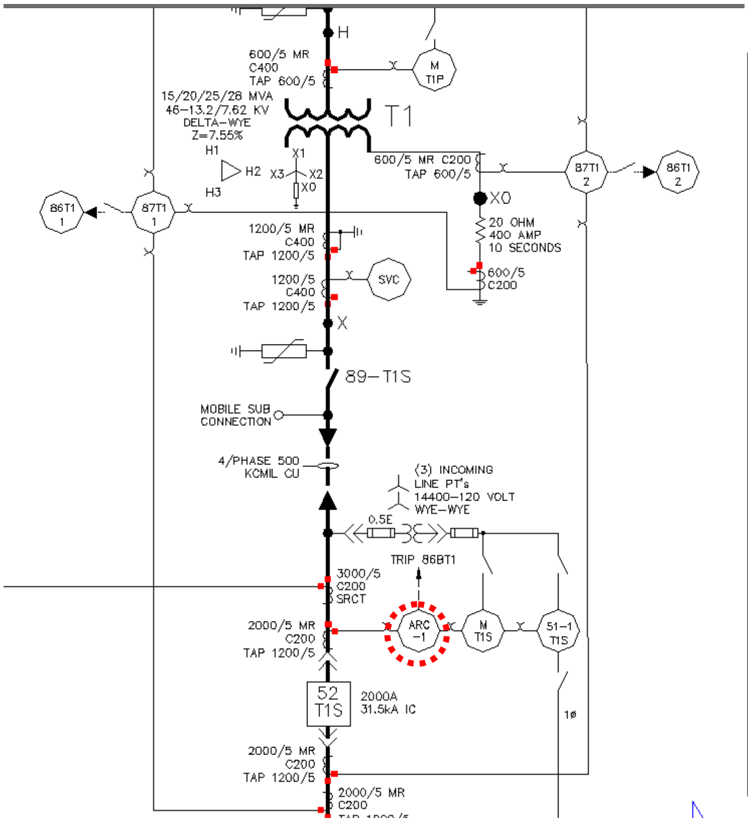


6) **Position Strain Relief Boot.**
Slide the Stress Relief Boot on to the Ferrule assembly until it stops.

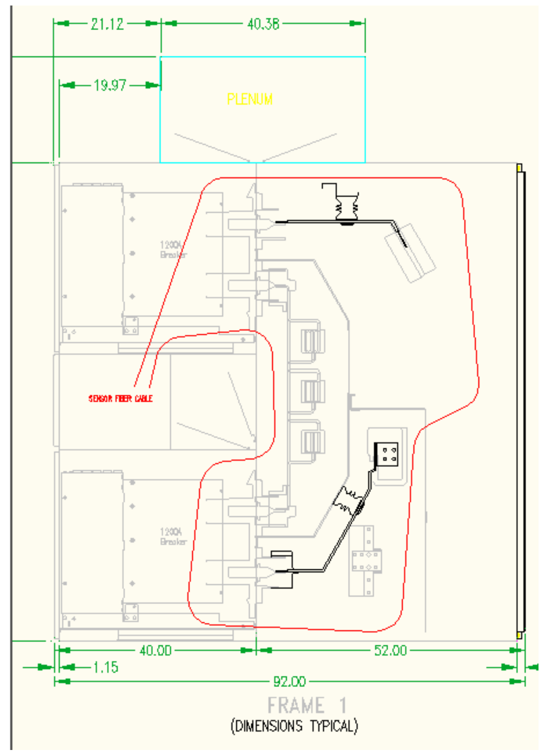


7) **A completed Splice Adapter.**

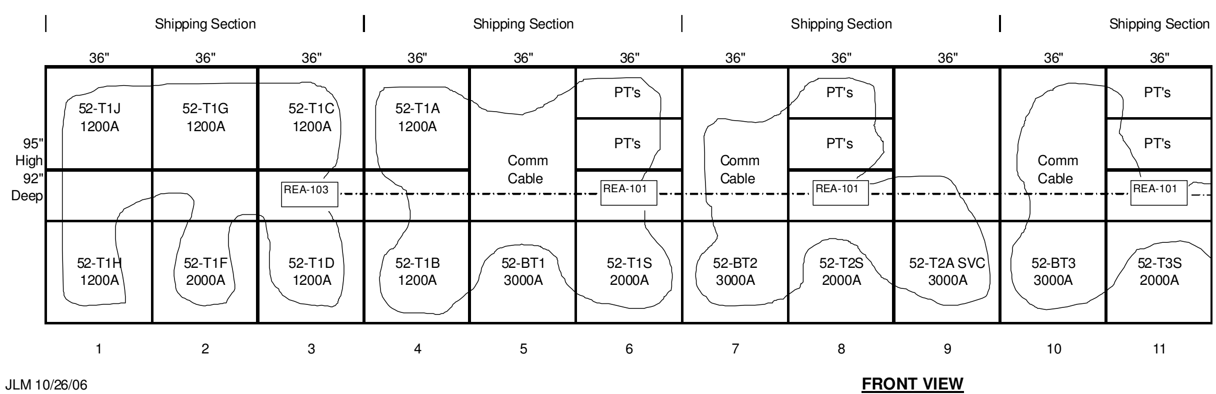
Sample Drawings & Pictures



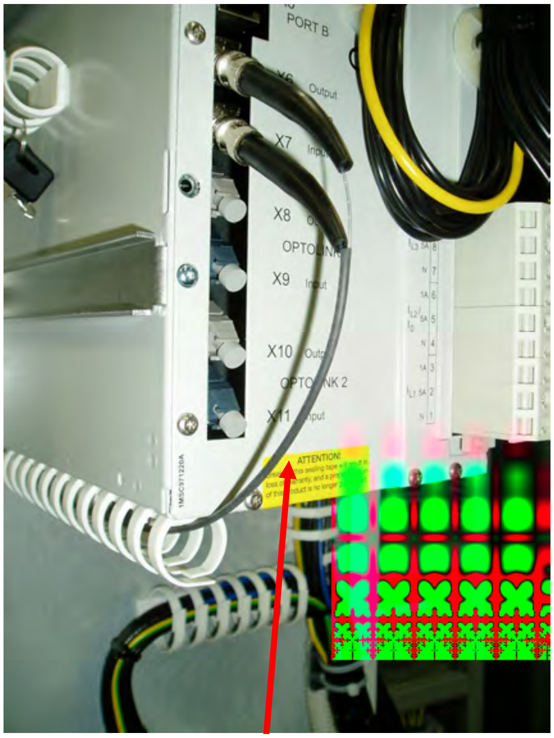
One-line with REA



Section View of fiber routing

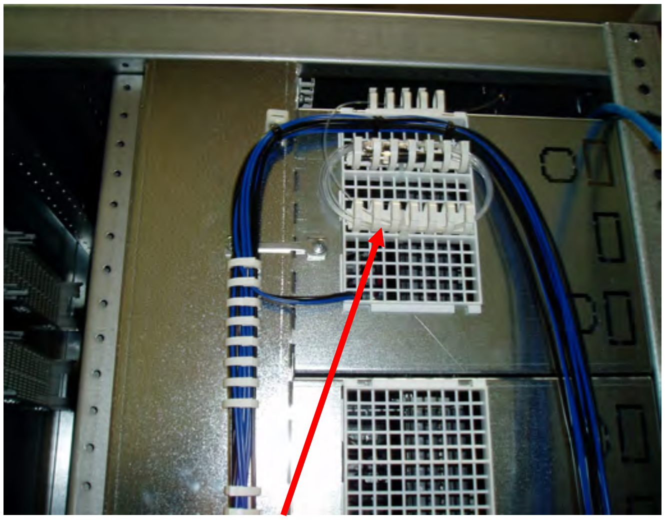


Front View of fiber routing, taking into account shipping splits in loop design

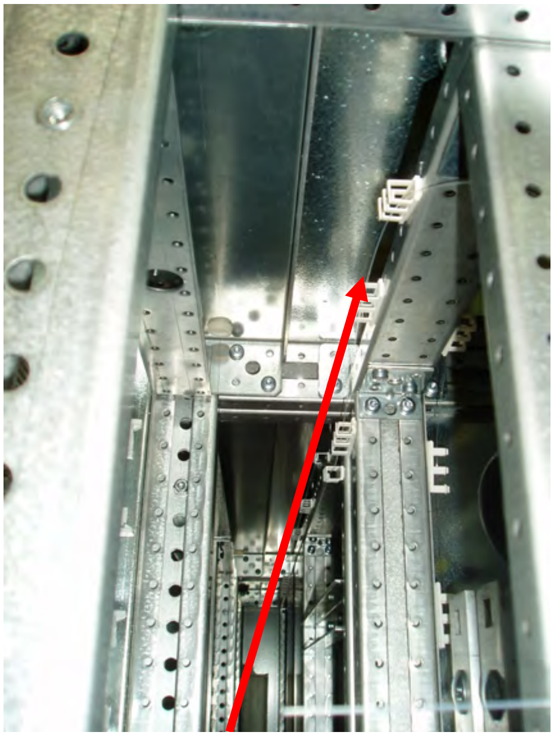


Protective tubing to help with wire management on swing panel

Protective tubing to help with wire management on swing panel



Proper storage of fiber for shipping



Routing away from potential snags

Sensor Fiber Testing Procedures

Automatic Sensor Fiber Loop Testing

Once in operation, the continuity of the Sensor Fiber is monitored by sending a short test pulse through the fiber loop approximately every minute. Unless the test pulse is received at regular intervals at the other end of the loop, the Sensor Fault LED and the IRF (Internal Relay Fault) LED are each activated and the IRF relay output closes. If a there is a break in the Sensor Fiber, the Sensor Fiber connected to the REA10_ Input port will continue to operate. The Sensor Fiber connected to the REA10_ Output port will not be active until the break is repaired.

If the fault is in the Sensor Fiber connected to a downstream extension unit e.g. REA105, the fault is indicated in the extension unit by LED Sensor fault and the REA101 will also indicate an IRF as well as a Port A/B Fault, depending on which port the extension unit is connected. If the sensor self-monitoring feature is not needed, it can be deactivated by means of switch SG3/4 in the REA101 and SG1/5 in the REA103 and SG1/8 in the REA105. When the self-monitoring feature is deactivated, no test pulses are sent. The self-monitoring feature must be deactivated for radial Sensor Fiber applications.

Simulating a Sensor Fiber Break

A Sensor Fiber fault may be simulated by disconnecting one end of the Sensor Fiber. The sensor fault indication will appear within approximately one minute, depending on when the last test pulse has been sent.

Warning: A broken or disconnected fiber loop does not inhibit the operation of the arc protection system. On the contrary, the connected REA101, REA103 or REA105 unit will typically see MORE light because the exposed ends of the fiber are far more receptive to light than the normal external cylindrical surface. This could result in an unexpected trip operation if the current supervision has been deactivated (Trip Condition key switch set to "Light") or if the supervising current level is simultaneously exceeded.

Simulating an Arc Flash

Typically, for security reasons, the arc protection system is implemented such that both light and current are simultaneously required to trip (Trip Condition key switch set to "Current & Light"). However, if this key switch is set to "Light", only light is required to trip. (There is no "Current" setting whereby the relay will trip on only current. Light is always required for a trip.)

The current level is sensed by the REA101 via its connected current transformers (CTs). Two of these CT inputs are dedicated as phase CT inputs. The third CT input may be used either as the third phase CT or as a ground CT for more sensitive ground fault settings. The current supervision acts as a fault detector, supervising the light detection portion of the REA system.

The REA101 front panel includes separate LEDs indicating whether current and light requirements are being met for tripping. If the LED marked "Current" is lit, the current threshold requirement has been met, and, thus, is always on when the Trip Condition key is set to "Light". The "Light" LED will become temporarily lit whenever the minimum light requirements have been met or sealed-in in the case of an actual trip.

The testing equipment needed includes a current source and a light source. The current source must be capable of delivering sufficient current to exceed the current level settings of the REA101. A camera flash unit may be used for the light source with some restrictions: Most modern built-in camera flashes will not activate the REA system because the flashing time is too short and/or not sufficiently intense. The flash must last at least 1 millisecond. Medium-power to high-power camera flash units are required for testing purposes.

Current Check

A secondary current source is needed to check the current circuit from the CT to the REA101. If either the phase or neutral current setting is exceeded, the "Current" LED in the REA101 will light. This testing should be done separately for each REA101 unit. And each phase should be checked one at a time to ensure continuity of each. Flexitest test switches are recommended for current and trip circuits to allow the most favorable testing conditions.

Light Check

After the current circuit supervision circuitry has been tested, the light portion of the arc protection system can be tested. If the position of the Trip Condition ("Current & Light" or "Light") key is turned to the "Light" position, the necessary current is simulated internally by the REA101 so that a separate current supply is not required and only a light flash is required to initiate tripping. The "Current" LED on the REA101 will be lit indicating that the supervising current requirement is being met. The overcurrent data is transmitted through the entire system as required by the application.

Initial flash tests should be carried out with the actual breaker trip circuits disconnected. The arc is simulated using the camera flash. The arc simulation should be done in every compartment protected by the Sensor Fiber for every relay in the arc protection system. The camera flash should be directed toward the Sensor Fiber and within about 2 feet. If the Trip Condition key has been set to "Light", the Trip LED light will light and stay lit until the REA101 reset button has been pushed. If the Trip Condition key is set to "Current & Light", the Light LED on each appropriate REA unit will temporarily light (about 1 second) but since no current is present, no tripping action will take place.

The table below summarizes the expected LED indicator light status as a function of the key switch position and the current and light inputs:

REA101 INPUT QUANTITIES			**REA101 OUTPUT LEDs**		
Trip Condition Key Position	**Injected Current > Pickup**	**Light Flash > Pickup**	**Current LED**	**Light LED**	**TRIP LED**
Light	NO	NO	ON	OFF	OFF
Light	NO	YES	ON	ON	ON
Light	YES	NO	ON	OFF	OFF
Light	YES	YES	ON	ON	ON
Current & Light	NO	NO	OFF	OFF	OFF
Current & Light	NO	YES	OFF	FLASH	OFF
Current & Light	YES	NO	ON	OFF	OFF
Current & Light	YES	YES	ON	ON	ON

Once the proper LED trip indicators have been confirmed for arc simulations in each cubicle, it is recommended that the tests be repeated with actual breaker tripping in order to test the complete trip circuits. The procedure is the same as before except the breakers are included in the test.

Final Steps

If all tests pass as expected and the work in the switchgear is finished according to safety regulations, the gear is ready for energizing. Any temporary setting changes should be restored to their original in-service position (e.g. the key switch).

Sensor Fiber Installation and Testing Trouble-shooting

A. The REA101 doesn't respond to my camera flash.

- Make sure REA101 SG1/6 (Sensor ON/OFF) is ON, or the applicable extension unit Sensor ON/OFF dip switch is also ON.
- The flash's pulse length may be too short. It must be more than 1 ms.
- The flash's intensity is not strong enough. A medium to high power flash is required. Built-in camera flashes typically will not work.

B. My IRF LED and Sensor Fault LED are on.

- The sensor fiber supervision has detected a break in the loop. First, check that the sensor fiber is connected properly to the REA relay. Next, trace the sensor fiber loop path to locate the break.

C. Port A (or Port B) Fault LED is lit.

- If the Port Fault LED is solidly lit then there is a communication error with the communication cable or SG1/1 (Terminator) is in the wrong position on one of the attached extension units. Make sure there are no breaks in communication cable and that the final extension unit has the Terminator dip switch set to ON.
- If the Port Fault LED is blinking then a downstream extension unit has a break in one of its fiber loops. Check downstream extension units for a lit IRF LED and Fault LED to identify which sensor fiber loop is damaged. Then trace the suspect sensor fiber loop until the break is located.

D. Nothing happens when I flash my downstream REA103

- Check that the Port (A or B) of the REA101 that the downstream extension unit is connected to is turned ON (SG1/7 or SG1/8).
- Next make sure no other extension units between the REA101 and the last extension unit have SG1/1 (Terminator) ON. This will cut off signal from any extension units that are farther downstream. Only the last extension unit in the daisy chain should have the SG1/1 (Terminator) dip switch set to ON.

E. When I flash the REA105, one upstream REA101 trips but the other doesn't...why?

- The REA105 will only send a light detection signal to the REA101 that is attached to port IN1and only if SG1/5 (Light to port IN1 ON/OFF) is ON. The purpose of port IN2 is to transmit current information between 2 different REA101 zones for the tie breaker to trip if either zone sees a flash. If both main breakers and tie breaker need to trip for a flash in the tie breaker zone, then the first HSO (High-Speed Output) of the REA105 is wired to the tie breaker, the "Light to port IN1" is ON and the second HSO of the REA105 should be wired to the main breaker associated with the REA101 connected to port IN2 of the REA105.

Sample Installation Accessories

	Name A	Manufacturer B	Part Number C	Supplier D	Contact Information E	Web Site F	Comment G	Picture H
1	Wing Push Mount Tie	Panduit Corp.	PRWP1S-C	Panduit Corp.	Tel.: 1-800-387-9689	www.panduit.com	Length of Tie is 5.2", Width 0.190", Thickness 0.052", Maximum panel thickness 0.105" (Slightly different design is supplied with the long fiber sensor)	
2	Corrugatied Loom Tubing	Panduit Corp.	CLT25F-C20	Panduit Corp.	Tel.: 1-800-387-9689	www.panduit.com		
3	Snap-In-Clips (SICH)	Panduit Corp.	SICH50-C	Panduit Corp.	Tel.: 1-800-387-9689	www.panduit.com		
4	Grommet 1 (small)	Spaenauer	RB-236	Spaenauer	Tel.: 1-800-265-8772	www.spaenaur.com		
5	Grommet 2 (big)	Spaenauer	315-464	Spaenauer	Tel.: 1-800-265-8772	www.spaenaur.com		
6	Tie Rap Anchor	Techspan	MPNY-1000-9-C	Techspan	Tel.: 1-800-363-1588	www.techspan.biz		
7	Screw Mounts	Techspan	SMNY-001-9-C	Techspan	Tel.: 1-800-363-1588	www.techspan.biz	Requires #4 - #6 Screw (screws are not included)	
8	Duct Seal Compound	Thomas & Betts	CIDUCT-1	Thomas & Betts	Tel.: 1-888-862-3289	www.tnb.com		

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ABB Inc.

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