

# **PowerWave 2™ Bus System 250-800A**

## **Installation and Operation**



**Ctrl Nr: PM375106  
Revision: 002**

Thank you for your recent purchase of a PowerWave 2™ Bus System from Power Distribution, Inc. For safety reasons as well as to ensure optimal performance of your PowerWave 2™ Bus System, please carefully read the instructions before trying to install, operate, service, or maintain the system.

For any questions regarding the installation, operation, service, or maintenance of your PowerWave 2™ Bus System, please contact us:

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**PowerWave 2™ Bus System  
250-800A  
Installation and Operation  
Ctl Number: PM375106 Rev 002**

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Release date: November, 2017

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### **Power Distribution, Inc. (PDI)**

Power Distribution, Inc. (PDI) designs, manufactures, and services mission critical power distribution, static switching, and power monitoring equipment for corporate data centers, alternative energy, industrial and commercial customers around the world. For over 30 years, PDI has served the data center and alternative energy markets providing flexible solutions with the widest range of products in the industry.

# Contents

<b>1 Introduction.....</b>	<b>1</b>
<b>2 Components Catalog .....</b>	<b>3</b>
<b>2.1 <i>Designing Your Bus Run</i> .....</b>	<b>3</b>
2.1.1 Revit Models .....	3
2.1.2 PDI Assistance .....	3
2.1.3 Component Options Compatibility .....	3
<b>2.2 <i>Bus Run Layouts</i>.....</b>	<b>4</b>
2.2.1 Vertical Straight Bus Runs.....	4
2.2.2 Horizontal Straight Bus Runs (250-400A).....	5
2.2.3 Angled or Branched Vertical Bus Runs .....	6
<b>2.3 <i>Standard End Feeds</i> .....</b>	<b>7</b>
2.3.1 Standard End Feed 250A.....	7
2.3.2 Standard End Feed 400A.....	8
2.3.3 Standard End Feed 800A.....	9
2.3.4 Standard End Feed Options 250A/400A/800A.....	10
2.3.5 Standard End Feed Options Summary and Part Numbers.....	12
<b>2.4 <i>Center Feeds</i> .....</b>	<b>13</b>
2.4.1 Center Feeds 250-400A.....	13
2.4.2 Center Feed Options Summary and Part Numbers .....	14
<b>2.5 <i>Starter Rails</i>.....</b>	<b>15</b>
2.5.1 Starter Rails (250-400A) .....	15
2.5.2 Starter Rail (800A) .....	17
2.5.3 Starter Rail Options Summary and Part Numbers.....	18
<b>2.6 <i>Standard Rails</i> .....</b>	<b>19</b>
2.6.1 Standard Rail (250-400A).....	19
2.6.2 Standard Rail (800A) .....	21
2.6.3 Standard Rail Options Summary and Part Numbers .....	23
<b>2.7 <i>Elbows</i>.....</b>	<b>24</b>
2.7.1 Elbow 250-400A .....	24
2.7.2 Elbow 800A .....	25
2.7.3 Elbow Neutral Positions.....	26
2.7.4 Elbow Options Summary and Part Numbers .....	26
<b>2.8 <i>Tees</i>.....</b>	<b>27</b>
2.8.1 Tee 250-400A .....	27
2.8.2 Tee 800A.....	28
2.8.3 Tee Neutral Positions.....	29
2.8.4 Tee Options Summary and Part Numbers.....	29
<b>2.9 <i>Accessories</i>.....</b>	<b>30</b>
2.9.1 Couplers 250-400A.....	30
2.9.2 Coupler 800A.....	31

2.9.3	Vertical Hanger 250-400A.....	32
2.9.4	Vertical Hanger 800A.....	33
2.9.5	Horizontal Hanger .....	34
2.9.6	End Cap 250-400A .....	35
2.9.7	End Cap 800A.....	35
2.9.8	Accessory Parts Numbers.....	36
<b>2.10</b>	<b><i>Tap Off Boxes .....</i></b>	<b>37</b>
2.10.1	Quick Connect Tap Off Box.....	37
2.10.2	Tap Off Box with Universal U-Channel.....	39
2.10.3	Limitations on Number of Tap Off Boxes per Bus Run .....	41
<b>3</b>	<b>Installation Planning .....</b>	<b>42</b>
<b>3.1</b>	<b><i>Planning Electrical Requirements.....</i></b>	<b>42</b>
3.1.1	Source Voltage and Frequency.....	42
3.1.2	Neutral Size .....	42
3.1.3	Current Loads.....	42
3.1.4	Upstream Circuit Breakers .....	42
3.1.5	Power Feed Disconnects .....	42
3.1.6	Dual Bus Runs .....	42
3.1.7	Grounding.....	43
<b>3.2</b>	<b><i>Planning Monitoring Requirements .....</i></b>	<b>43</b>
<b>3.3</b>	<b><i>Physical Layout and Component Selection .....</i></b>	<b>43</b>
3.3.1	Overhead Support Structure .....	43
3.3.2	PDI Application Engineering.....	44
3.3.3	Horizontal or Vertical Orientation.....	44
3.3.4	Bus Run Length and Capacity.....	44
3.3.5	Keep-Out Areas for Tap Off Boxes.....	44
3.3.6	Small Corrections to Bus Run Length (250A/400A).....	45
<b>3.4</b>	<b><i>Conclusion.....</i></b>	<b>45</b>
<b>4</b>	<b>Bus Run Installation.....</b>	<b>46</b>
<b>4.1</b>	<b><i>Receive, Inspect, and Unpack Bus System Components.....</i></b>	<b>46</b>
<b>4.2</b>	<b><i>Storage Conditions.....</i></b>	<b>46</b>
<b>4.3</b>	<b><i>Moving Components .....</i></b>	<b>47</b>
<b>4.4</b>	<b><i>Installation Sequence.....</i></b>	<b>48</b>
<b>4.5</b>	<b><i>Installation Differences 250-400A vs. 800A.....</i></b>	<b>48</b>
<b>4.6</b>	<b><i>STEP 1: Create the Overhead Support Structure.....</i></b>	<b>48</b>
<b>4.7</b>	<b><i>Installing Vertical Hangers.....</i></b>	<b>49</b>
4.7.1	Vertical Hangers (250-400A) .....	49
4.7.2	Vertical Hangers 800A.....	50
<b>4.8</b>	<b><i>STEP 2: Hang the Starter Rail and Standard End Feed.....</i></b>	<b>50</b>
4.8.1	Hang the Starter Rail.....	51

- 4.8.2 Hang the Standard End Feed ..... 51
- 4.8.3 Attach Starter Rail to the Standard End Feed ..... 51
- 4.8.5 Attach Ground Wire to Enclosure Lug..... 52
- 4.8.6 Attach (Optional) Isolated Ground Wire ..... 52
- 4.8.4 Installing an 800A Starter Rail and Standard End Feed..... 52
- 4.9 STEP 3: Complete the Bus Run Structure ..... 53**
  - 4.9.1 Install Standard Rails ..... 53
  - 4.9.2 Install Elbows and Tees..... 53
  - 4.9.3 Adjust Bus Rail C-Clips ..... 53
  - 4.9.4 Install End Cap ..... 54
- 4.10 STEP 4: Install Couplers ..... 55**
  - 4.10.1 Installing a 250-400A Coupler ..... 55
  - 4.10.2 Installing an 800A Coupler..... 59
- 4.11 Horizontally Oriented Bus Runs (250-400A)..... 62**
- 5 Power Connections ..... 63**
  - 5.1 Lugs, Wires, and Torque..... 63**
  - 5.2 Power and Ground, Standard End Feed, 250-400A..... 64**
  - 5.3 Power and Ground, Standard End Feed, 800A..... 65**
  - 5.4 Connections for Monitoring Source Power ..... 65**
    - 5.4.1 Comm Box Wiring ..... 65
    - 5.4.2 Install CTs on Phase Cables ..... 65
    - 5.4.3 Connect Voltage Sensing Wires ..... 66
  - 5.5 Power and Ground, Center Feed, 250-400A..... 67**
- 6 Tap Off Box Installation ..... 68**
  - 6.1 Tap Off Box Safety..... 68**
  - 6.2 Coupler Overlap 250-400A..... 69**
  - 6.3 Inspect Tap Off Boxes Before Installing ..... 69**
  - 6.4 Quick Connect Tap Off Box..... 70**
    - 6.4.1 Installing a Quick Connect Tap Off Box ..... 70
    - 6.4.2 Removing a Quick Connect Tap Off Box ..... 71
  - 6.1 Tap Off Box with Universal U-Channel ..... 72**
    - 6.1.1 Installing a Tap Off Box with Universal U-Channel ..... 72
    - 6.1.2 Removing a Tap Off Box with Universal U-Channel ..... 74
- 7 Start-Up Procedure ..... 75**
  - 7.1 Power-Up Checklist ..... 75**
  - 7.2 Power Up..... 76**
- 8 Maintenance ..... 78**



**8.1 Annual Inspection ..... 78**

**8.2 Procedure After Short Circuit or Ground Fault ..... 78**

**8.3 IR Scanning..... 78**

**8.4 Spares Kits ..... 79**

**Glossary ..... 80**

**Bibliography ..... 81**

## Safety

Please pay special attention to the use of “Danger” and “Warning” symbols throughout this manual indicating electrical or other safety hazards. Following these safety instructions is extremely important to avoid possible injury or death.



### **DANGER!**

**This symbol is used throughout this manual to indicate the presence of high voltages, representing a hazard for electric shock, burn or explosion. Follow the instructions carefully to avoid serious or fatal injury.**

### **Follow safe electrical work practices:**

- Read, understand, and follow the instructions before installing this product.
- Disconnect and lock-out all power supplying equipment before working on or installing PowerWave 2 Bus System components. Use a properly rated voltage sensing device to confirm power is OFF.
- Install the bus system in an appropriate electrical environment per local regulations.
- PCBs are ESD sensitive equipment. Ground yourself, discharge any static charge and ensure that the device is effectively grounded before handling.

Electrical equipment should be installed, operated, serviced, and maintained only by qualified personnel and in accordance with all local safety codes. Power Distribution, Inc. assumes no responsibility for any consequences arising out of the use of this manual. **This document should not be viewed as sufficient by otherwise non-qualified personnel to operate, service, or maintain the equipment discussed.**

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# 1 Introduction

This manual describes PowerWave 2™ Bus System components, installation planning, installation, startup, and maintenance.

Monitoring for PowerWave 2 Bus System is described in *PowerWave 2 Bus System, Branch Circuit Monitoring System, Setup and Operation*, PM375107.

## System Summary

PowerWave 2™ Bus Systems are compact, lightweight busways that can be deployed quickly using easy-to-assemble kits. PowerWave 2™ Bus Systems are designed for demanding data center power environments.

PowerWave 2 Bus Systems allow any voltage  $\leq 600V$  and are available in 250A, 400A, and 800A systems. Neutral options are available 100% or 150% on all bus systems.

PowerWave 2 Bus Systems provide compact power distribution systems to server racks:

- PowerWave 2 is installed completely overhead, requiring no server room floor space.
- Power and communications for monitoring are integrated in a single bus run, reducing space required for multiple cable and conduit runs.
- Busway space is very efficiently used. Continuous rail design allows Tap Off Boxes to be inserted nearly anywhere along the rail.
- On 250A and 400A systems, a Tap Off Box can overlap a Coupler (splice), resulting in little or no “lost” bus rail space at the Coupler. Consequently, Couplers can be placed directly above servers without displacing Tap Off Boxes..

Through Tap Off Boxes, the exact circuit breaker capacity and receptacle type can be specified at any location along the rail, simply by inserting the correct Tap Off Box into the busway:

- Tap Off Boxes are highly configurable to meet load demands and specific requirements, including monitoring.
- Tap Off Boxes are available for horizontal and vertical orientations.
- Up to (6) poles can be monitored for current and voltage, such as (2) x (3)-phase circuits.

Tap Off Box installation is safe for live systems:

- PowerWave 2 Bus Systems have an IP2X finger-safe rating (IEC 60529).
- Tap Off Boxes have a two-stage insertion into the bus rail: ground connections are made automatically before contact is made with conductors.

Infrared scanning is available without requiring exposure to high voltages:

- The Quick Connect Tap Off Box allows infrared scanning through the front panel without opening the box.
- Power feeds have optional infrared windows for scanning customer power connections to the bus run.

PowerWave 2 Bus Systems have diagnostic and monitoring capabilities:

- Overhead bus run circuits are easily traceable, unlike underfloor cables.
- The optional Branch Circuit Monitoring System (BCMS) can monitor the power source to each busway at the end feed and at up to (31) Tap Off Boxes or, if input power is not monitored, up to (32) Tap Off Boxes per end feed.
- BCMS offers monitoring for current only or both current and voltage.
- Modbus RTU, Modbus TCP/IP, or SNMP protocols for interfacing to a Data Center Infrastructure Management System (DCIM) or a Building Management System (BMS)
- Power monitoring can be aggregated in several ways:
  - Building Management System (BMS).
  - PowerWave 2 7” Local Display monitoring up to (6) bus runs, each with (15) Tap Off Boxes, or (96) devices in total.
  - WaveStar® BCMS Hub, monitoring up to (240) devices.

Product specifications are found in these documents:

- *PowerWave 2 Bus System Brochure* contains specifications in tabular format.
- *PowerWave 2 Bus System Guide Specifications* has specifications suitable for proposals.

See the **Bibliography** for information on downloading specifications and other documentation from the PDI website.

## 2 Components Catalog

PowerWave 2 Bus Systems are assembled at the customer site using kitted components according to customer bus run designs. All PowerWave 2 bus runs are variants of three basic bus run structures:

- Straight vertically oriented bus runs
- Straight horizontally oriented bus runs
- Angled or branched vertically oriented bus runs

Most of the components used to create these structures are common to all of them. Moreover, components and bus run structures are similar across all rated amperages (250, 400, and 800A).

This chapter surveys PowerWave 2 Bus System layouts, components, and component options.

### 2.1 Designing Your Bus Run

#### 2.1.1 Revit Models

To help you design your bus runs, PDI Revit® Models are available for PowerWave 2 Bus Systems. Models can be downloaded from the PowerWave 2 Bus System page on the PDI web site:

<http://www.pdicorp.com/products/distribute/powerwave-2-bus-system>

Click the **Downloads** tab on the page and click the following titles to download:

PowerWave 2™ Revit Model Library (.zip file)

*PDI Revit® Model Instructions/Power Distribution Units, Remote Power Panels, Static Transfer Switches, Floor Stands, PowerWave 2™ Bus Systems, Ctrl Nr PM375127*

#### 2.1.2 PDI Assistance

PDI Applications Engineering can assist you in designing your bus system and specifying the components you need. Ask for assistance through your sales representative, or contact PDI at 1.800.225.4838 or 1.804.737.9880 and ask for the Applications Engineering Manager.

#### 2.1.3 Component Options Compatibility

When specifying components for your bus run, keep in mind that some options must be the same throughout the bus run:

- Bus run amperage (250, 400, or 800A)
- Neutral size (100 or 150%)
- Source voltage as connected at the power feed (required for Tap Off Box specification), maximum 600V
- If BCMS Tap Off Box monitoring is specified, a communications cable must be run throughout the bus run and is specified for all structural components, such as Bus Rails and Elbows.
- If Isolated Ground is specified, an isolated ground strip is provided in a bus run channel throughout the bus run to provide isolated ground to each Tap Office Box. The Isolated Ground Option must be specified for all structural bus run components.
- Horizontal or vertical orientation must be uniform for the bus run, though it is only an option for hangers.

## 2.2 Bus Run Layouts

### 2.2.1 Vertical Straight Bus Runs

A straight bus run is the simplest and by far the most common bus run.

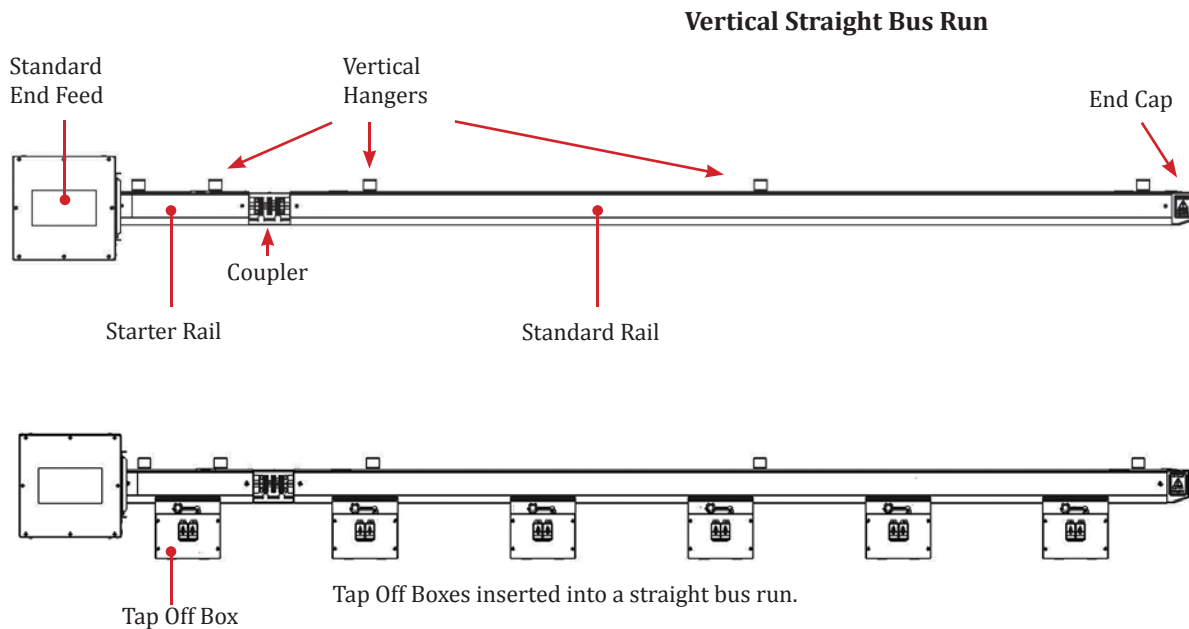
A straight bus run has at minimum:

- (1) Power feed: A Standard End Feed or alternatively a Center Feed, where customer power, ground, isolated ground (optional), and monitoring communications cable (optional) are connected to the Starter Rail.
- (1) Starter Rail, which is always the first bus rail in the bus run. Customer 3-phase + neutral power connections are made directly to the Starter Rail inside the Standard End Feed or to bus bars in the Center Feed.

A straight bus run can be extended by adding

- Standard Rails
- Couplers to join bus rails together

The neutral conductor must be aligned on the same side of the rail throughout the bus run. Tap Off Boxes can be inserted into bus rails nearly anywhere along the bus run and must all face outward from the neutral side.



**Available Amperages:**

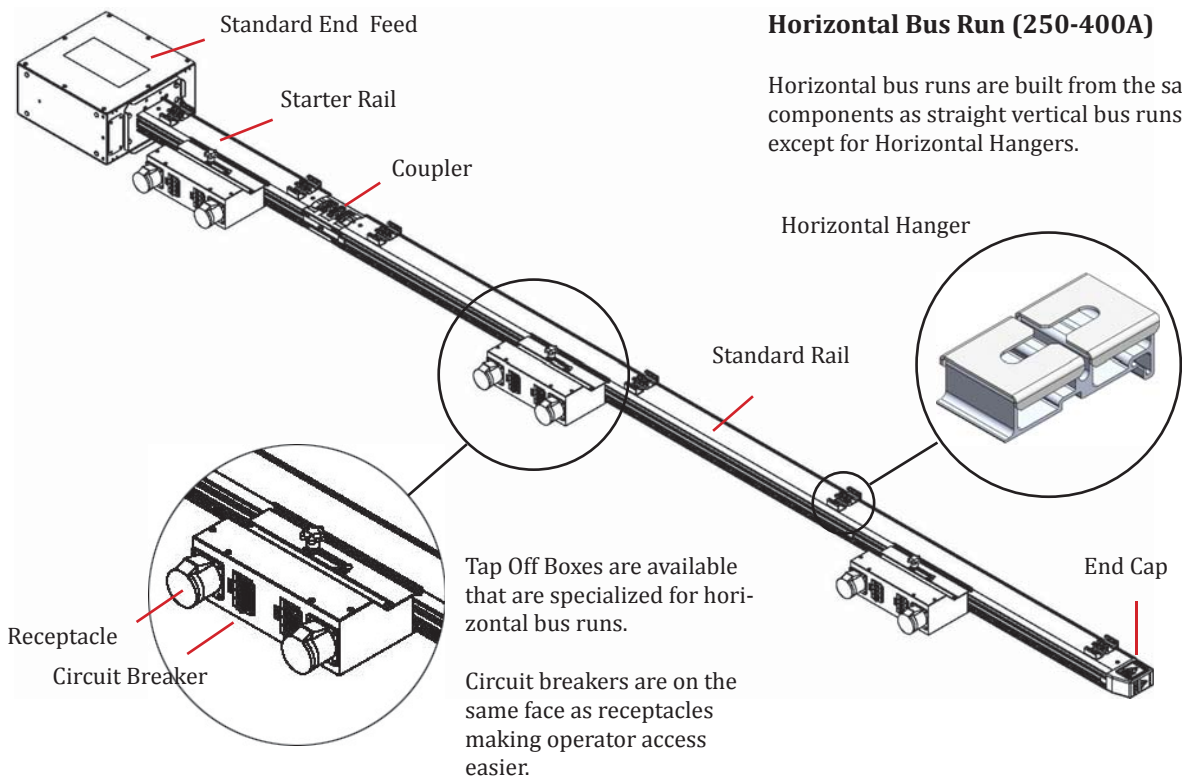
- 250A
- 400A
- 800A

### 2.2.2 Horizontal Straight Bus Runs (250-400A)

Straight bus runs can also be horizontally oriented, that is, rotated 90° so that Tap Off Boxes face upwards. Orienting the bus run horizontally is uncommon and is typically used when there is not enough overhead space for a normal vertically oriented bus run.

Horizontal bus runs have these special adaptations and restrictions:

- Horizontal bus runs are available for 250-400A bus runs only.
- Horizontal bus runs must be straight runs. There are no Elbows or Tees for this orientation.
- Neutral and Tap Off Boxes should face upwards.
- Tap Off Boxes are available that are specialized for horizontal bus runs. These Tap Off Boxes have circuit breakers positioned on the connector/receptacle side for easier operator access.
- Horizontal hangers are positioned on the wide side of bus rails with (2) all-thread rod positions for extra support.



**Horizontal Bus Run 250-400A**

Side View

**Available Amperages:**

- 250A
- 400A

### 2.2.3 Angled or Branched Vertical Bus Runs

With an Elbow a vertical bus run is turned at a right angle. With a Tee a leg is branched off at a right angle from a straight bus run.

#### Elbows:

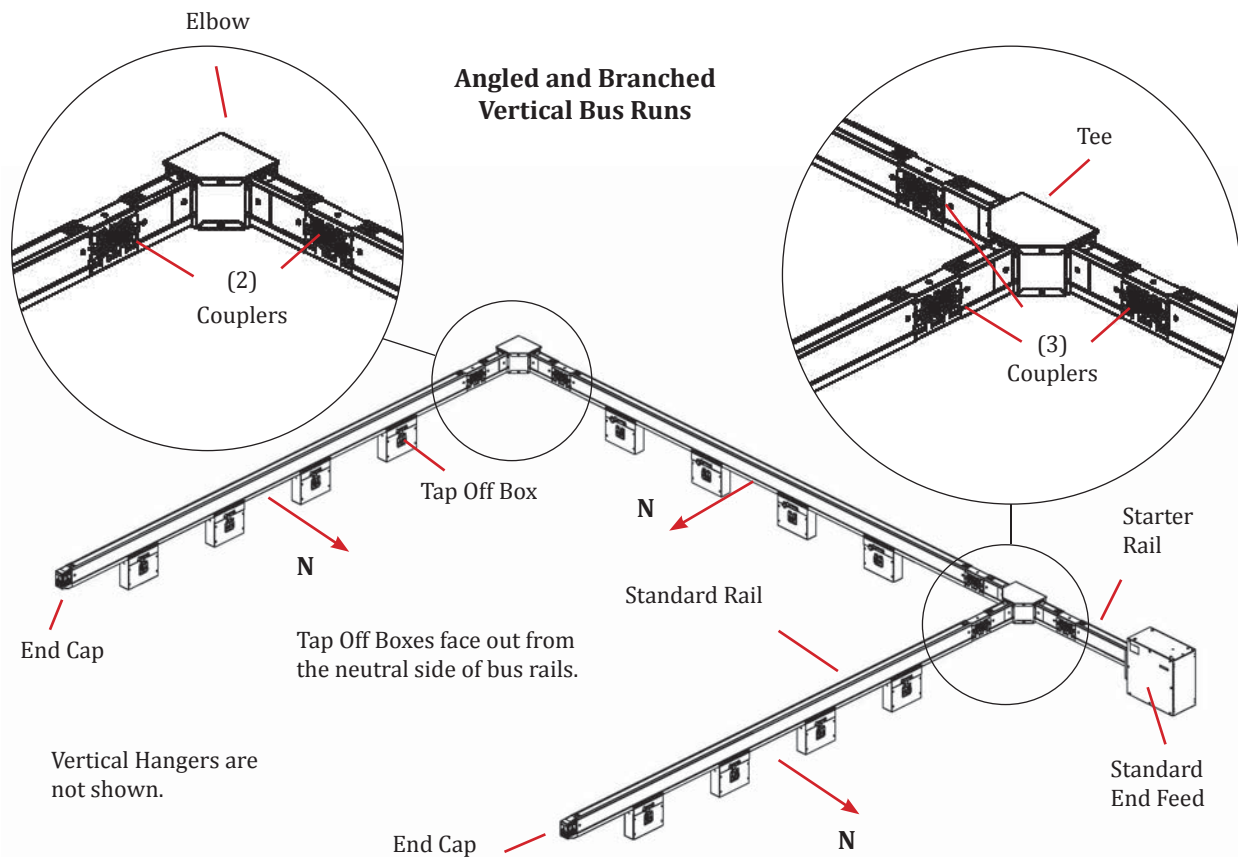
- In 250-400A bus runs, the orientation of neutral after the turn is customer-selectable—the neutral can remain on the same side or can cross over. Because Tap Off Boxes must face outward from the neutral side of the bus run, this flexibility allows Tap Off Boxes to be appropriately oriented for server racks.
- In 800A bus runs, neutrals must stay on the same side (“inside” or “outside”) and cannot cross over.

#### Tees:

- Neutral on the branched-off leg can be on either side of the bus rail.

For more information on neutral orientation, refer to the sections on Elbows and Tees later in this chapter.

There are no Elbows or Tees for horizontally oriented bus runs. Horizontal bus runs must be straight runs.



#### Available Amperages:

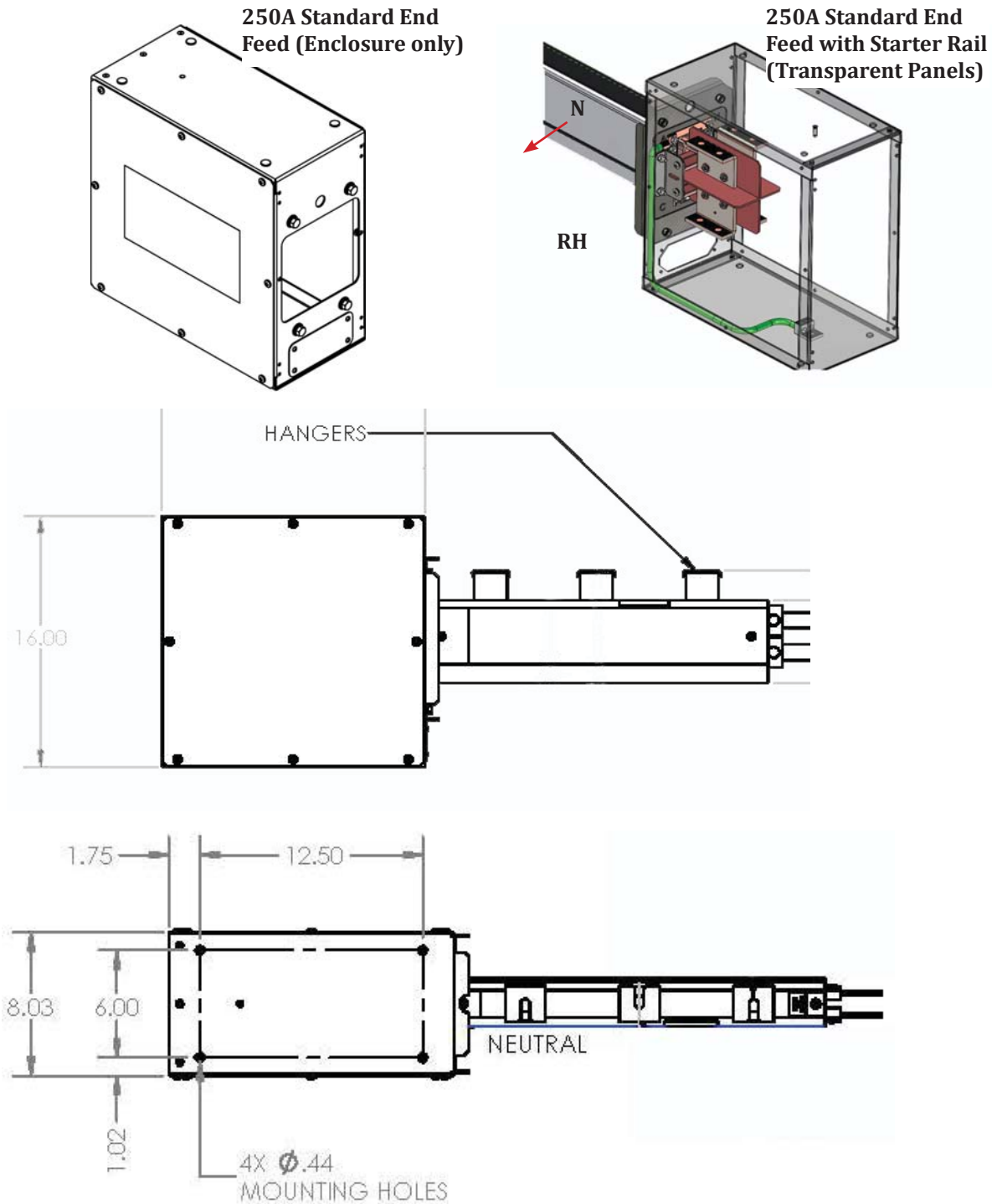
- 250A
- 400A
- 800A

### 2.3 Standard End Feeds

A Standard End Feed is an enclosure where customer power, grounding, and communications are connected for a bus run. Each Standard End Feed must be ordered with a Starter Rail, which must be the first bus rail in the bus run.

Although a Standard End Feed enclosure can be used in either right-hand (RH) or left-hand (LH) orientation, the combination of a Standard End Feed and its Starter Rail must be ordered in LH or RH orientation, which determines the position of neutral in the bus run.

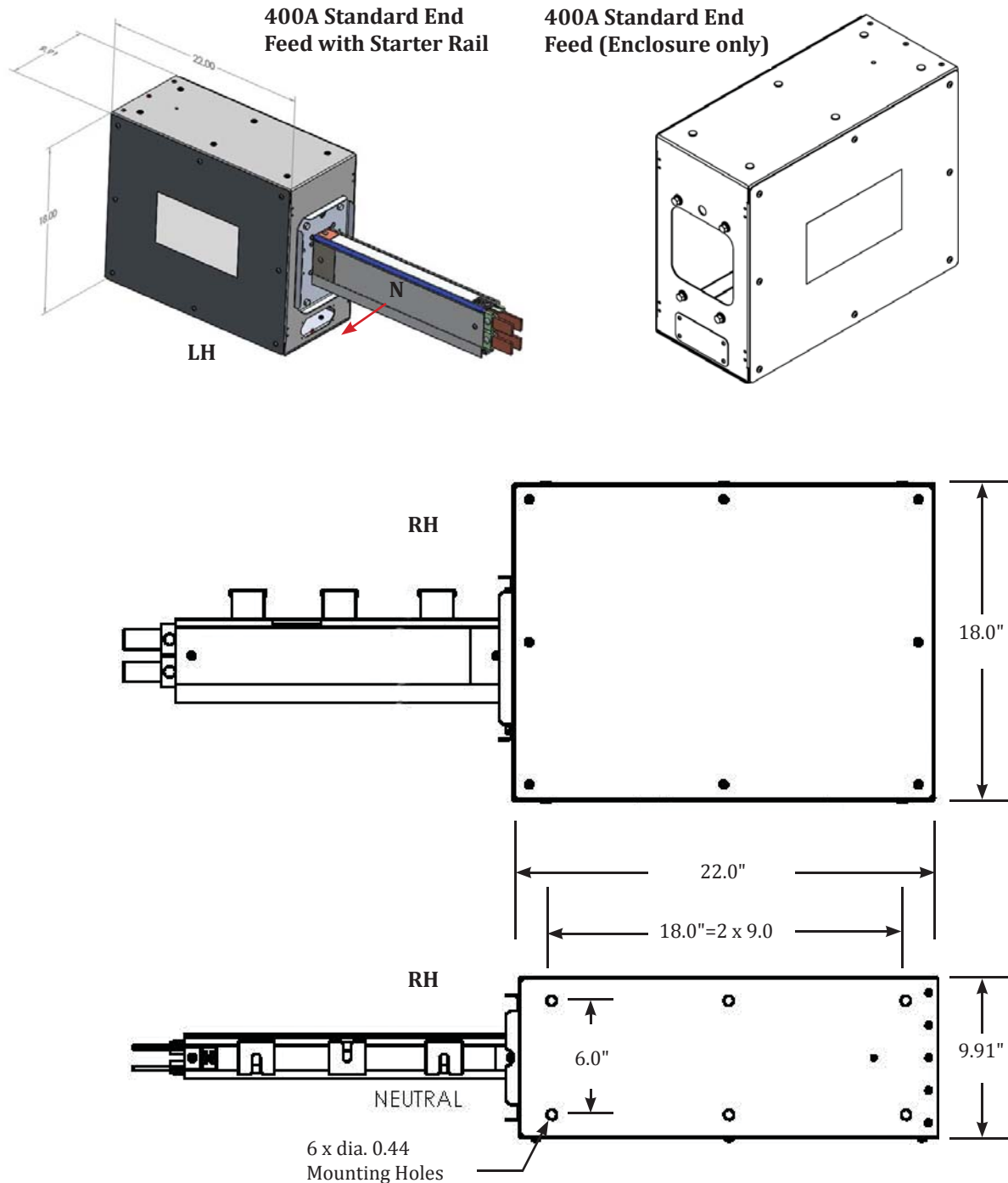
#### 2.3.1 Standard End Feed 250A



### 2.3.2 Standard End Feed 400A

The Standard End Feed for 400A Bus Systems is larger than the 250A enclosure to accommodate larger conductors, conduit, and cable bend radius. Each Standard End Feed must be ordered with a Starter Rail, which must be the first bus rail in the bus run.

Like the 250A Standard End Feed, the 400A enclosure can be used in either right-hand (RH) or left-hand (LH) orientation, but the combination of the End Feed and its Starter Rail must be ordered in LH or RH orientation, which determines the position of neutral in the bus run.

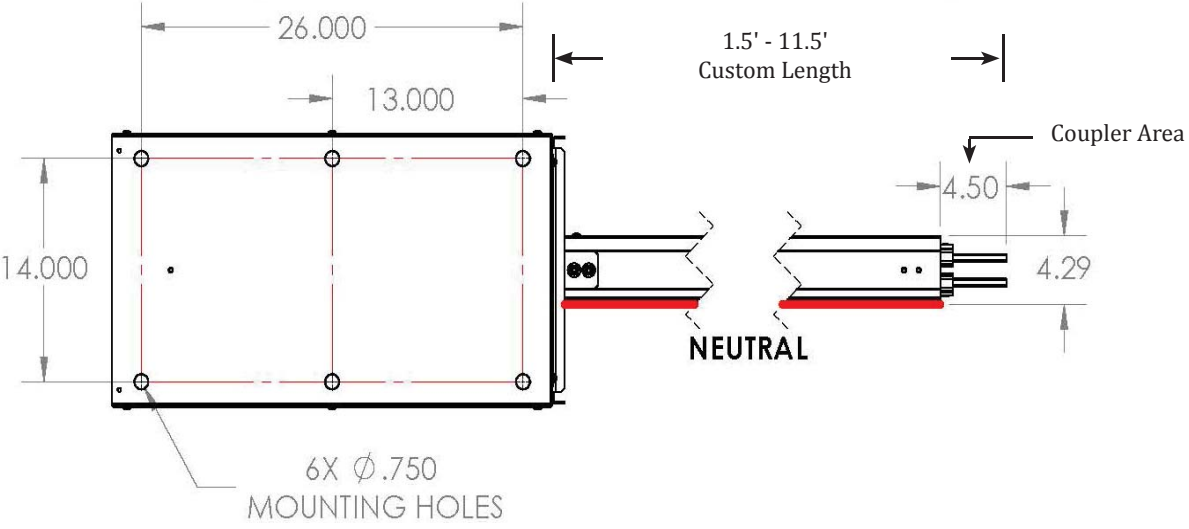
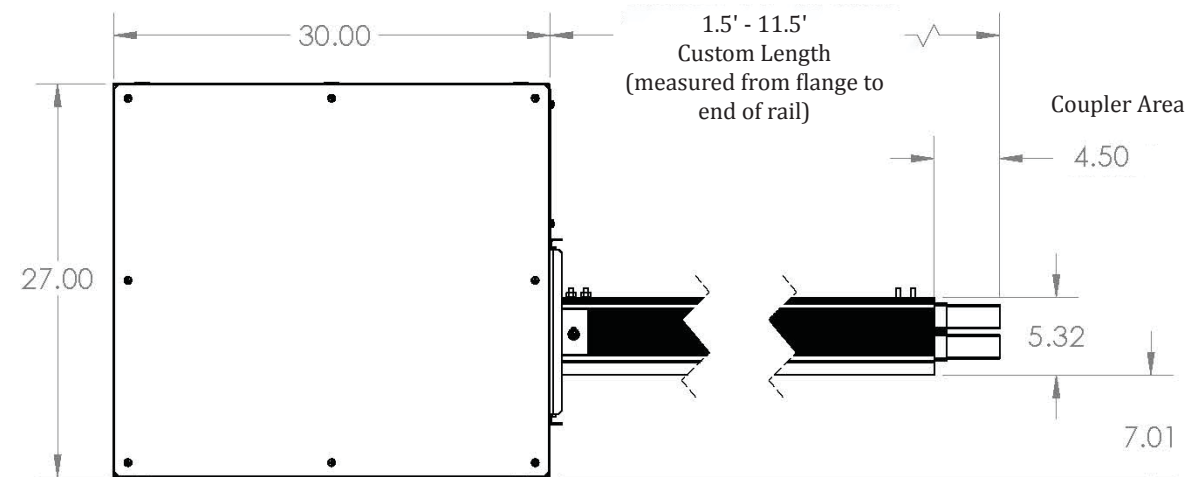
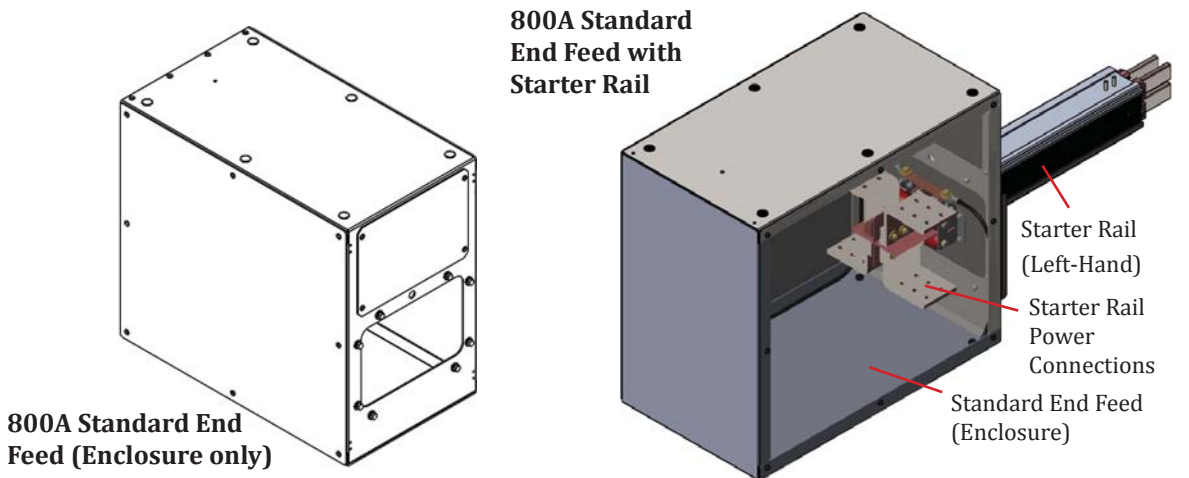




### 2.3.3 Standard End Feed 800A

The Standard End Feed for 800A Bus Systems is larger than the 400A and 250A enclosures to accommodate larger conductors, conduit, and cable bend radius. Each Standard End Feed must be ordered with a Starter Rail, which must be the first bus rail in the bus run.

Like the other Standard End Feeds, the 800A enclosure can be used in either right-hand (RH) or left-hand (LH) orientation, but the combination of the Standard End Feed and its Starter Rail should be ordered in LH or RH orientation, which determines the position of neutral in the bus run.



### 2.3.4 Standard End Feed Options 250A/400A/800A

Both LH and RH Standard End Feeds can have the following options:

- Monitoring
  - Source Power Monitoring
  - Tap-Off Box Monitoring
- Isolated ground
- Power disconnect (various options), providing local circuit breaker, usually on bottom of end feed, or fuse
- Infrared scan window

#### Monitoring

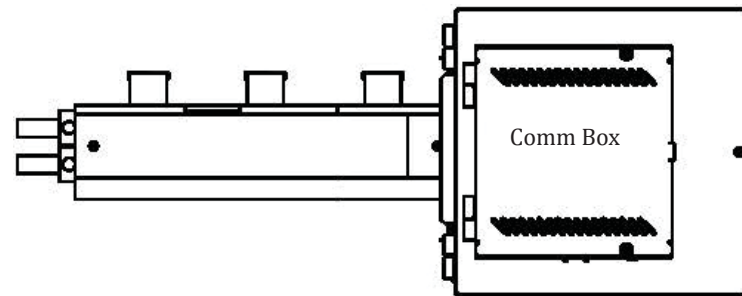
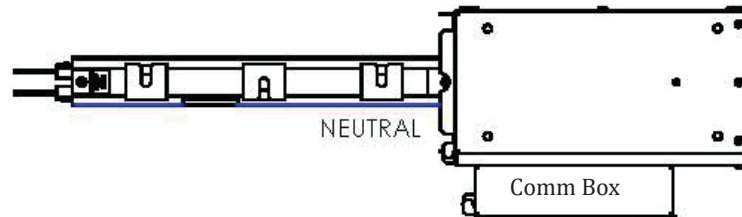
Monitoring can be selected for

- Source Power
- Tap-Off Boxes
- Both

Any Monitoring option requires a Comm Box, which contains monitoring PCBs and other communications devices.

The Comm Box is installed on a side panel door, which replaces a side panel. The Comm Box and panel door can be on either side of the end feed enclosure.

The Comm Box itself has a door that opens 180° for easy service access.

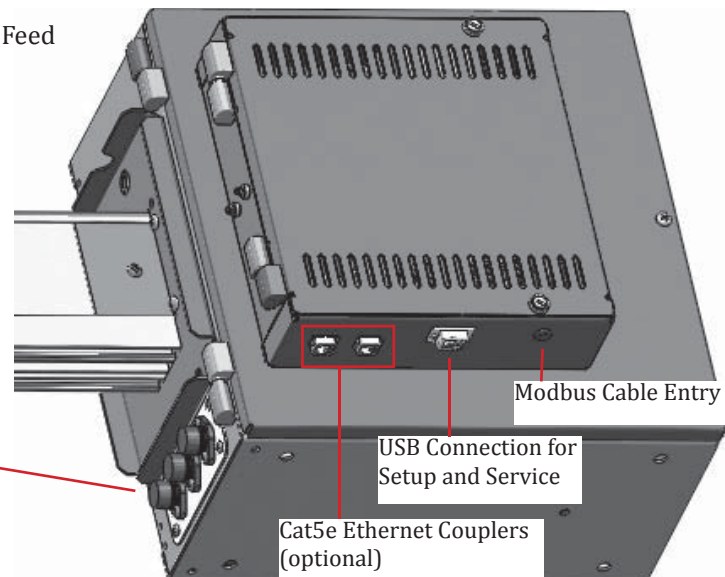


Standard End Feed  
250A RH with  
Monitoring

The Comm Box has external Ethernet connections for Modbus TCP/IP and SNMP, a USB connection used in Setup for BCMS monitoring, and a cable entry port for a Modbus RTU cable.

Fuses for monitoring ABC bus rail voltage phases are easily accessible at the bottom on the enclosure.

The Comm Box itself has a door that opens 180° for easy service access.

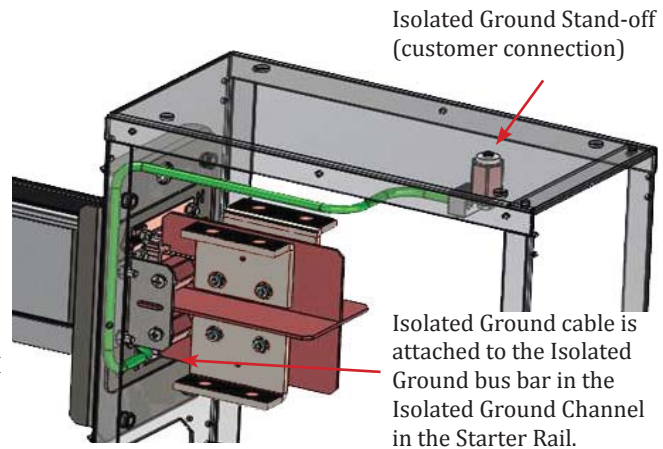


### Isolated Ground

When the Isolated Ground option is selected, a stand-off is installed in the top panel of the Standard End Feed where customer isolated ground is connected.

The isolated ground cable is then connected to the isolated ground bus bar in the Starter Rail and propagated through the bus run.

Standard End Feed 250A RH  
(Panels Off)



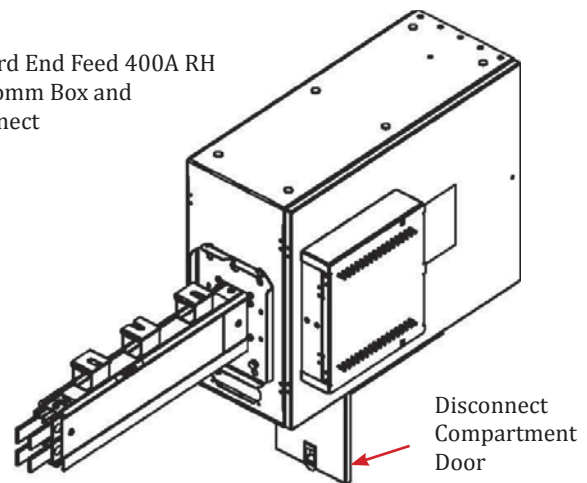
### Power Disconnects

Any Standard End Feed can have a disconnect mounted in the bottom of the enclosure, providing a local disconnect for the bus run that is accessible to operators.

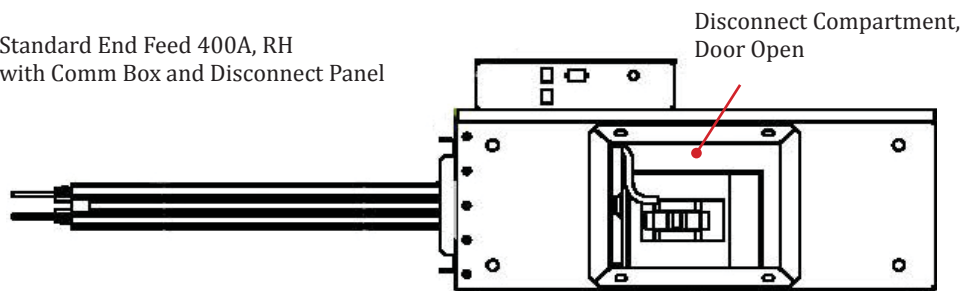
The following disconnects are available:

- 3-Pole Main Circuit Breaker (80% or 100% rated)
- 3-Pole Main Switch/Isolator
- 4-Pole Main Circuit Breaker (80% or 100% rated)
- 4-Pole Main Switch/Isolator
- 3-Pole Fuse Disconnect

Standard End Feed 400A RH  
with Comm Box and  
Disconnect



Standard End Feed 400A, RH  
with Comm Box and Disconnect Panel

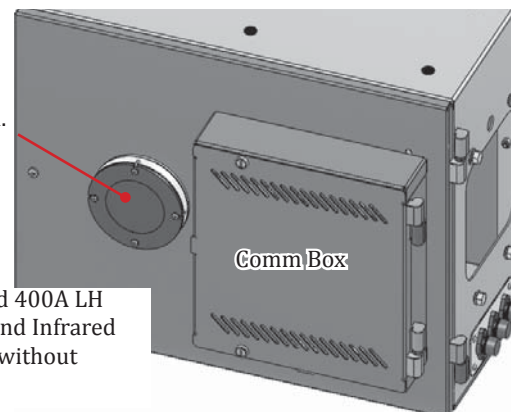


### Infrared Scan Window

An infrared scan window can be installed on the left or right panel or panel door of the Standard End Feed enclosure. The scan window allows infrared scanning of the bus bar connections on the Starter Rail.

**Infrared Scan Window**  
4.75" external dia.  
3" window dia.

Standard End Feed 400A LH  
with Monitoring and Infrared  
Scanning (shown without  
Starter Rail)



### 2.3.5 Standard End Feed Options Summary and Part Numbers

#### Standard End Feed Options Summary:

- Neutral: 100% (Standard) or 150%
- Isolated Ground
- Monitoring:
  - Source Power
  - Tap Off Boxes
- Panel Door (with Monitoring)
  - Standard (same side as Neutral on Starter Rails)
  - Reverse (opposite side from Neutral)
- Disconnects:
  - 3-Pole Main Circuit Breaker (80% or 100% rated)
  - 3-Pole Main Switch/Isolator
  - 4-Pole Main Circuit Breaker (80% or 100% rated)
  - 4-Pole Main Switch/Isolator
  - 3-Pole Fuse Disconnect
- Infrared Scan Window

Enclosure Type	Amperage Rating	Base Part Number (options to be filled in)
Left-Hand - Standard Door	250	HPW2-250-4PG-...-...-EN-LH-....
Left-Hand - Reverse Door	250	HPW2-250-4PG-...-...-EN-LH-RD-....
Right-Hand - Standard Door	250	HPW2-250-4PG-...-...-EN-CH-....
Right-Hand - Reverse Door	250	HPW2-250-4PG-...-...-EN-CH-RD-....
Left-Hand - Standard Door	400	HPW2-400-4PG-...-...-EN-LH-....
Left-Hand - Reverse Door	400	HPW2-400-4PG-...-...-EN-LH-RD-....
Right-Hand - Standard Door	400	HPW2-400-4PG-...-...-EN-CH-....
Right-Hand - Reverse Door	400	HPW2-400-4PG-...-...-EN-CH-RD-....
Left-Hand - Standard Door	800	HPW2-800-4PG-...-...-EN-LH-....
Left-Hand - Reverse Door	800	HPW2-800-4PG-...-...-EN-LH-RD....
Right-Hand - Standard Door	800	HPW2-800-4PG-...-...-EN-RH-....
Right-Hand - Reverse Door	800	HPW2-800-4PG-...-...-EN-LH-RD....

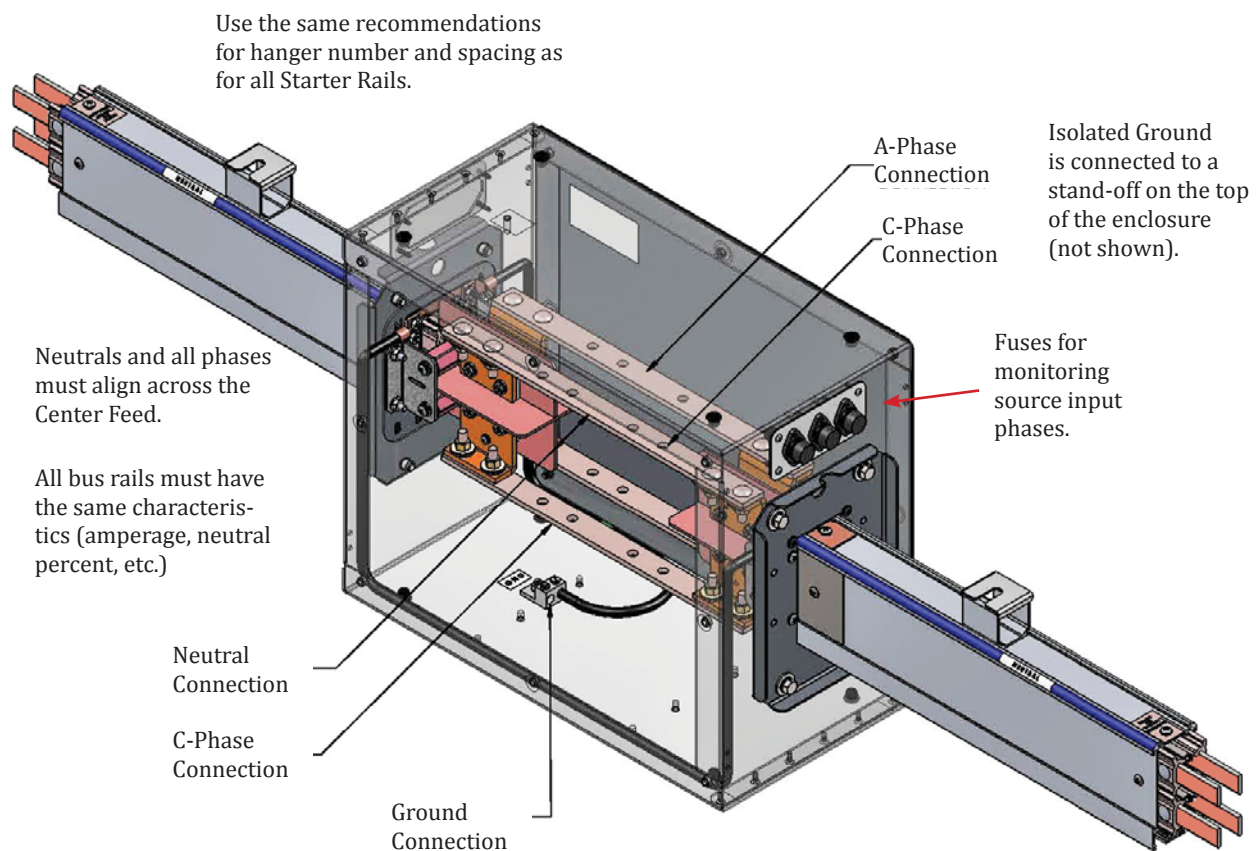
## 2.4 Center Feeds

A Center Feed provides an alternative customer connection location for power, grounding, and monitoring in the center of a bus run, rather than at one end. Center Feeds are available for 250-400A Bus Systems.

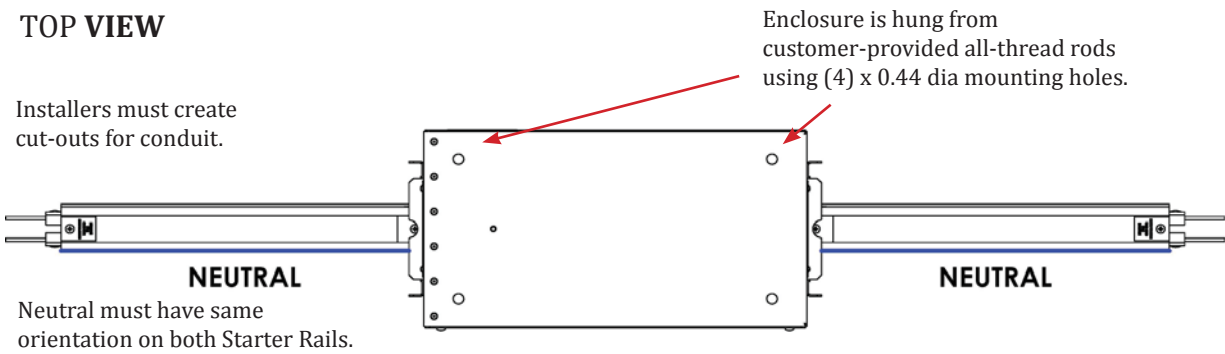
### 2.4.1 Center Feeds 250-400A

The Center Feed has two Starter Rails and has these characteristics:

- The bus run has uniform electrical characteristics: both bus run legs must have the same amperage, neutral rating (100 or 150%), and neutral orientation. Tap-Off Boxes must face the same direction on both legs of the bus run.
- Unlike Standard End Feeds, the Center Feed is shipped with both Starter Rails already installed as a single pre-assembled unit.
- The length of each Starter Rail can be separately customized from 1' to 11.5'. However, shorter Starter Rails minimize the difficulty of shipping, storing, moving, and installing the pre-assembled unit.
- The two Starter Rails are cross-connected with bus bars in the Center Feed enclosure. Customer power is connected to these bus bars.
- Starter Rails are also cross-connected for grounding. Customer safety ground and optional isolated ground connections are the same as for the Standard End Feed: ground is made to a single point (shown below) and isolated ground (optional) is made to a stand-off at the top of the enclosure (not shown).
- The enclosure is the same size for both 250A and 400A.



**TOP VIEW**



**2.4.2 Center Feed Options Summary and Part Numbers**

Center Feed Options Summary:

- Neutral: 100% (Standard) or 150%
- Isolated Ground
- Monitoring:
  - Source power
  - Tap Off Boxes
- Panel Door (with Monitoring)
  - Standard (same side as Neutral on Starter Rails)
  - Reverse (opposite side from Neutral)
- Disconnects (see Standard End Feed for mounting location):
  - 3-Pole Main Circuit Breaker (80% or 100% rated)
  - 3-Pole Main Switch/Isolator
  - 4-Pole Main Circuit Breaker (80% or 100% rated)
  - 4-Pole Main Switch/Isolator
  - 3-Pole Fuse Disconnect
- Infrared Scan Window (see Standard End Feeds for mounting location)

**Note:** Center Feed Options are very similar to Standard End Feed options. See Standard End Feed Options in the previous section for illustrations and descriptions.

Enclosure Type	Amperage Rating	Base Part Number (options to be filled in)
Center Feed-Standard Door	250	HPW2-250-4PG-...-EN-CH-....
Center Feed-Reverse Door	250	HPW2-250-4PG-...-EN-CH-RD-....
Center Feed-Standard Door	400	HPW2-400-4PG-...-EN-CH-....
Center-Feed-Reverse Door	400	HPW2-400-4PG-...-EN-CH-RD-....

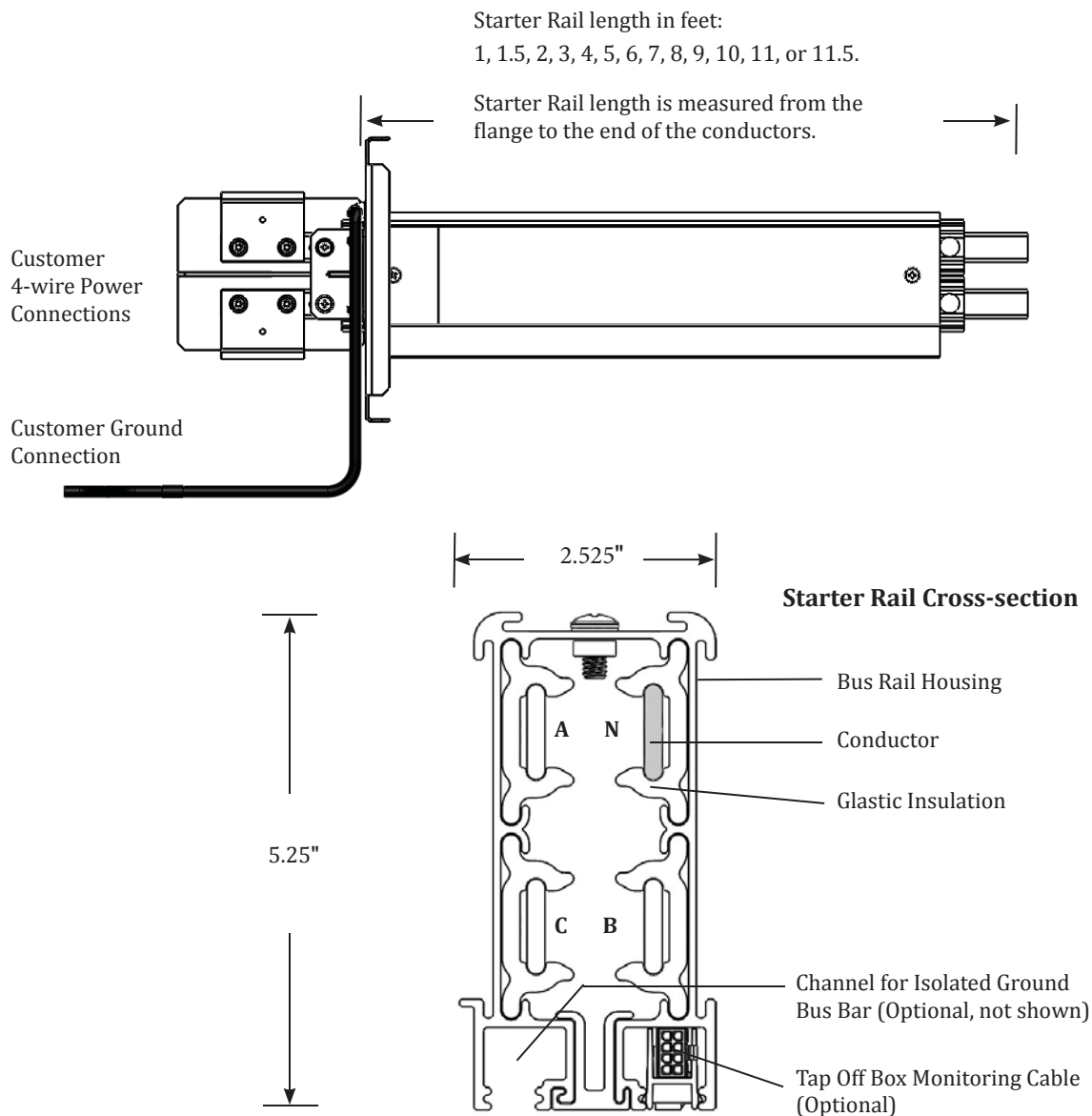
## 2.5 Starter Rails

Each bus run has one and only one Starter Rail. A Starter Rail must be the first bus rail connected to a power feed and has the following connections:

- Power cables (ABCN) from customer power are connected directly to the Starter Rail.
- Ground is connected from the power feed to the Starter Rail and propagated through the rail housing.
- (Optional) isolated ground is connected from the power feed to the isolated ground bus bar in the Starter Rail's isolated ground channel.
- (Optional) Modbus RTU communications cable is connected from the power feed Comm Box to the Communications Channel Modbus connector if Tap Off Box BCMS monitoring is selected.

### 2.5.1 Starter Rails (250-400A)

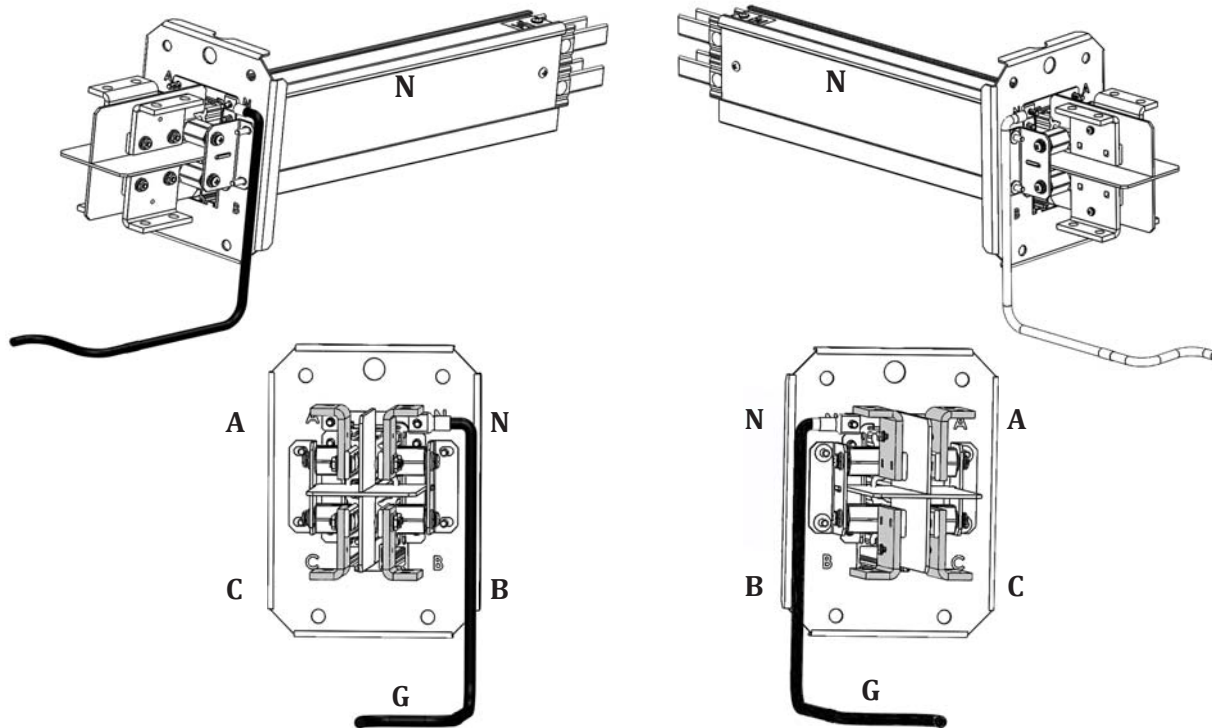
A 250-400A Starter Rail does not come with Side Plates or a Ground Jumper Plate, as Standard Rails do. If a Starter Rail is coupled to a Standard Rail, Elbow, or Tee, the Side Plates and Ground Jumper Plate are provided with the adjoining part. If the Starter Rail is the only bus rail in a short bus run, a Coupler is not required.



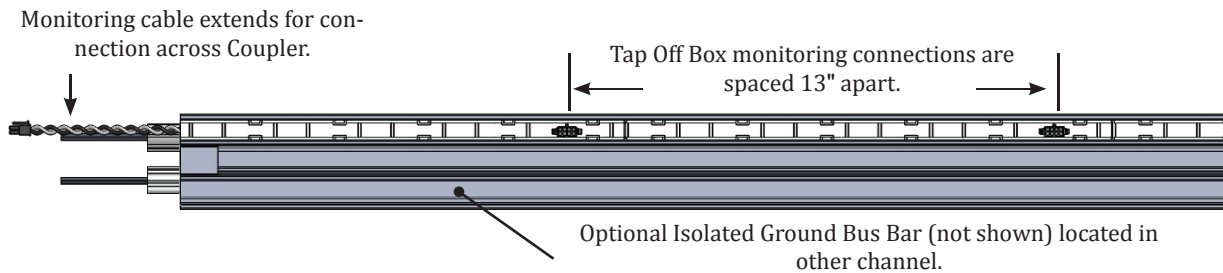
Starter Rails must be ordered as Left-Hand or Right-Hand, which determines the position of neutral and phase conductors and the orientation of Tap Off Boxes.

**Left-Hand (LH)**

**Right-Hand (RH)**



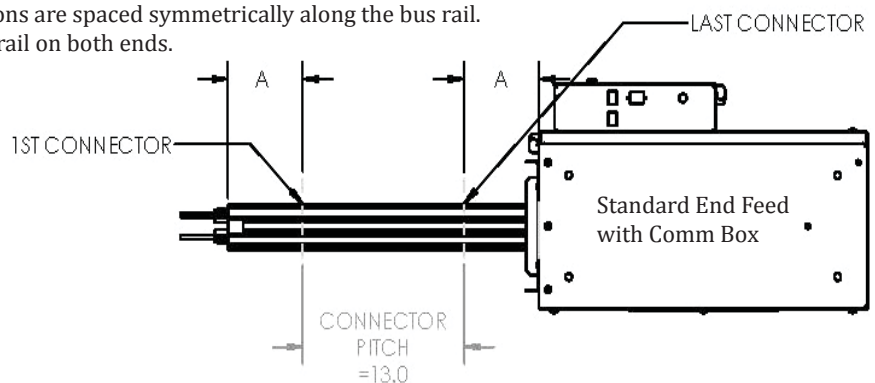
**Bottom Channels: Optional Tap Off Box Monitoring Cable and Isolated Ground Bus Bar**



Tap Off Box monitoring connections are spaced symmetrically along the bus rail.

A = Distance from the end of the rail on both ends.

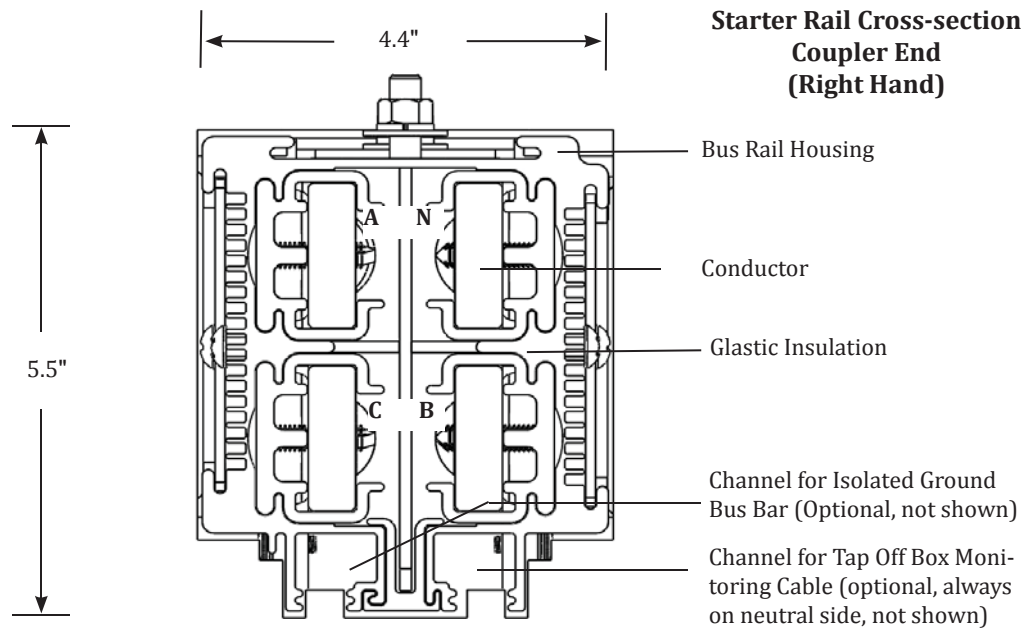
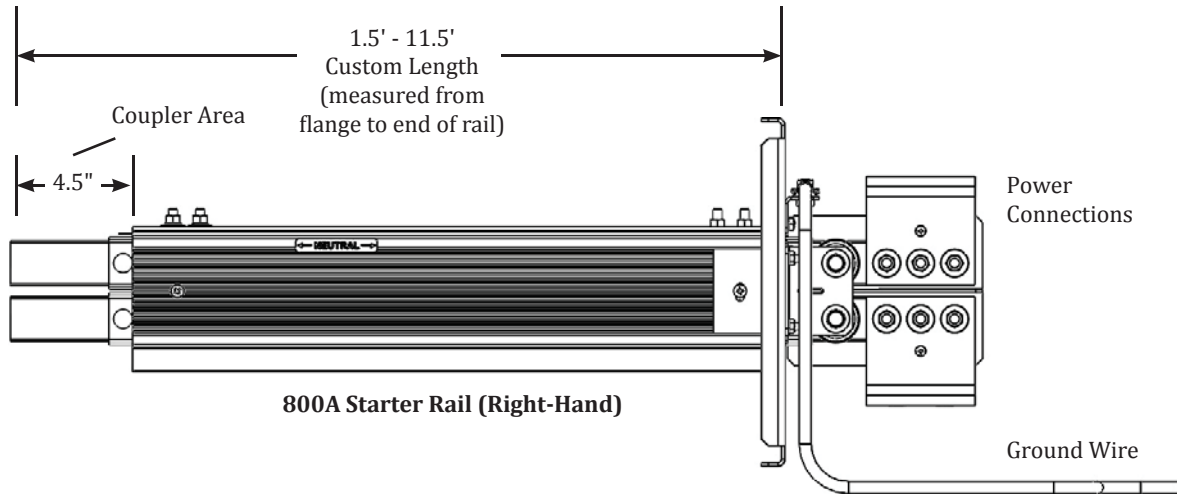
RAIL LENGTH	A	CONNECTOR QTY.
11.5 FEET	8.91	10
11 FEET	4.31	10
10 FEET	11.31	8
9 FEET	5.31	8
8 FEET	12.31	6
7 FEET	6.31	6
6 FEET	13.31	4
5 FEET	7.31	4
4 FEET	7.81	2
3 FEET	1.81	2





### 2.5.2 Starter Rail (800A)

A 800A Starter Rail does not come with Side Plates or a Ground Strap, as 800A Standard Rails do. If a Starter Rail is coupled to a Standard Rail, Elbow, or Tee, the Side Plates and Ground Strap are provided with the adjoining part. If the Starter Rail is the only bus rail in a short bus run, then a Coupler is not required.



### 2.5.3 Starter Rail Options Summary and Part Numbers

Starter Rail Options Summary:

- Neutral: 100% or 150%
- Tap Off Box Monitoring: Modbus RTU cable provided in Starter Rail bottom channel.
- Isolated Ground: Isolated Ground Bus Bar provided in a Starter Rail bottom channel.

Starter Rail	Amperage Rating	BasePart Number (some options to be filled in)
Starter Rail - Left Hand	250	HPW2-250-4PG-...-...-SR-LH-...
Starter Rail - Right Hand	250	HPW2-250-4PG-...-...-SR-RH-...
Starter Rail - Left Hand	400	HPW2-400-4PG-...-...-SR-LH-...
Starter Rail - Right Hand	400	HPW2-400-4PG-...-...-SR-RH-...
Starter Rail - Left Hand	800	HPW2-800-4PG-...-...-SR-LH-...
Starter Rail - Right Hand	800	HPW2-800-4PG-...-...-SR-RH-...

**Note 1:** Left-Hand or Right-Hand determines neutral position. Neutral position determines the direction that Tap Off Boxes face.

**Note 2:** Starter Rails must be ordered with a compatible Standard End Feed or Center Feed.

**Note 3:** PDI recommends that bus run length be customized by specifying a custom length for the Starter Rail while using full-length 12' Standard Rails.

Customer must specify Starter Rail length: 1-11.5 ft. in 6" increments.

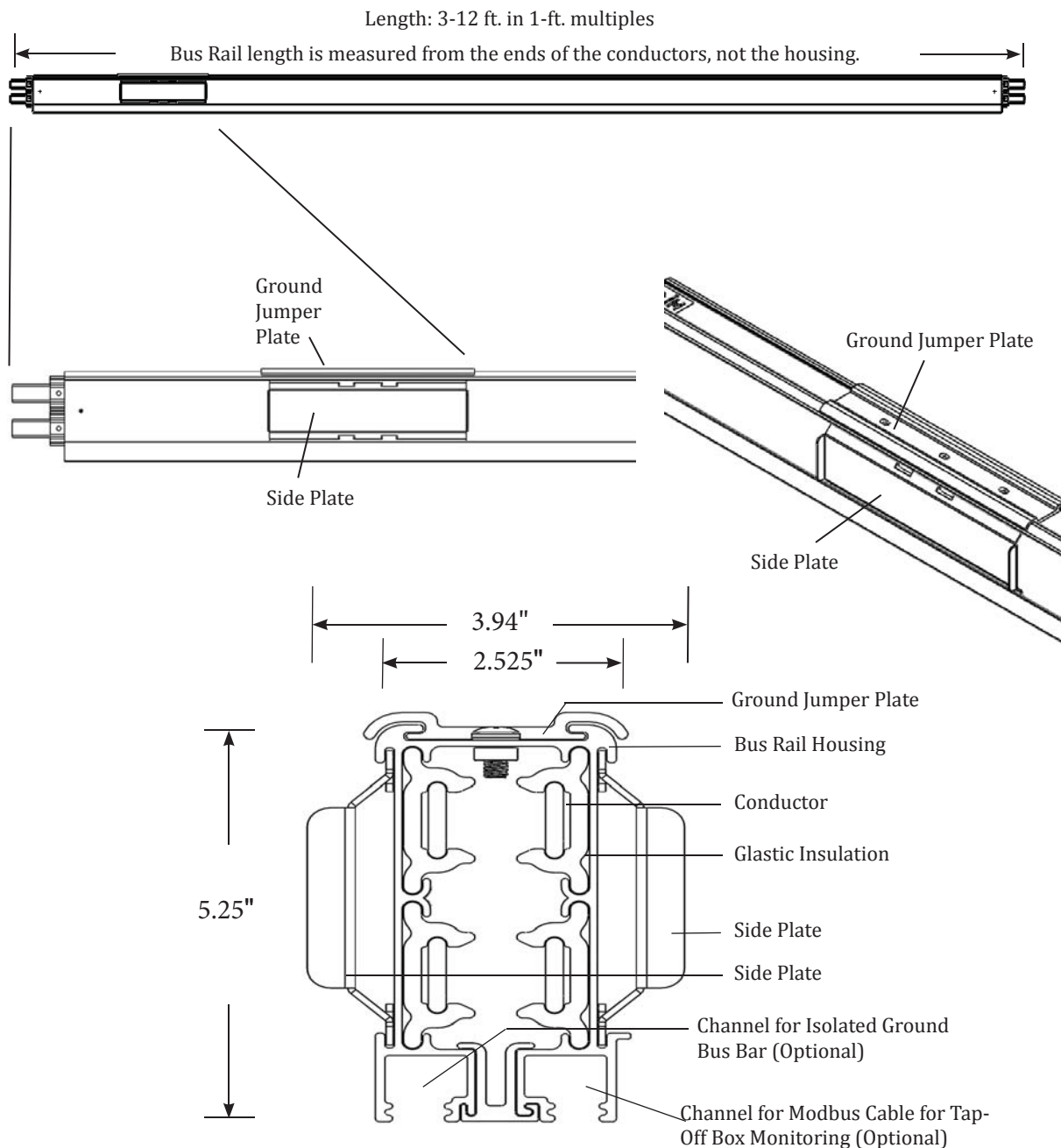
## 2.6 Standard Rails

All bus rails in a bus run after the Starter Rail are Standard Rails. A Standard Rail must be joined to a Starter Rail, Elbow, or Tee using a Coupler.

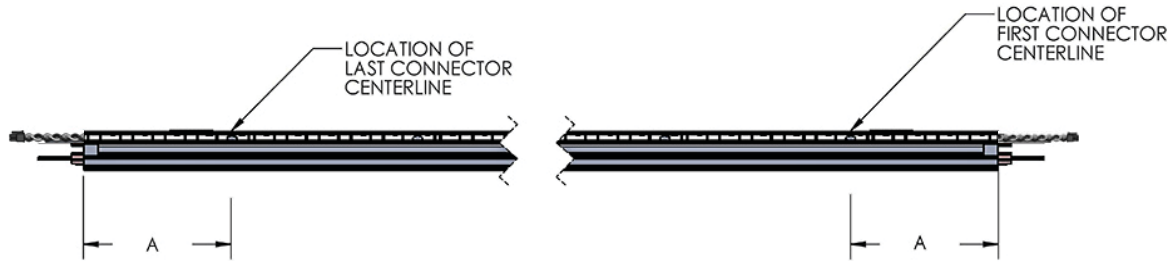
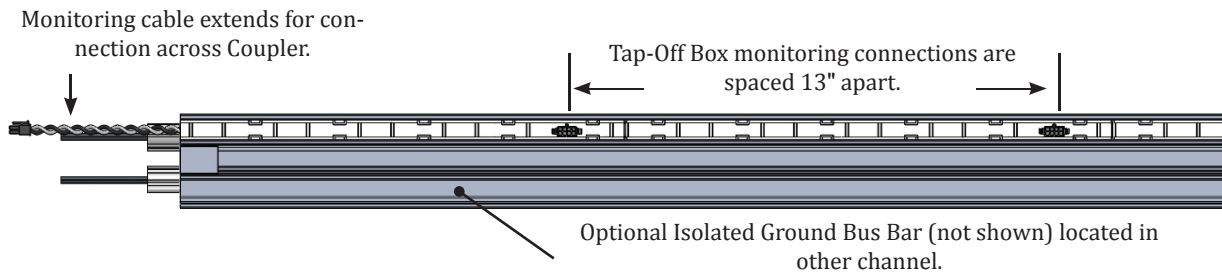
### 2.6.1 Standard Rail (250-400A)

The 250-400A Standard Rail kit includes the following:

- (1) Standard Rail
- (1) Coupler
- (2) Side Plates to slide over the Coupler
- (1) Ground Jumper Plate to connect ground from the bus rail housing across the Coupler to the housing of another bus rail, Elbow, or Tee.



**Bottom Channels: Optional Tap-Off Box Monitoring Cable and Isolated Ground Bus Bar**



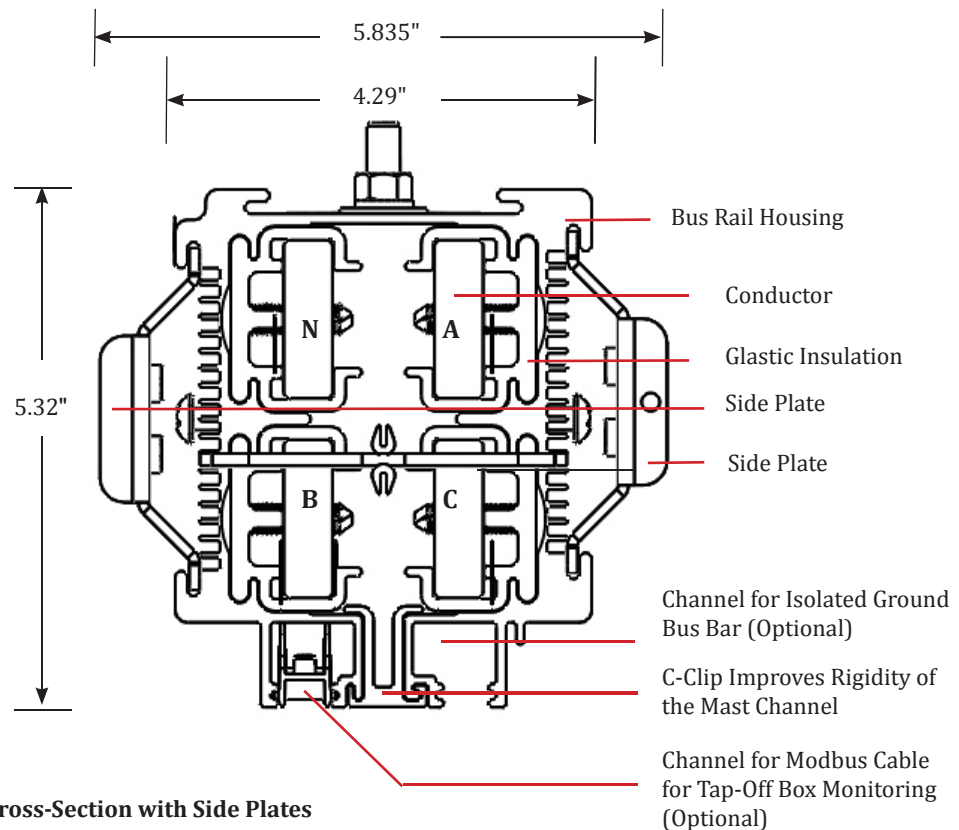
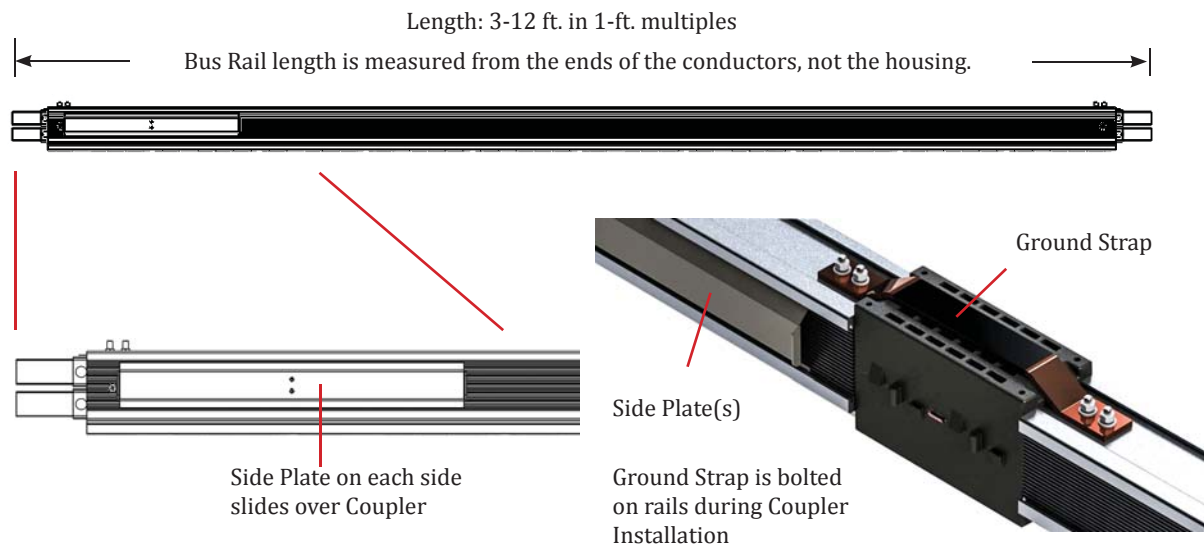
Tap-Off Box monitoring connections are spaced symmetrically along the bus rail.  
 A = Distance from the end of the rail on both ends.

RAIL LENGTH	A	CONNECTOR QTY.
12 FEET	10.31	10
11 FEET	4.31	10
10 FEET	11.31	8
9 FEET	5.31	8
8 FEET	12.31	6
7 FEET	6.31	6
6 FEET	13.31	4
5 FEET	7.31	4
4 FEET	7.81	2
3 FEET	1.81	2

### 2.6.2 Standard Rail (800A)

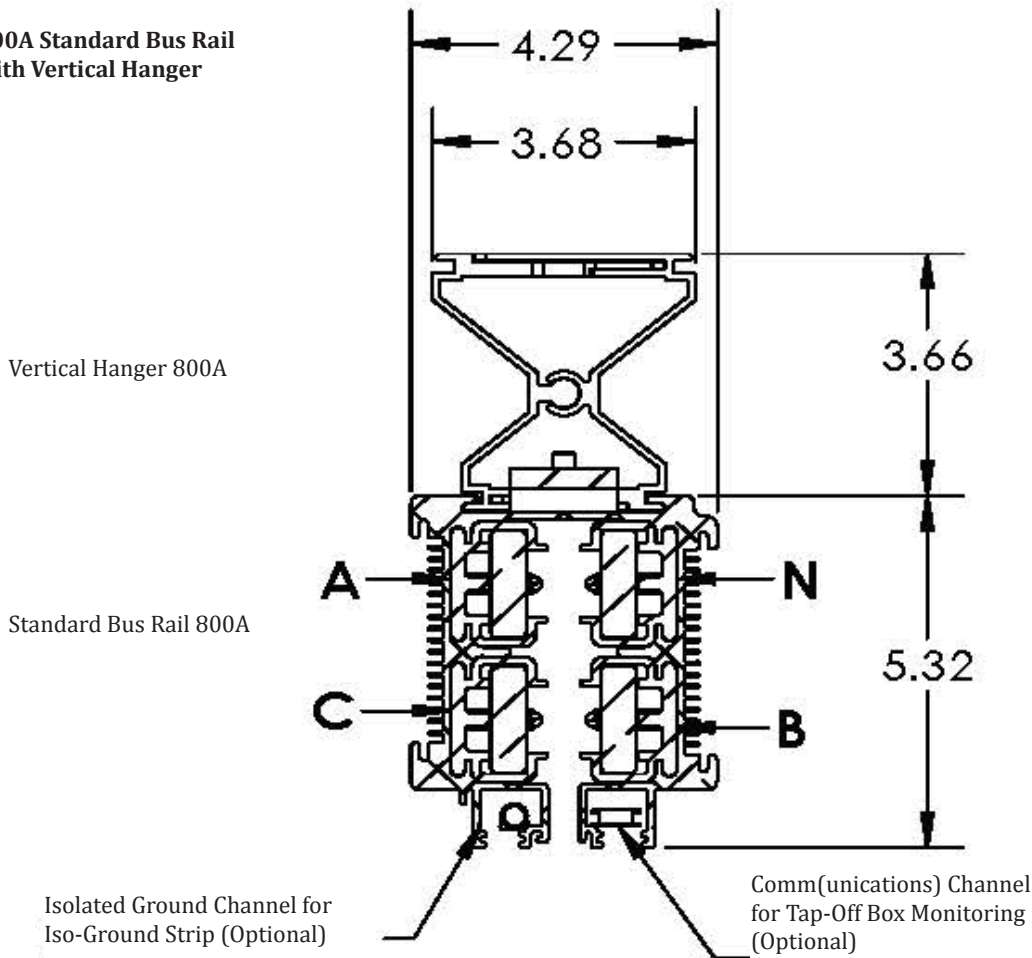
The 800A Standard Rail kit includes includes the following :

- (1) Standard Rail
- (1) Coupler
- (2) Side Plates to slide over the Coupler
- (1) Ground Strap to connect ground across the Coupler to the housing of another bus rail, Elbow, or Tee.



**800A Standard Rail Cross-Section with Side Plates**

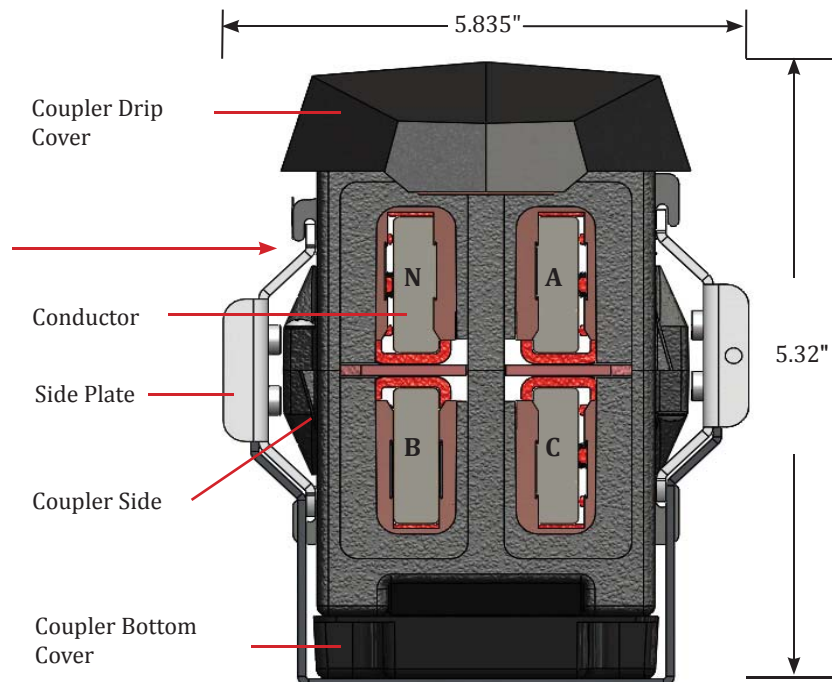
**800A Standard Bus Rail with Vertical Hanger**



The Comm Channel is always on the Neutral side of the rail.

**800A Standard Rail with Coupler Installed**

On 800A Bus Systems, the Side Plate on the Neutral side of the rail is lower than on the other side. This asymmetry assures that Neutrals are aligned on adjacent rails, Elbows, or Tees when they are coupled together.



### 2.6.3 Standard Rail Options Summary and Part Numbers

Standard Rail Options Summary:

- Neutral 100% or 150%
- Tap-Off Box Monitoring: Modbus RTU cable provided in Standard Rail bottom channel.
- Isolated Ground: Isolated Ground Strip provided in a Standard Rail bottom channel.

Standard Rail Length	Rated Amperage	Part Number (Some Options to be Filled in)
3 Ft	250	HPW2-250-4PG-.....-BR-036-....
5 Ft	250	HPW2-250-4PG-.....-BR-060-...
6 Ft	250	HPW2-250-4PG-.....-BR-072-....
10 Ft	250	HPW2-250-4PG-.....-BR-120-..
12 Ft	250	HPW2-250-4PG-.....-BR-144-....
3 Ft	400	HPW2-400-4PG-.....-BR-036-....
5 Ft	400	HPW2-400-4PG-.....-BR-060-....
6 Ft	400	HPW2-400-4PG-.....-BR-072-....
10 Ft	400	HPW2-400-4PG-.....-BR-120-....
12 Ft	400	HPW2-400-4PG-.....-BR-144-....
3 Ft	800	HPW2-800-4PG-.....-BR-036-....
5 Ft	800	HPW2-800-4PG-.....-BR-060-....
6 Ft	800	HPW2-800-4PG-.....-BR-072-....
10 Ft	800	HPW2-800-4PG-.....-BR-120-....
12 Ft	800	HPW2-800-4PG-.....-BR-144-....

**Note 1:** Left-Hand or Right-Hand determines neutral position. Neutral position determines the direction that Tap-Off Boxes face.

**Note 2:** PDI recommends that bus run length be customized by specifying a custom length for the Starter Rail while using full-length 12' Standard Rails.

**Note 3:** Customer must specify Standard Rail length: 1-12 ft. in 6" increments.

## 2.7 Elbows

An Elbow turns the bus run at a right angle. An Elbow has two legs and must be connected to bus rails on each leg with Couplers. Elbows are standard parts with fixed leg lengths. Leg lengths cannot be customized.

Options for the neutral conductor:

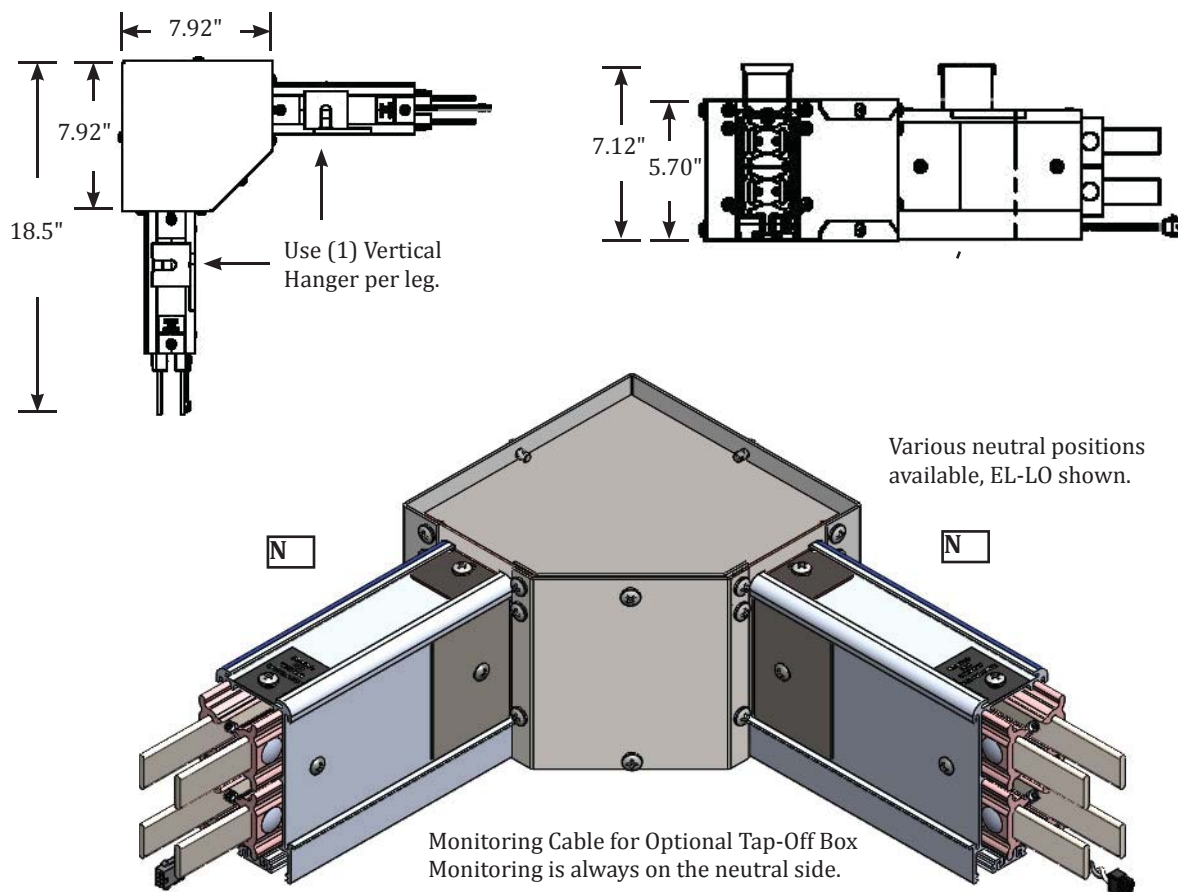
- The neutral position can “cross-over” or change sides from one leg of the Elbow to the other. See “Elbow Neutral Orientations.”
  - Because Tap-Off Boxes must face out from the neutral side of the bus run, changing the neutral side from one Elbow leg to the other repositions the bus run for a different server-rack orientation.
  - As with other bus run components, the position of neutral on each leg determines the position of all conductors, the optional Tap-Off Box monitoring cable, and the optional isolated ground bus bar on that leg.
- Neutral percent can be 100% or 150% of phase conductors. However, the amperage rating and neutral percent must be the same as the bus rails in the same bus run.

Other Elbow characteristics:

- Elbows are available for vertical bus runs only.
- Elbows use the same hangers as vertical bus rails of the same amperage.
- Optional Tap-Off Box BCMS monitoring and optional Isolated Ground must be specified identically to that for the adjacent bus rails.

### 2.7.1 Elbow 250-400A

Part dimensions are the same for both 250A and 400A Elbows, although the conductor bus bars are larger for 400A. See the following illustration for part dimensions.





### 2.7.2 Elbow 800A

800A Elbows have two (2) available neutral configurations:

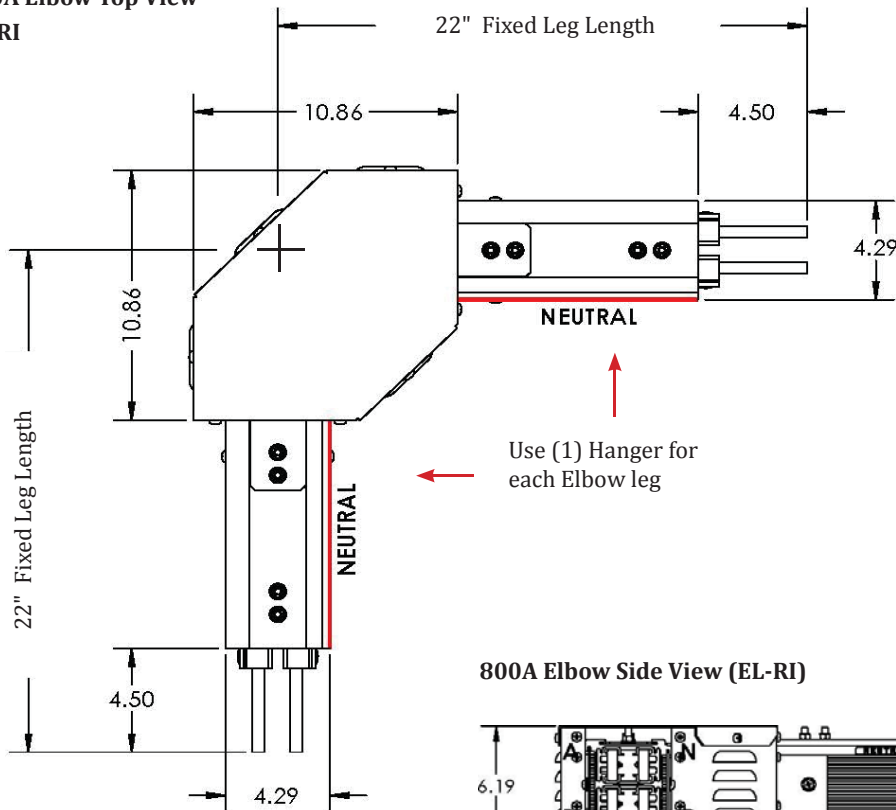
- Both neutrals on the inside of the elbow bend (RI=Right Inner)
- Both neutrals on the outside of the elbow bend (LO=Left Outer)
- Neutral cross-over configurations are not available.

Elbow leg lengths are fixed at 22".

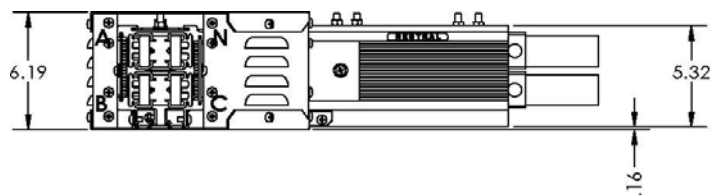
Other options are the same as for 250A and 400A Elbows.

#### 800A Elbow Top View

EL-RI

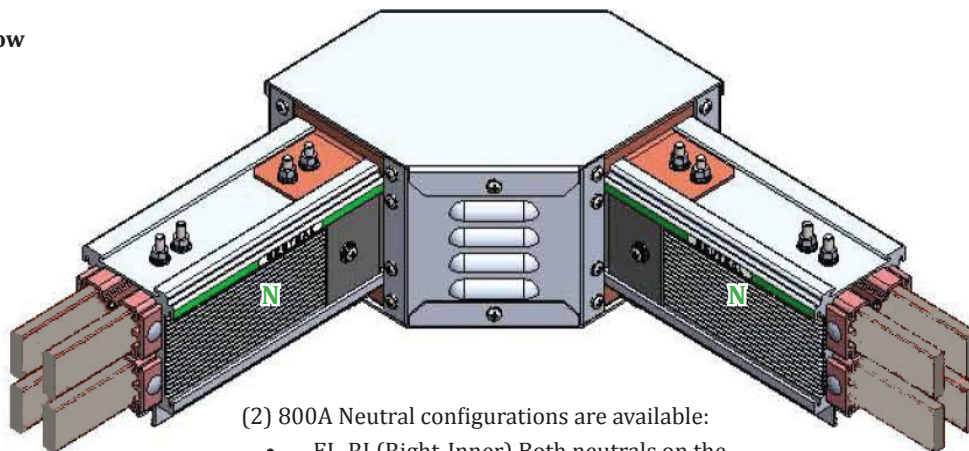


#### 800A Elbow Side View (EL-RI)



#### 800A Elbow

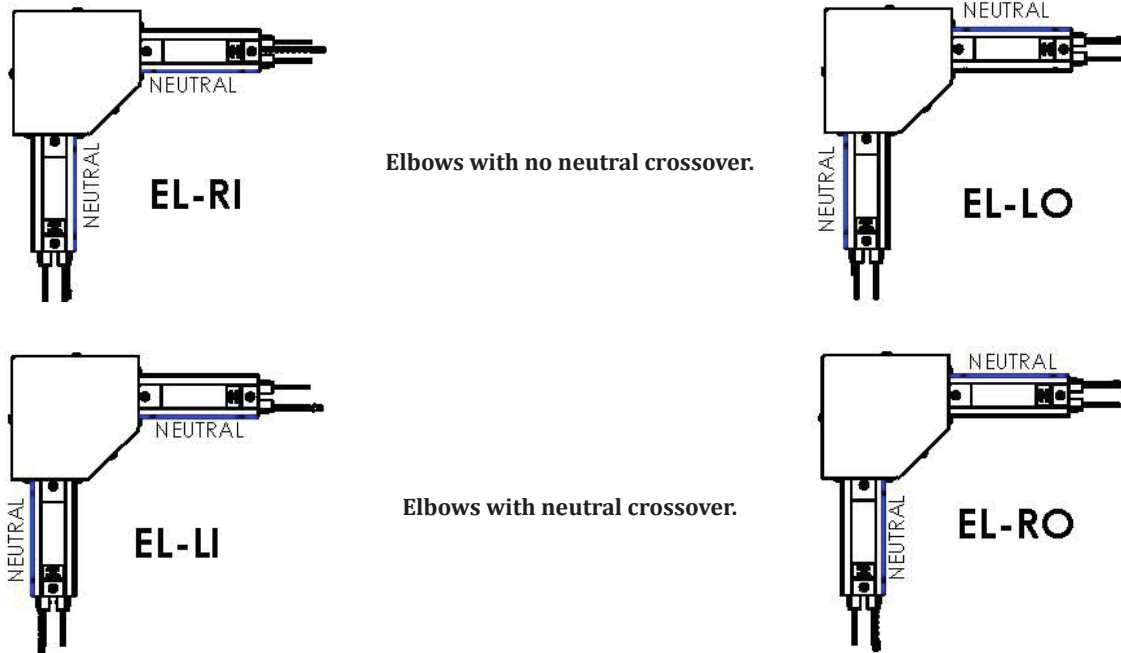
EL-RI



(2) 800A Neutral configurations are available:

- EL-RI (Right-Inner) Both neutrals on the "inside" (shown)
- EL-LO (Left-Outer) Both neutrals on the "outside"

### 2.7.3 Elbow Neutral Positions



### 2.7.4 Elbow Options Summary and Part Numbers

Elbow Options Summary:

- Neutral 100% or 150%
- Tap-Off Box Monitoring: Modbus RTU cable provided in Standard Rail bottom channel.
- Isolated Ground: Isolated Ground Strip provided in a Standard Rail bottom channel.

Elbow Orientation	Amperage Rating	Part Number
ELLO	250	HPW2-250-4PG-X-ELLO-A012-B012
ELLI	250	HPW2-250-4PG-X-ELLI-A012-B012
ELRO	250	HPW2-250-4PG-X-ELRO-A012-B012
ELRI	250	HPW2-250-4PG-X-ELRI-A012-B012
ELLO	400	HPW2-400-4PG-X-ELLO-A018-B018
ELLI	400	HPW2-400-4PG-X-ELLI-A018-B018
ELRO	400	HPW2-400-4PG-X-ELRO-A018-B018
ELRI	400	HPW2-400-4PG-X-ELRI-A018-B018
ELLO	800	HPW2-800-4PG-X-ELLO-A024-B024
ELRI	800	HPW2-800-4PG-X-ELRI-A024-B024

**Note:** Amperage and elbow orientation determine part number.

## 2.8 Tees

A Tee creates a bus run leg perpendicular to a straight bus run. A Tee has three legs and must be connected to bus rails on each leg with Couplers. Tees are standard parts with fixed leg lengths. Leg lengths cannot be customized.

Options for the neutral conductor:

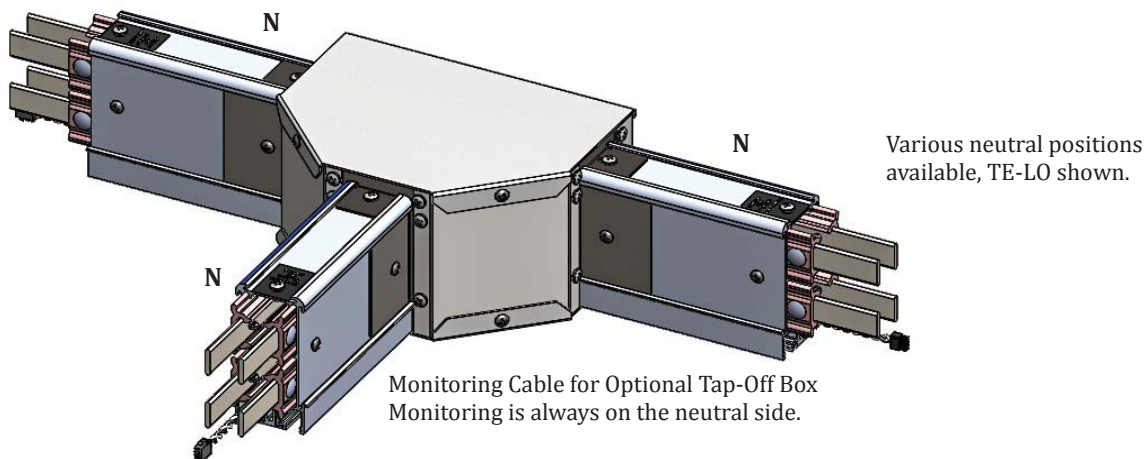
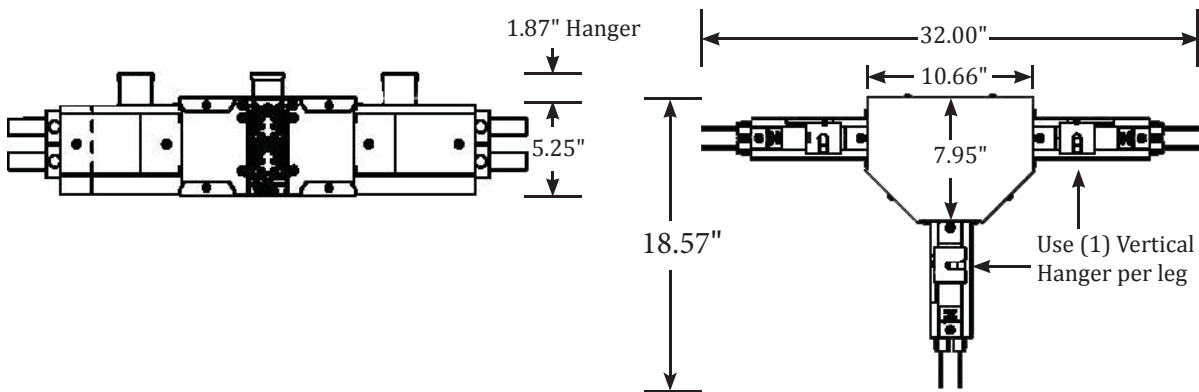
- A Tee has two legs that are part of the straight bus run. The neutral can be on either side of these legs but must always be on the same side on both legs.
- The Tee has a third perpendicular leg that branches off 90° from the straight bus run legs. The neutral position on this leg can be on either side. See “Tee Neutral Orientations” on the next page.
  - Because Tap-Off Boxes must face out from the neutral side of the bus run, you should specify the neutral side of the perpendicular leg according to server-rack orientation.
  - As with other bus run components, the position of neutral on each leg also determines the position of all conductors, the optional Tap-Off Box monitoring cable, and the optional isolated ground bus bar on that leg.
- Neutral percent can be 100% or 150% of phase conductors. However, the amperage rating and neutral percent must be the same as the attached bus rails.

Other Tee characteristics:

- Tees are available for vertical bus runs only.
- Tees require one hanger per leg, that should be the same hanger used for vertical bus rails of the same amperage.
- Optional Tap-Off Box BCMS monitoring and optional Isolated Ground must be specified identically to that for the adjacent bus rails.

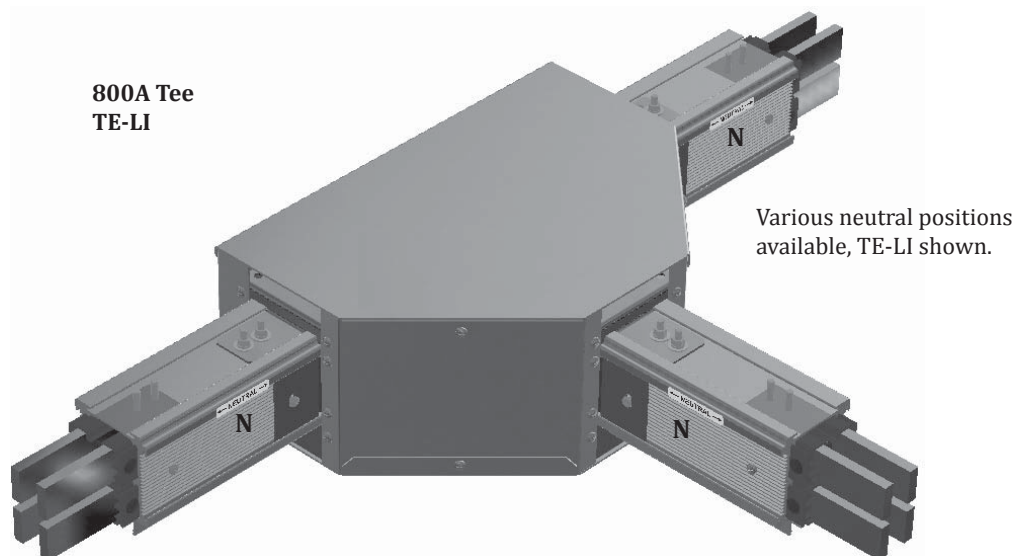
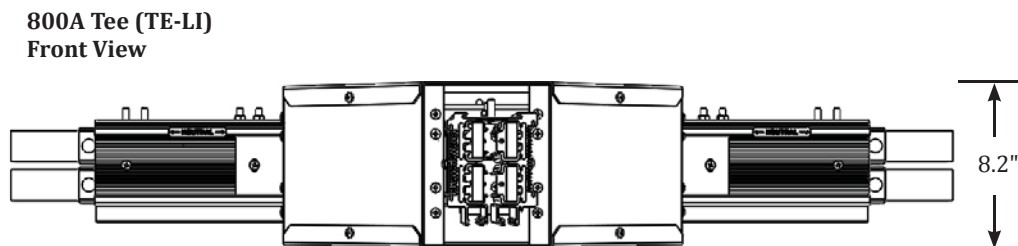
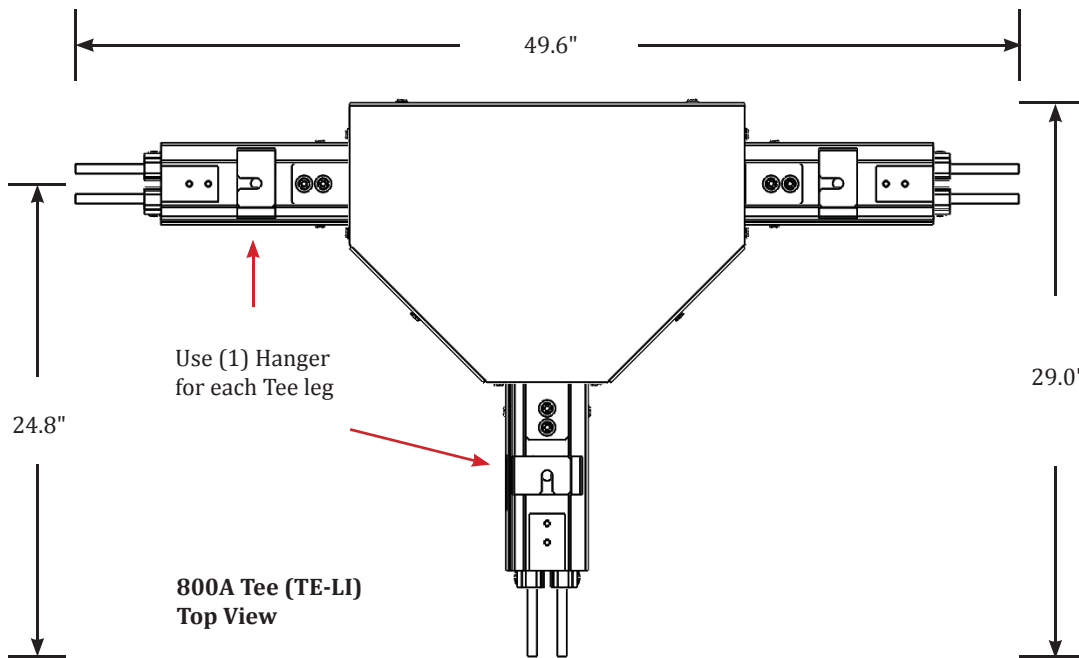
### 2.8.1 Tee 250-400A

Part dimensions are the same for both 250A and 400A Tees, although the conductor bus bars are larger for 400A. See the following illustration for part dimensions.



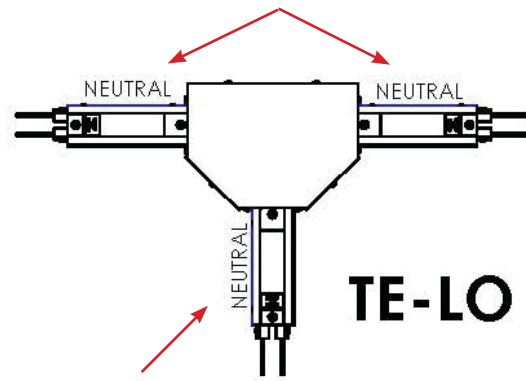
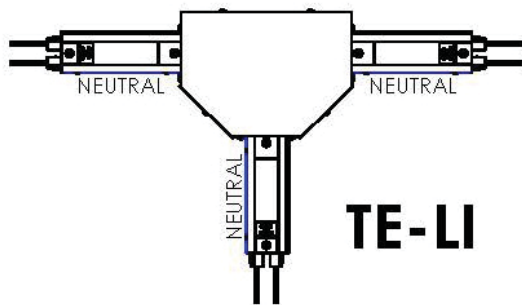
**2.8.2 Tee 800A**

800A Tees are larger than 250A and 400A Tees but neutral configuration options and other options are the same.

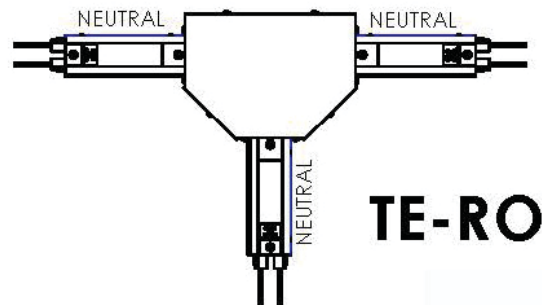
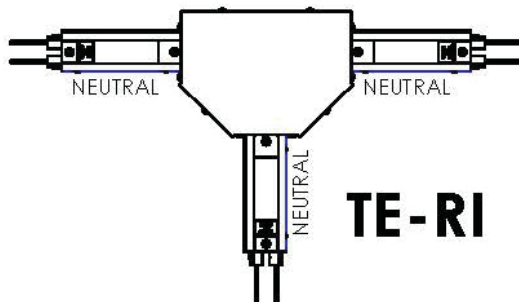


### 2.8.3 Tee Neutral Positions

On the “straight” legs of the bus run, **neutral** must be on the same side on both legs.



The branched leg can have neutral on either side.



### 2.8.4 Tee Options Summary and Part Numbers

Tee Options Summary:

- Neutral 100% or 150%
- Tap-Off Box Monitoring: Modbus RTU cable provided in Standard Rail bottom channel.
- Isolated Ground: Isolated Ground Strip provided in a Standard Rail bottom channel.

Elbow Orientation	Amperage Rating	Part Number
TELO	250	HPW2-250-4PG-X-TELO-A012-B012-C012
TELI	250	HPW2-250-4PG-X-TELI-A012-B012-C012
TERO	250	HPW2-250-4PG-X-TERO-A012-B012-C012
TERI	250	HPW2-250-4PG-X-TERI-A012-B012-C012
TELO	400	HPW2-400-4PG-X-TELO-A018-B018-C018
TELI	400	HPW2-400-4PG-X-TELI-A018-B018-C018
TERO	400	HPW2-400-4PG-X-TERO-A018-B018-C018
TERI	400	HPW2-400-4PG-X-TERI-A018-B018-C018
TELO	800	HPW2-800-4PG-X-TELO-A018-B018-C018
TELI	800	HPW2-800-4PG-X-TELI-A018-B018-C018
TERO	800	HPW2-800-4PG-X-TERO-A018-B018-C018
TERI	800	HPW2-800-4PG-X-TERI-A018-B018-C018

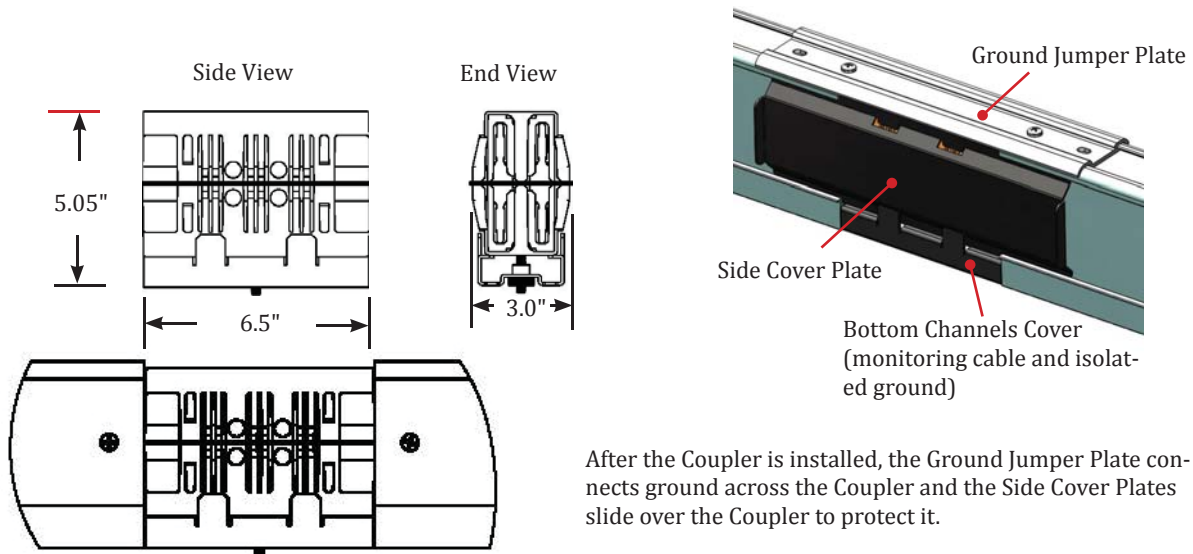
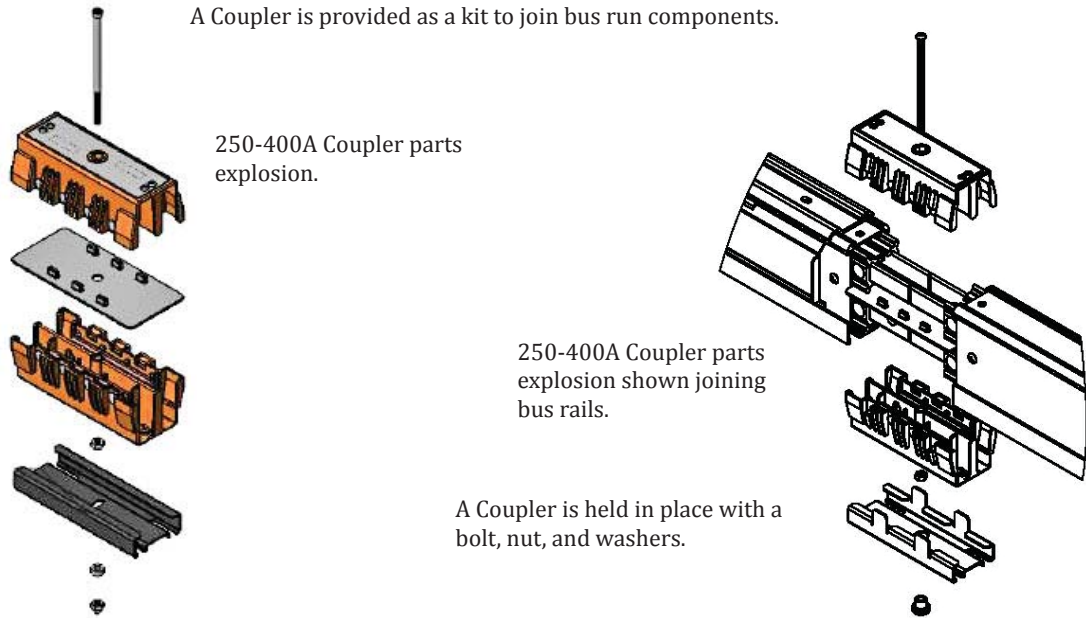
**Note:** Amperage and Tee orientation determine part number.

## 2.9 Accessories

### 2.9.1 Couplers 250-400A

A Coupler is provided as a kit to join Starter Rails, Standard Rails, Elbows, and Tees into a bus run. (1) Coupler and (1) Ground Jumper Plate are included with each Standard Rail.

250-400A Couplers install quickly and require no special tools. 250A and 400A Couplers have the same dimensions, but the 400A Coupler accommodates the larger 400A conductor bus bars.



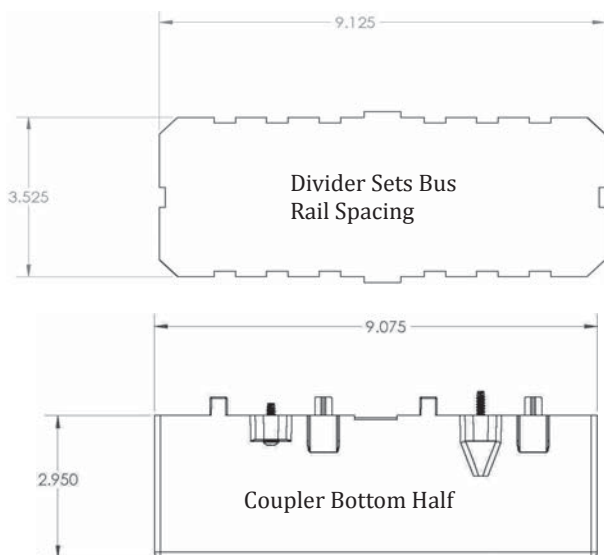
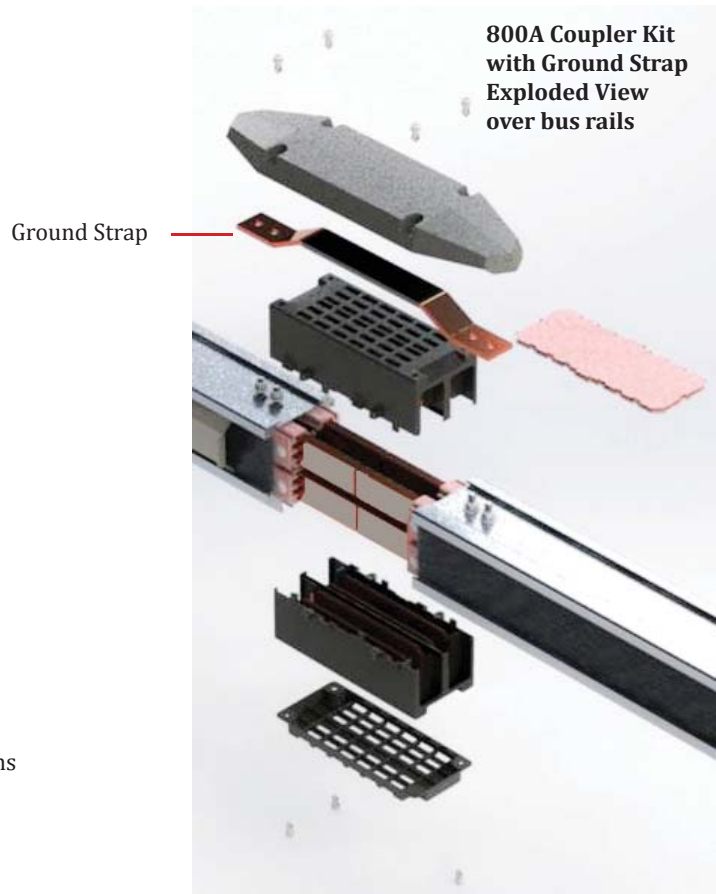
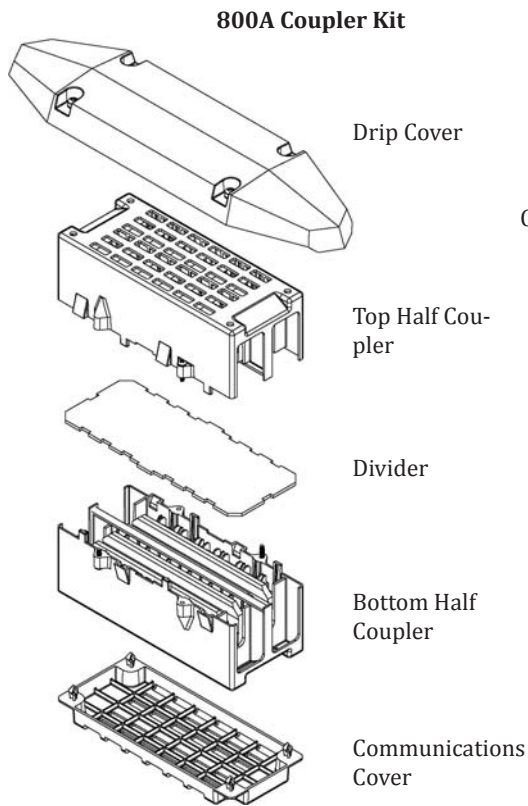
After the Coupler is installed, the Ground Jumper Plate connects ground across the Coupler and the Side Cover Plates slide over the Coupler to protect it.

Optional monitoring communications cable and isolated ground strip are connected through the Bottom Channels Cover.

### 2.9.2 Coupler 800A

A Coupler is provided as a kit to join Starter Rails, Standard Rails, Elbows, and Tees into a bus run. Each Standard Rail is shipped with (1) Coupler and (1) Ground Strap.

800A Couplers are larger than 250A or 400A Couplers to accommodate the larger 800A conductor bus bars and have a different but similar structure.



### 2.9.3 Vertical Hanger 250-400A

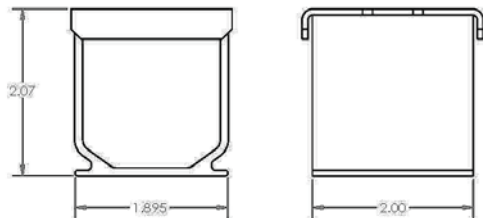
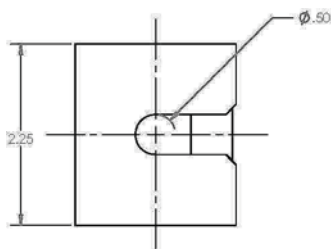
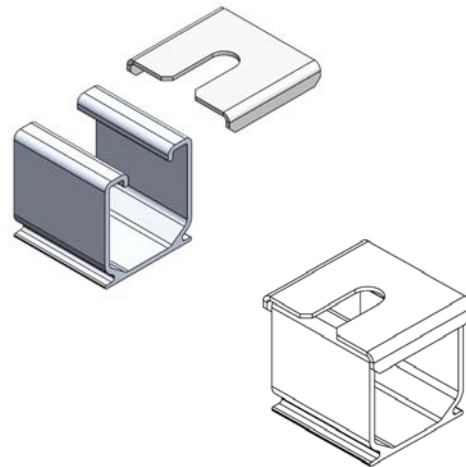
Vertical Hangers are used in vertical bus runs to suspend Starter Rails, Standard Rails, Elbows, and Tees from overhead structures (but not Standard End Feeds or Center Feeds).

PDI recommends three (3) Vertical Hangers per 12' (3.66 m) bus rail:

- Place a hanger within 1' of each bus rail end.
- Place one (1) hanger evenly spaced between the end hangers at about 5' spacing on full-sized rail.
- Hangers should be spaced no more than 5' from each other.

Elbows and Tees: Place a hanger on each leg of the Elbow or Tee.

Vertical Hangers are suspended using all-thread and Unistrut nuts. Hangers are for 0.375" rods. All-thread rods and Unistrut nuts are provided by the customer.



Customer provides suspension hardware including Unistrut nuts and all-thread rods.

Unistrut nut





### 2.9.4 Vertical Hanger 800A

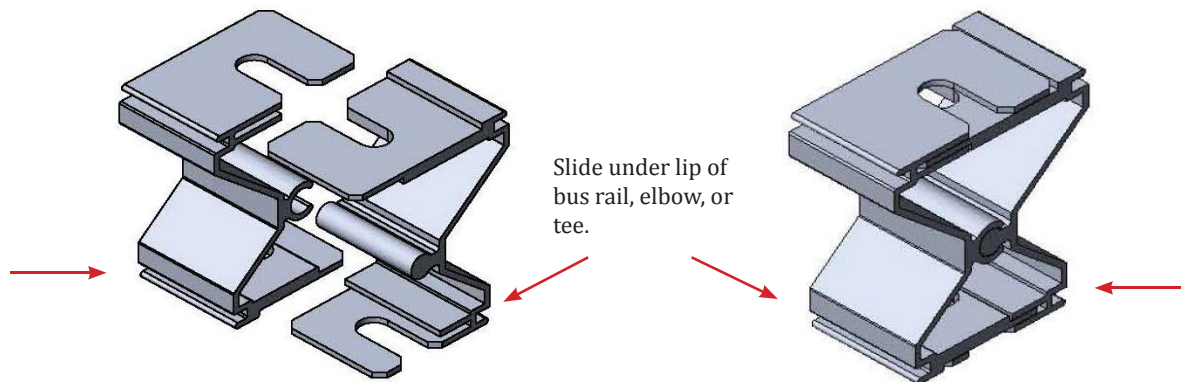
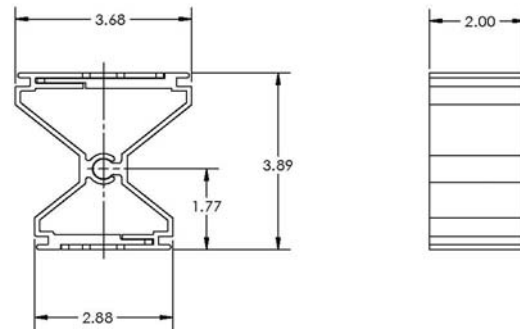
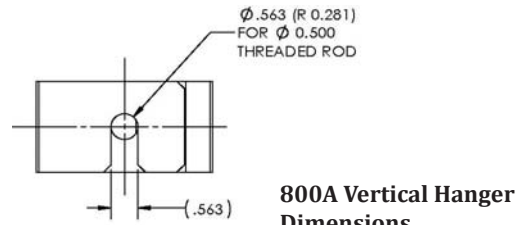
Vertical Hangers are used in vertical bus runs to suspend Starter Rails, Standard Rails, Elbows, and Tees from overhead structures (but not Standard End Feeds).

PDI recommends three (3) Vertical Hangers per 12' (3.66 m) bus rail:

- Place a hanger within 1' of each bus rail end.
- Place one (1) hanger evenly spaced between the end hangers at about 5' spacing on full-sized rail.
- Hangers should be spaced no more than 5' from each other.

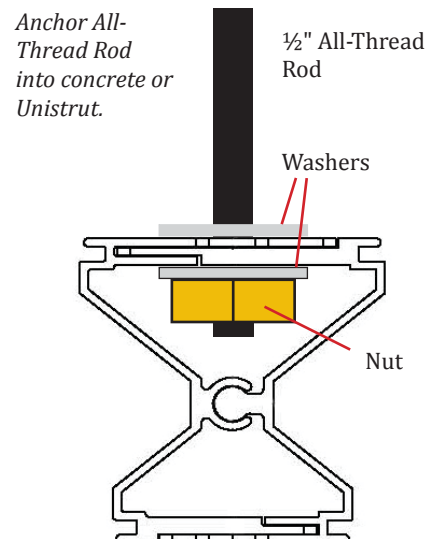
Elbows and Tees: Place a hanger on each leg of the Elbow or Tee.

Vertical Hangers are suspended from concrete or Unistruts. Hangers are for 0.50" rods. Suspension hardware other than hangers is provided by the customer.



800A Vertical Hangers can be inserted into bus rails at any point. Insert the halves into the rail, securing them to the lip of the top (ground) channel and slide them together.

When the halves are joined together, the hanger provides a robust support point for the bus run.



### 2.9.5 Horizontal Hanger

Horizontal Hangers are used to suspend Starter Rails and Standard Rails from ceilings or overhead support structures.

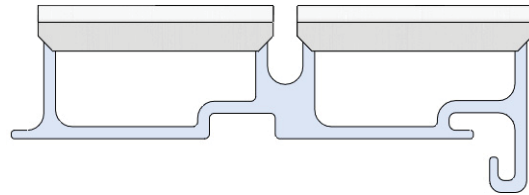
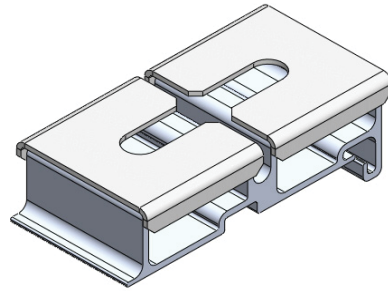
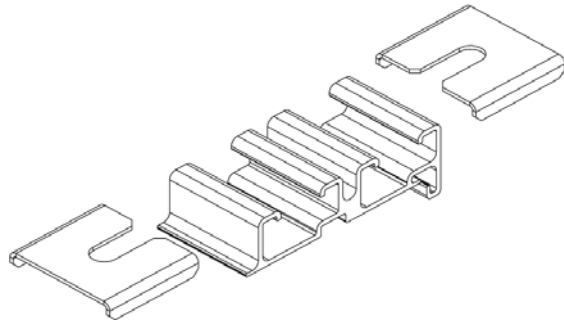
Horizontal Hangers are suspended using all-thread and Unistrut nuts. Hangers are for 0.375" rods. All-thread rods and Unistrut nuts are provided by the customer.

Horizontal bus runs require a wider hanger because the broad side of the bus rail faces upward. Horizontal bus runs also require more hangers per length than vertical runs.

PDI recommends (4) four horizontal hangers per 12' (3.66 m) bus rail:

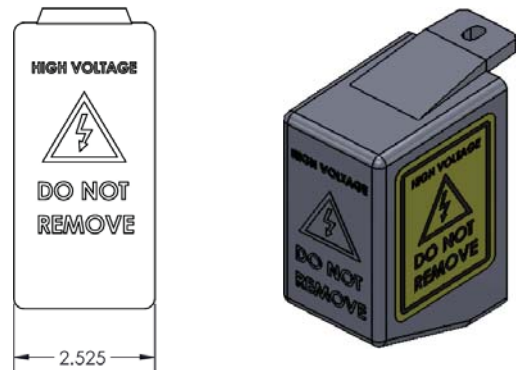
- Place a hanger within 1' of each bus rail end.
- Place two (2) hangers evenly spaced between the end hangers or about 3.33' spacing.
- Hangers should be spaced no more than 3.5' from each other.

Horizontal Hangers are not used to suspend Standard End Feeds or Center Feeds.



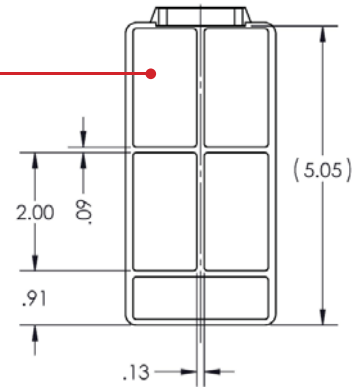
### 2.9.6 End Cap 250-400A

The end of each bus run has exposed high voltage and amperage bus bars and must be covered by an End Cap. If the bus run is forked by a Tee, the bus run will need an extra End Cap to cover the exposed leg of the forked bus run.



Conductors are individually isolated.

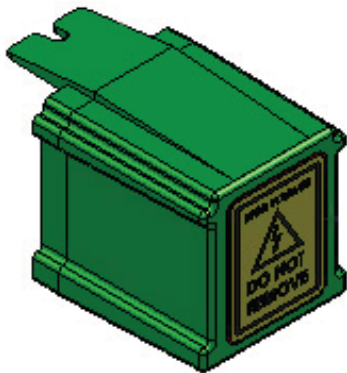
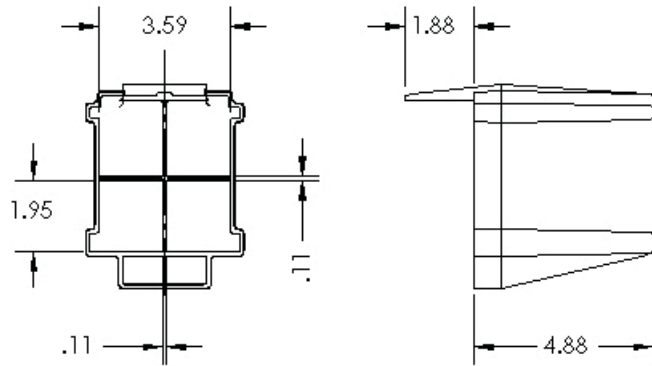
Inside Dimensions



### 2.9.7 End Cap 800A

The end of each bus run has exposed bus bars and must be covered by an End Cap.

If the bus run is forked by a Tee, the exposed end of the extra bus rail leg must also be covered by an End Cap.



**2.9.8 Accessory Parts Numbers**

<b>Accessory</b>	<b>Amperage Rating</b>	<b>Part Number</b>
<b>Coupler</b>	250	HPW2-250-4PG-SP
<b>Coupler</b>	400	HPW2-400-4PG-SP
<b>Coupler</b>	800	HPW2-800-4PG-SP
<b>End Cap</b>	250	HPW2-250-EC
<b>End Cap</b>	400	HPW2-400-EC
<b>End Cap</b>	800	HPW2-800-EC
<b>Vertical Hanger</b>	250	HPW2-250-VH38
<b>Vertical Hanger</b>	400	HPW2-400-VH38
<b>Vertical Hanger</b>	800	HPW2-800-VH38
<b>Horizontal Hanger</b>	250	HPW2-250-HH38
<b>Horizontal Hanger</b>	400	HPW2-400-HH38

## 2.10 Tap Off Boxes

Tap Off Boxes are inserted into Bus Rails, providing power to server racks.

- PowerWave 2 Bus Systems are continuous rail applications. Tap Off Boxes can be inserted nearly anywhere along bus rails.
- Each Tap Off Box along the bus run can have a unique configuration.
- Currently offered Tap Off Boxes and legacy Tap Off Boxes can be all be used together in the same PowerWave 2 bus run, including Tap Off Boxes configured for Tap Off Box monitoring.

### 2.10.1 Quick Connect Tap Off Box

PDI's newest Tap Off Box is the Quick Connect Tap Off Box, which is light weight with automatic latching to bus rails for easier installation. The Quick Connect Tap Off Box can be used in all currently installed PowerWave 2 Bus System bus rails.

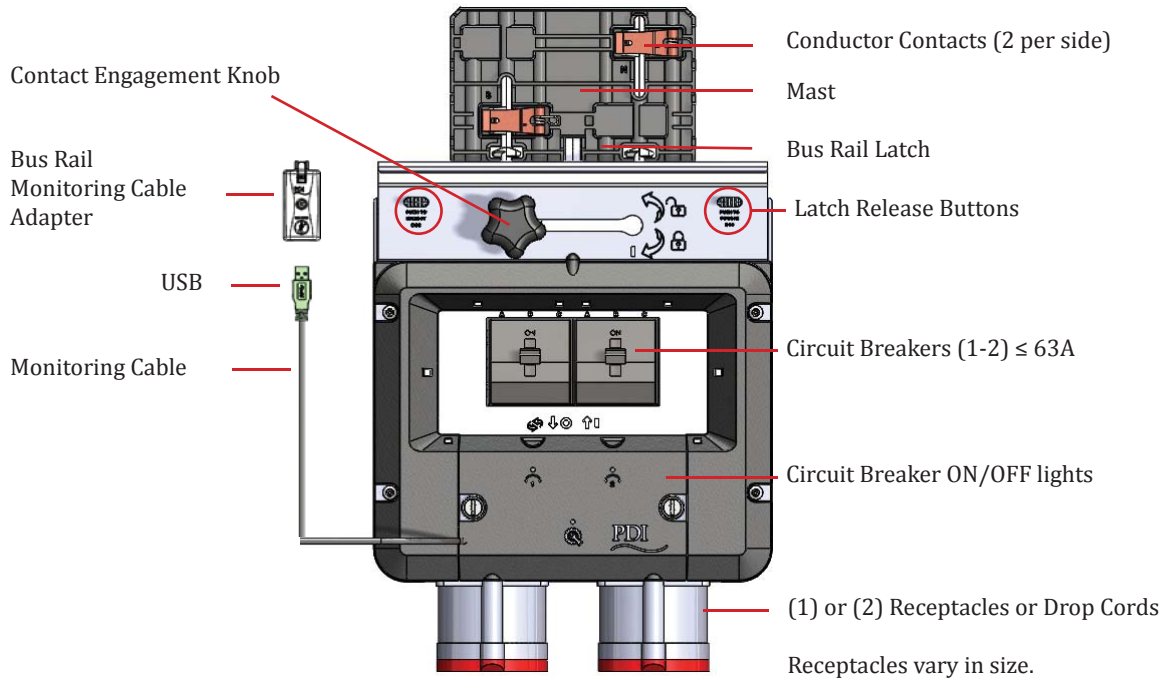
The Quick Connect Tap Off Box has revenue-grade circuit monitoring and is compatible with current PowerWave 2 monitoring systems. The Tap Off Box has a USB monitoring cable that connects to existing bus rail monitoring cables with an adapter.

The Quick Connect Tap Off Box has a standard structure with the same dimensions for all configurations. Circuit amperages greater than 30A, however, require a slightly deeper enclosure.

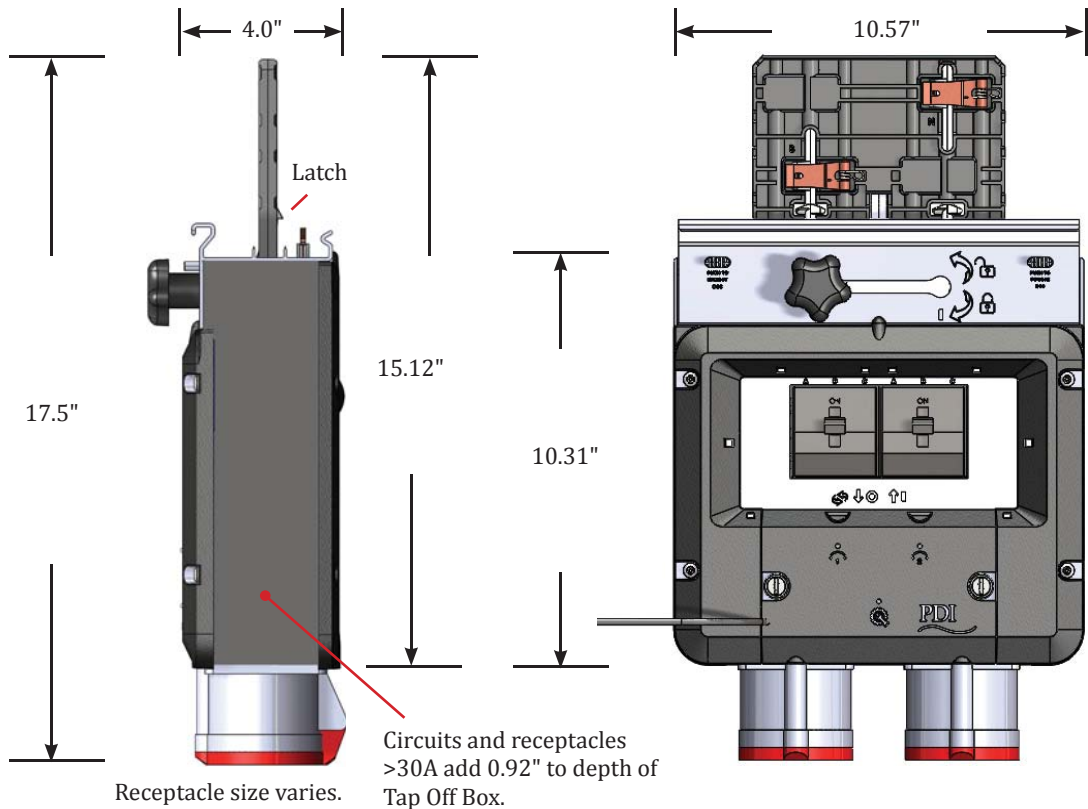
Quick Connect Tap Off Box features and options:

- (1) - (2) 3-phase, 2-phase, or 1-phase circuit breakers
- (1) - (2) receptacles or drop cords
- Circuit breakers and receptacles are available from a variety of vendors with various amperages and kAIC ratings.
  - Masts are rated 128A, allowing (2) x 63A circuits
  - Circuit breakers and receptacles or drop cords are rated up to 63A
  - > 30A require a deeper Tap Off Box (+.92")
- Fuses up to 60A
- Tap Off Box monitoring
  - Requires Tap Off Box monitoring in the bus rail and other bus run components
  - Front USB monitoring cable with adapter connects to a bus rail monitoring connection
- Isolated ground: requires Isolated Ground option in all bus run components
- Infrared scanning of circuit breakers connections through front panel without operator exposure to high voltages

**Quick Connect Tap Off Box Structure**



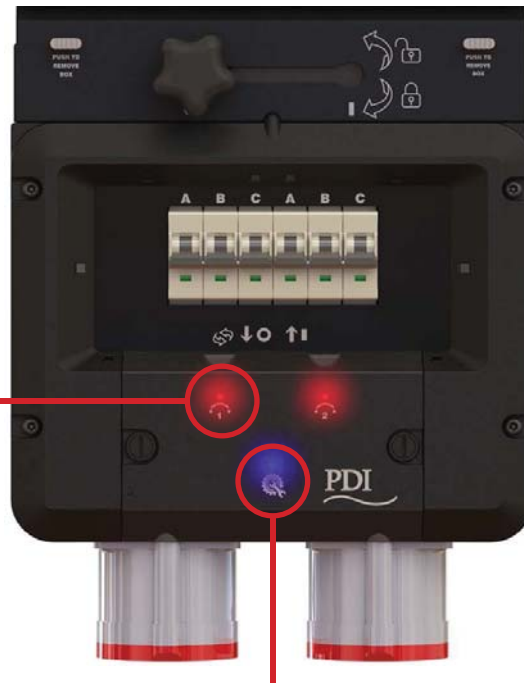
**Quick Connect Tap Off Box Dimensions**



### Quick Connect Tap Off Box Lights

The Quick Connect Tap Off Box has informational lights providing at-a-glance operator awareness:

- Each circuit breaker has a light showing breaker status.
- A maintenance light provides information during Tap Off Box initialization.
- LED lighting is powered by an on-board battery providing status in case of power loss.



Circuit Breaker LED State	Description
Red	Breaker Closed, Power flowing
Red Flashing	Breaker Closed, current is over the warning limit
Green	Breaker Open
Green Flashing	Breaker Unknown, Busway De-energized
Dark	Fault condition

Maintenance Light LED State (Blue)	Description
1 Flash	Firmware initialized
Fast Blink	Bad firmware image or problem with boot-loader
Slow Blink	Identifies Tap Off Box during Setup

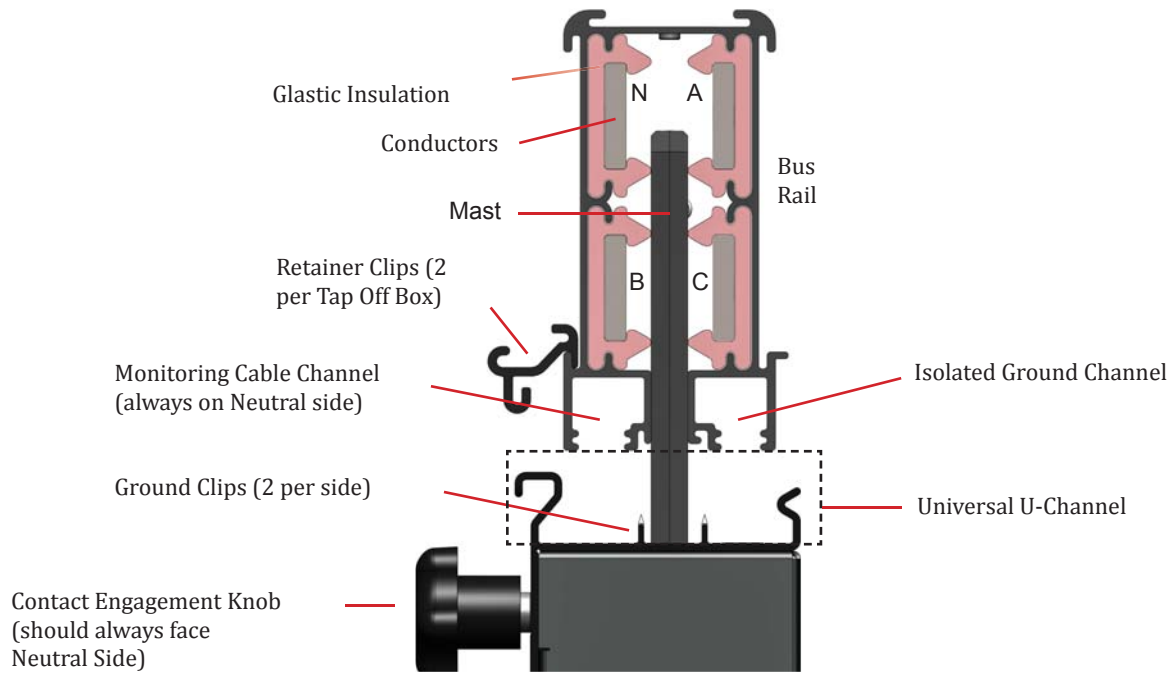
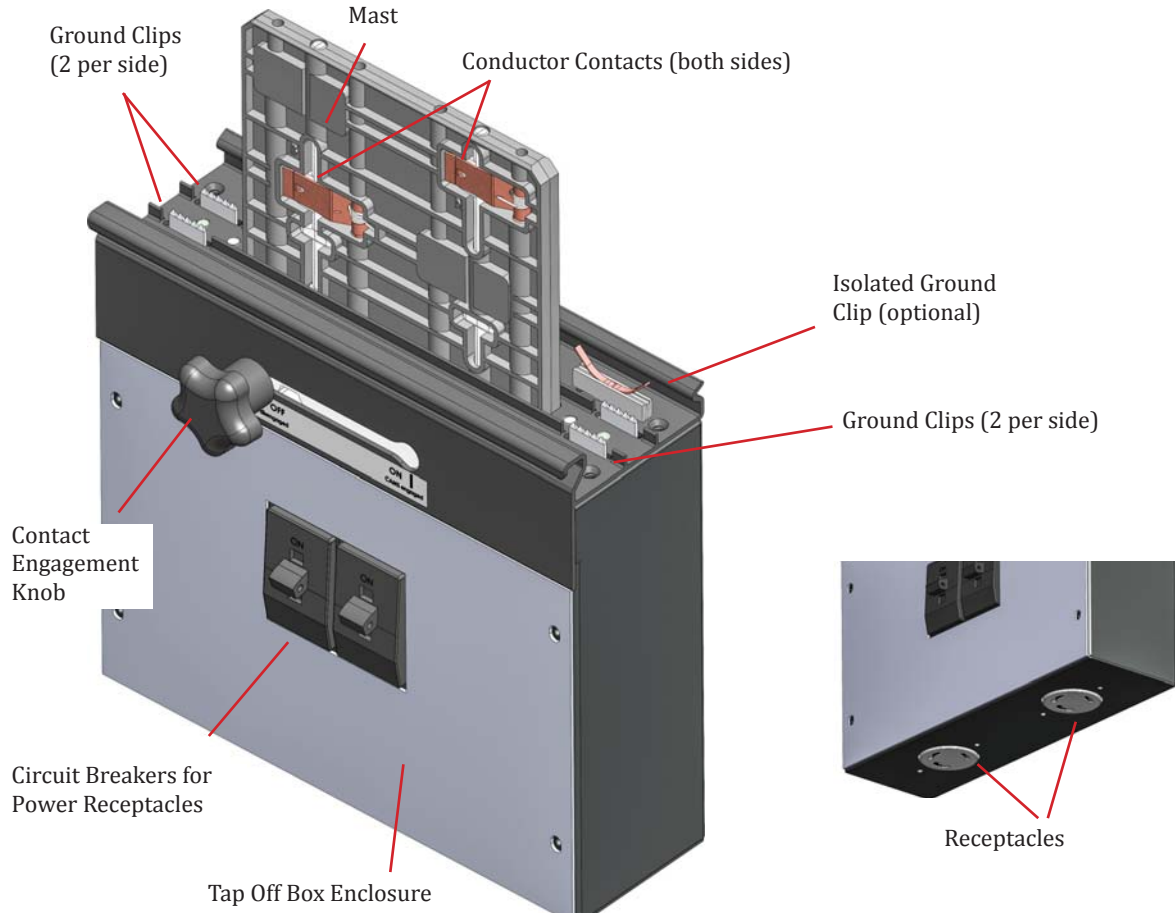
### 2.10.2 Tap Off Box with Universal U-Channel

The Universal U-Channel provides a standard physical interface to all bus rails with amperage  $\leq 800A$ . Tap Off Boxes with the universal U-Channel are secured to bus rails with retainer clips rather than thumb-screws, as in earlier Tap Off Boxes.

Tap Off Boxes are available in a variety of configurations and sizes:

- Up to (5) Circuits:
  - Up to (5) Circuit Breakers and Receptacles/Connectors
  - Up to 63A-rated circuit breakers, and receptacles
  - 128A mast allows up to (2) 63A circuits
  - NEMA and IEC drop cords
  - Various kAIC options
- Fuses up to 60A
- Isolated Ground Option (requires Isolated Ground Option in all bus run components)
- Enclosure widths: 10.25", 12", 14", 17"
- BCMS Tap Off Box Monitoring (requires monitoring cable in the bus run)
- Tap Off Boxes specialized for horizontal orientation with circuit breakers on the same face with receptacles. This configuration makes it easier for operators to access circuit breakers.

**Universal U-Channel Tap Off Box Components**

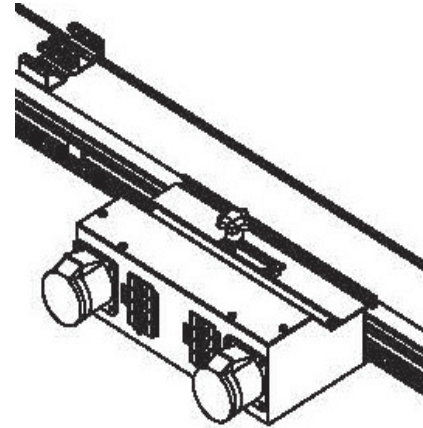
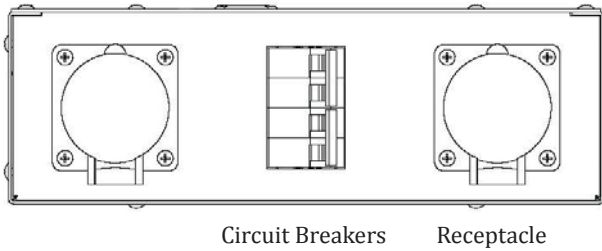


**Universal U-Channel Tap Off Box Enclosure (Side View)**



### Tap Off Boxes Specialized for Horizontal Orientation

250 and 400A bus runs can be rotated 90° for horizontal applications.



Tap Off Boxes specialized for horizontal orientation have circuit breakers and receptacles on the same face for easier operator access..

#### 2.10.3 Limitations on Number of Tap Off Boxes per Bus Run

The number of Tap Off Boxes that can be installed per bus run is limited by the following:

- The total amperage load of the Tap Off Boxes compared to the amperage rating of the bus run
- The monitoring capacity of the bus run, if Tap Off Box monitoring is selected
- Space available on the bus rails

Maximum monitoring capacity per bus run:

- Maximum (32) devices per power feed (Standard End Feed or Center Feed) or bus run can be monitored by PowerWave 2 BCMS (optional):
  - (1) Input power source (monitored at the power feed) + up to (31) Tap Off Boxes
  - Up to (32) Tap Off Boxes if the input power source is not monitored.
  - **Warning! Maximum (15) Tap Off Boxes per bus run can be monitored by the optional 7" PowerWave 2 Bus System Local Display, regardless of whether the input source power is monitored.**

For additional PowerWave 2 BCMS information see *PowerWave 2™ Bus System, Branch Circuit Monitoring System, Setup and Operation* Ctrl Nr: PM375107.



**Warning: Connecting more than (32) devices for monitoring on a single bus run may render the monitoring PCBs inoperable.**

## 3 Installation Planning

To plan a PowerWave 2 Bus System installation, select contiguous groups of servers as bus run candidates, determine their electrical and monitoring requirements, and translate these into physical bus run layouts with parts selections.

### 3.1 Planning Electrical Requirements

Determine the electrical requirements of a bus run before designing the physical layout.

#### 3.1.1 Source Voltage and Frequency

Source voltage at end feed: PowerWave 2 allows any voltage  $\leq 600V$ . Voltage is uniform throughout the bus run (except for voltage drop characteristics—see the Specification). The source voltage and frequency are necessary parameters for Tap Off Boxes and circuit breakers.

#### 3.1.2 Neutral Size

Neutral size as percent (100 or 150%) of amperage rating must be the same for the entire bus run. See Specification for available sizes.

#### 3.1.3 Current Loads

Server rack current load translates to load for a Tap Off Box receptacle. Tap Off Box circuit breakers must exceed expected load.

Determine if bus run reserve capacity is needed for load spikes or expansion.

Based on the sum of Tap Off Box loads, select the amperage capacity of the bus run (250A, 400A, or 800A). The sum of Tap Off Box (TOB) loads must not exceed the rated amperage of the bus run:

- $\text{Load(TOB-1)} + \text{Load(TOB-2)} + \dots + \text{Load(TOB-N)} + (\text{reserve capacity}) \leq \text{Bus Run Rating}$ .

If the sum of loads and reserve capacity exceeds the amperage rating of the bus run, then

- select the next higher rated product (e.g., 250A  $\rightarrow$  400A), or
- divide the server group into multiple bus runs.

#### 3.1.4 Upstream Circuit Breakers

Upstream circuit breakers are recommended to be rated at 100% of the bus run amperage rating to avoid stranding bus run capacity.

For dual bus runs, upstream circuit breakers should also be rated at 100% of a single bus run, or the dual run will not be suitable as a fully redundant system.

#### 3.1.5 Power Feed Disconnects

Disconnects are optionally available in the Standard End Feed and Center Feed and are typically used for these purposes:

- Power feed circuit breakers let the bus run be isolated for maintenance.
- Power feed circuit breakers provide a locally visible and accessible disconnect when the main power disconnect to the bus run is remote.
- Power feed fuse disconnects can provide a higher kAIC than is typically available through circuit breakers, providing additional protection for the bus run.

#### 3.1.6 Dual Bus Runs

Determine whether you will use single or dual bus runs. (This is not a parameter on any part.)

Dual bus runs are recommended in areas with unreliable utility power. Most servers can be dual-corded allowing redundant power source access.

Each power feed in a dual bus run should be powered from a separate independent power source.

Both bus runs should be balanced at  $\leq 50\%$  total load of the dual bus run, and the total load on both bus runs must not exceed the amperage rating of either bus run.

If Monitoring is selected and the power feeds are positioned side-by-side, position Comm Boxes on opposite sides (one “Standard Door” and one “Reverse Door”) so that both units can easily be serviced.

Positioning the power feed for each side of a dual bus run at opposite ends reduces the risk that accidentally cut cables will bring down the entire bus run.

### 3.1.7 Grounding

The customer must provide a single-point ground connection to the ground lug in each power feed. See wire size table in section **5.1 Lugs, Wires, and Torque**.

A Comm Box requires 18 AWG (0.82 mm<sup>2</sup>) ground wire for control wiring, connected to the single-point ground lug in the power feed, wired at the factory.

## 3.2 Planning Monitoring Requirements

Monitoring is recommended to track loads and to assess whether you are approaching the bus run’s limits. The PowerWave 2 Branch Circuit Monitoring System (BCMS) integrates monitoring and communications into the same bus run as power distribution.

BCMS is available with these options:

- Source monitoring (input power connected at end feed): current and voltage
- Tap Off Box monitoring: current and voltage
- Monitoring limitations per power feed:
  - (1) input power source +  $\leq$  (31) Tap Off Boxes
  - (0) input power source +  $\leq$  (32) Tap Off Boxes
  - **WARNING: Monitoring more than (32) devices (input power source + Tap Off Boxes) per power feed or on a single bus run may render the monitoring PCBs inoperable!**
  - Maximum (15) Tap Off Boxes per power feed can be monitored by the optional 7" display, regardless of whether the input power source is monitored.

## 3.3 Physical Layout and Component Selection

You should have a Plan View of your server room layout. (Some customers develop a 3D CAD software layout of the room.) Overhead obstructions, such as posts, CRAC units, fire detection and suppression equipment, should be noted on the Plan View or on an Elevation View.

Using the Plan View and your electrical and monitoring requirements, develop your physical bus run layouts. Make maximum use of floor space and long continuous bus runs.

PDI Revit® Models for PowerWave 2 Bus Systems are available for download from the PDI website. See information in the **Bibliography**.

### 3.3.1 Overhead Support Structure

PowerWave 2 Bus Systems are hung from an overhead support structure, such as a Unistrut or grid structure. It is the customer’s responsibility to evaluate, select, and install the overhead support structure and to provide the connecting hardware, such as bolts or all-thread, to connect Bus System hangers to the selected structure.

All seismic calculations must be done by a civil engineer prior to hanging the bus run.

### 3.3.2 PDI Application Engineering

PDI Application Engineering can provide you assistance with installation planning. You should provide PDI with the following at minimum:

- A Plan View (overhead view) of the server room or area being served by the bus run(s).
- An Elevation View of the server room.
- Show Interferences—posts, air handlers, etc.—that can impede the bus run(s).
- KW density of the server racks or equipment served by the bus run(s).

### 3.3.3 Horizontal or Vertical Orientation

Determine horizontal or vertical orientation.

Vertical orientation should be used for most applications. It is easier to install and has the most options, such as Elbows and Tees.

Horizontal orientation is best for applications where there is limited overhead space and is available for straight bus runs only.

Component orientations:

- Bus Rails, Couplers, and End Caps are usable for both horizontal and vertical applications.
- Standard End Feeds can be used in either orientation.
- All Tap Off Boxes can be inserted into a Bus Rail at either orientation, but Tap Off Boxes specialized for horizontal applications have both circuit breakers and receptacles on the bottom panel for operator visibility and easy access.
- Elbows and Tees are only available for vertical orientation.
- 800A Bus Systems are intended for vertical applications and do not have horizontal hangers.

### 3.3.4 Bus Run Length and Capacity

PowerWave 2 bus runs have no physical length limitation. However, voltage delivered along a bus run drops off with bus run length. The voltage drop off for PowerWave 2 Bus Systems is among the lowest in the industry. See the **Bibliography** for specifications references.

The number of Tap Off Boxes that can be inserted into a bus run is limited by

- the number and widths of the Tap Off Boxes compared to the length of the bus run.
- the sum total amperage load of the Tap Off Boxes compared to the amperage capacity of the bus run.
- small keep-out areas where Tap Off Boxes cannot be inserted. See 5.3.3 Keep-Out Areas for Tap Off Boxes.
- the number of Tap Off Boxes that can be monitored on a bus run (see **5.2 Monitoring Requirements**.)

### 3.3.5 Keep-Out Areas for Tap Off Boxes

PowerWave 2 Bus Systems are continuous rail installations, letting you insert Tap Off Boxes anywhere along the Bus Rail. However, there are small “keep-out areas,” where Tap Off Boxes cannot be placed.

#### Tap Off Box Placement next to Couplers (250A-400A)

Customers usually want Tap Off Boxes placed directly above servers to make the shortest run for power cords from server rack to Tap Off Box. Having a Tap Off Box directly above its server rack also makes it easier for operators to associate the Tap Off Box with its servers.

In bus systems, the Coupler (or “splice” in other systems) can displace Tap Off Boxes to either side. Consequently customers have sometimes designed the bus run to position the splice away from the servers. This design often uses truncated bus rails to get the splice in a position so that it does not interfere with Tap Off Box placement.

However, in PowerWave 2 bus runs, Tap Off Boxes can overlap Couplers, leaving little or no unused rail space. Ground connections on the left and right side of Tap Off Boxes are jumpered together so that the Tap Off Box is grounded to the bus rail on the Tap Off Box side that does not overlap the Coupler. See illustration in **6.3 Coupler Overlap 250-400A**.

Consequently,

- Tap Off Boxes can be positioned directly above servers, even if a Coupler is also positioned there. More bus run can be profitably used.
- There is no need to use shorter rails to position the Coupler.
- Customers can use more full length 12' (3.66 m) Bus Rails.
- With full length rails, customers need fewer Couplers in the bus run.

### **800A Bus System Keep-Out Areas**

Tap Off Boxes cannot overlap Couplers on 800A Bus Systems.

### **Using Older Tap Off Boxes**

Older Tap Off Boxes can be used in PowerWave 2 bus runs. However, they cannot overlap Couplers and or take advantage of the smaller “keep-out” areas. They are best used in the middle of Bus Rails and away from Couplers.

### **3.3.6 Small Corrections to Bus Run Length (250A/400A)**

For precise layout, be aware of these minor corrections to the bus run length:

- Standard Bus Rails are 12' (3.66 m) from the end of one conductor to the other. However, at the Coupler, there is a 1/8" (.3175 cm) gap between conductors.
- An End Cap adds 0.313" (0.8 cm) to the end of the bus run.
- Consequently, a bus run with (3) Bus Rails with (2) Couplers, the total length is
  - (3) Bus Rails + (2) Conductor Gaps at Couplers + End Cap, OR
  - $36'(3 \times 12') + (2 \times 1/8") + 0.313" = 36' 0.56" = 10.99 \text{ m}$

## **3.4 Conclusion**

Thorough planning for your PowerWave 2 installation will ensure that your installation goes smoothly, that your installation environment is prepared, that all parts kits are ordered, and that the parts kits integrate well to match your requirements.

Your next step should be to prepare an installation plan with installation sequences and assigned personnel.

## 4 Bus Run Installation

### 4.1 Receive, Inspect, and Unpack Bus System Components

Components are shipped as kits. Bus Rails are shipped in crates. Other components may be included in the crate or may be shipped separately on pallets. Tap Off Boxes are shipped boxed. Larger shipments of Tap Off Boxed, covered with a bubble wrap bag, shipped on pallets, and strapped down with metal straps..

Upon delivery, verify that you have received all kits and components:

1. Compare the actual shipment with the bill of lading. Report any missing items to the carrier and PDI immediately.
2. Also compare the bill of lading with your order. Report discrepancies to PDI immediately (see below for PDI contact information) .

**Inspect the shipped components or kits twice, upon receipt and after removing packaging materials.**

For moving the kits or components on their pallet, PDI recommends that you leave the retaining bands intact until you have moved the unit to a convenient location for removing them from their pallet.

3. Before removing packaging, inspect the packaging for visible damage. If damage is evident notify the shipping company and PDI.
4. Carefully uncrate bus rails and any included components.
5. For Tap Off Boxes and other boxed components shipped on pallets, carefully cut the retaining bands.



**Metal retaining bands are under tension. Exercise caution when cutting them.**

**Wear protective clothing including eye, face, and hand protection when cutting retaining bands!**

6. Carefully remove the protective bubble wrap bag and remove components from boxes. Use care to not puncture or scratch the components with cutting tools.
7. After removing the outer external packaging, inspect components for any visible damage such as scratches, dents, or cracks. If you discover any damage, notify the shipping company and PDI Service.

File any damage claims with the shipping company at time of delivery. Damage must be noted on the bill of lading. Failure to properly document all damage may result in the unit's warranty being voided.

PDI Service contact information:

Power Distribution Inc.  
4200 Oakleys Court  
Richmond, Virginia 23223  
(800)-225-4838  
service@pdicorp.com

### 4.2 Storage Conditions

If you are installing components soon after shipment, store them in a clean and dry location *in their original packaging* within this temperature range: 40°F to 158 °F [-40°C to 70°C].

### 4.3 Moving Components

1. Plan your route for moving the equipment. Ensure that all passages are large enough. Check for any non-negotiable corners or offsets in hallways. 12' bus rails can be difficult to move through stairwells and corners.
2. Use a forklift or pallet jack to move the kits or components on their shipping skid as close as possible to the final installation position. Do not exceed a 10-degree tilt if moving with a forklift.
3. If kits and components are shipped on pallets, carefully cut the bands holding the kits or parts to the pallets. Use caution: bands are under tension and can cause personal injury.

#### **DANGER!**

**This product must be installed and inspected by licensed electricians or by PDI-authorized technicians. This document should not be viewed as sufficient by otherwise non-qualified personnel to install, operate, service, or maintain this equipment.**



**Severe or fatal injury can result from electrical shock during contact with high voltage conductors, monitoring PCBs, or similar equipment!**

**Disconnect power before drilling holes, making cutouts, attaching conduit, or connecting to PDUs, RPPs, or other power distribution equipment.**

**Use Lock Out/Tag Out procedures.**

**Wear suitable personal protective clothing and use protective equipment for performing mechanical and electrical installations.**

**Leave ample space for attaching and routing wires.**

## 4.4 Installation Sequence

PDI recommends that you have an Installation Plan with an installation sequence, such as the following:

1. Create the overhead busway support structure.
2. Install the Standard End Feed and Starter Rail. (If a Center Feed is used, the two Starter Rails are connected in manufacturing.)
3. Complete the bus run with remaining structural components: Standard Rails, Elbows, Tees, and End Cap.
4. Install Couplers to join bus run structural components.
5. Connect site ground, optional isolated ground, and power to the power feed.
6. Execute the Start-Up checklist.
7. Power up and test the bus run.
8. Install Tap Off Boxes.
9. Connect server power strip whips.
10. Power up servers.
11. If using monitoring (BCMS), connect the site network to the Comm Box. Setup and test BCMS.

## 4.5 Installation Differences 250-400A vs. 800A

The following installation instructions are based on 250-400A bus system installation. Installation procedures for 250A and 400A systems are the same.

800A system installation follows the same flow, but differs in some details, specifically for Vertical Hangers, Couplers, and End Caps. 800A differences will be noted where appropriate.

## 4.6 STEP 1: Create the Overhead Support Structure

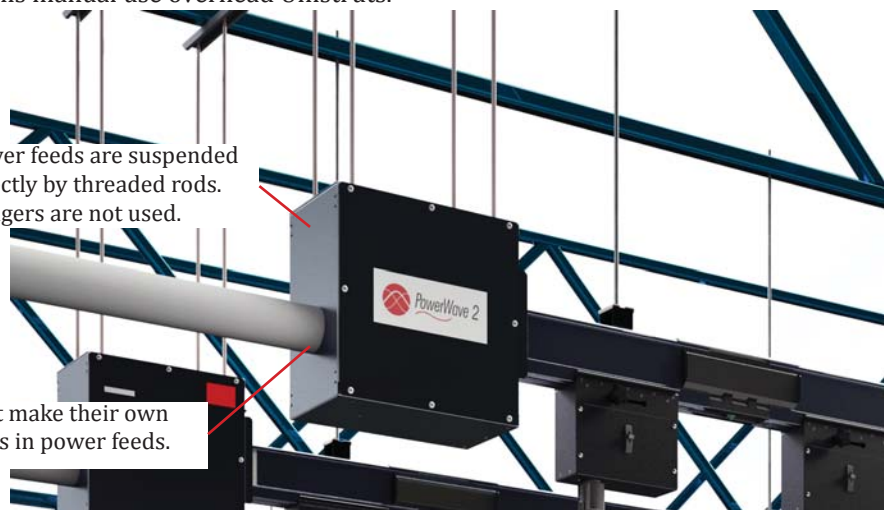
PowerWave 2 Bus Systems are hung from an overhead support structure, such as a Unistrut or grid structure. It is the customer's responsibility to evaluate, select, and install the overhead support structure and to provide the hardware to connect PowerWave 2 Bus System hangers to the selected structure.

- If using a ceiling drop grid, place threaded rods in a straight line according to your hanger layout.
- If hanging from a concrete ceiling, use a laser to line up the bus run, drill concrete anchors, and install rods.
- Installation examples in this manual use overhead Unistruts.

Customers are responsible for creating the overhead support structures.

Power feeds are suspended directly by threaded rods. Hangers are not used.

Installers must make their own conduit cutouts in power feeds.



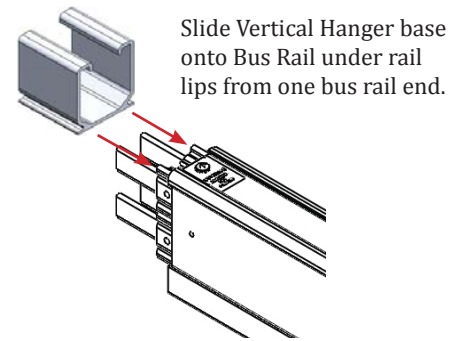


## 4.7 Installing Vertical Hangers

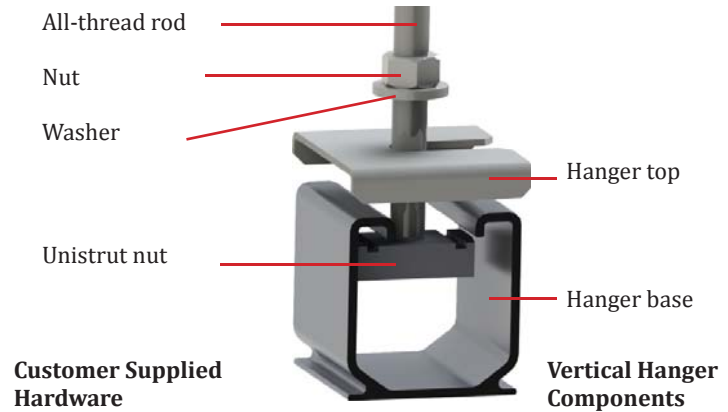
### 4.7.1 Vertical Hangers (250-400A)

Slide each hanger **base** onto the end of the Bus Rail and into position.

Install the base section of all 250-400A Vertical Hangers onto bus rails, Elbows, or Tees **before** hanging the part.

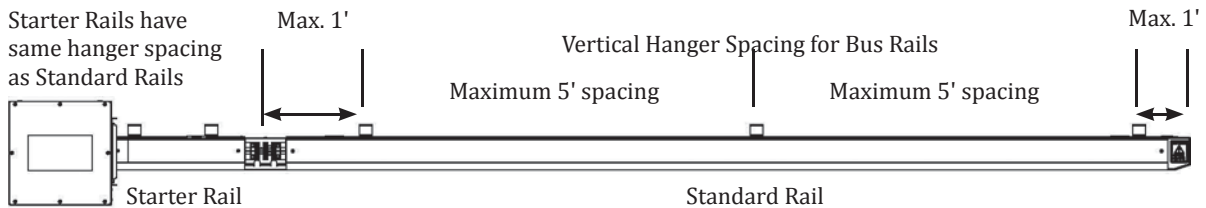


Then, while supporting the bus rail, assemble Vertical Hangers on the bus rail with customer-supplied nut, washer, and Unistrut nut, attaching the hanger to a threaded rod from the overhead structure.

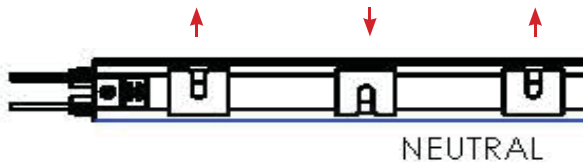


### Vertical Hanger Spacing on Bus Rails

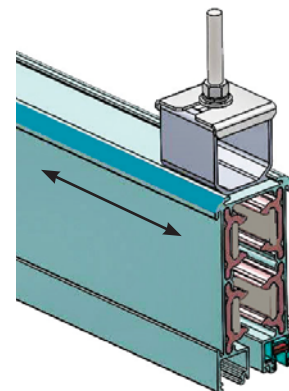
PDI recommends three (3) Vertical Hangers per 12' (3.66 m) of Bus Rail. One (1) hanger is should be installed within 12" (30.5 cm) from the end of each Bus Rail and one (1) hanger should be centered between them. Maximum spacing between hangers should be 5' (152.4 cm)..



Alternate the orientation of the Hanger top for better locking to the support structure..



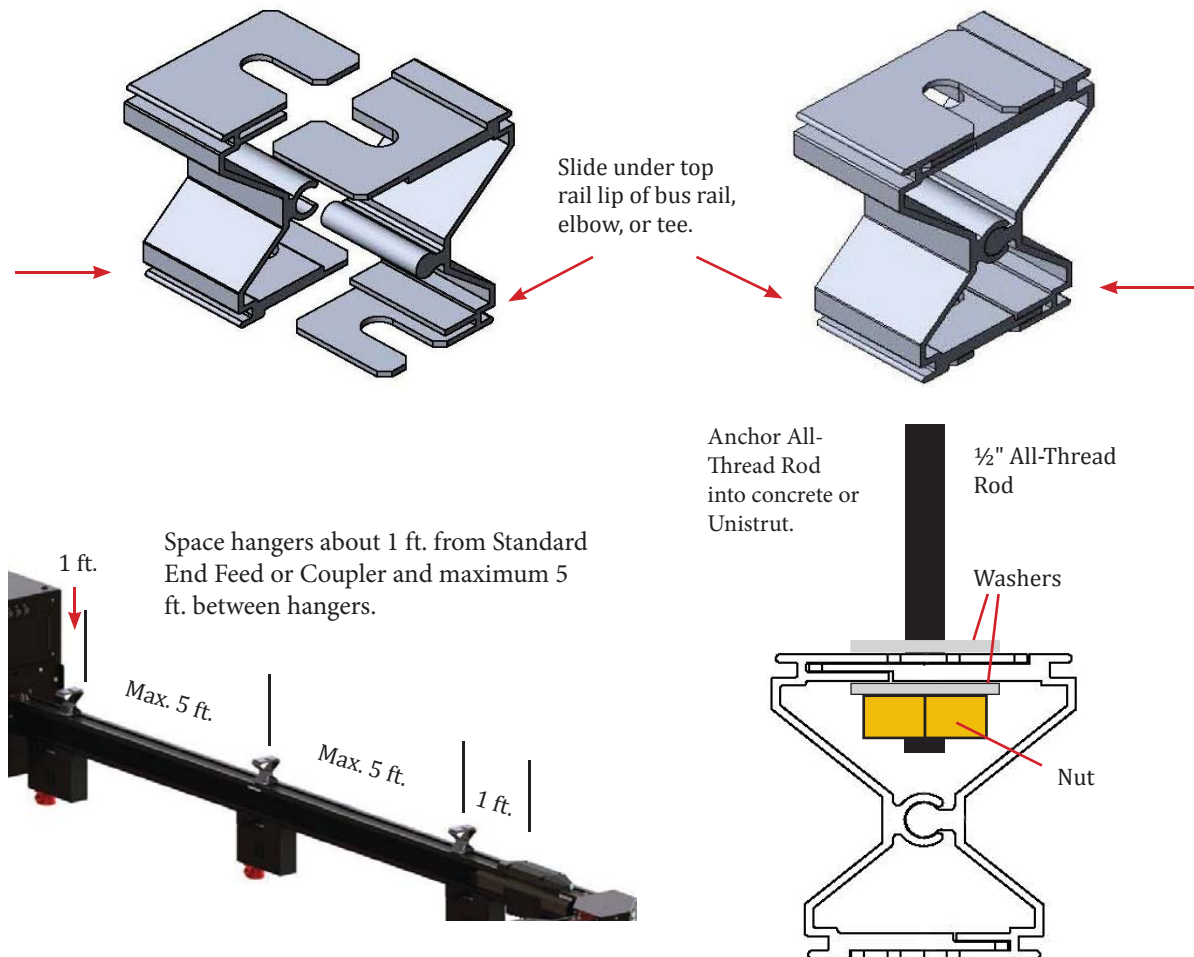
Make adjustments by sliding hangers along the rail.



#### 4.7.2 Vertical Hangers 800A

800A Vertical Hangers can be inserted into bus rails at any point, making it easy to add them at any time during installation. Insert the halves into the rail, securing them to the lip of the top (ground) channel and slide them together.

Hanger spacing is the same as for 250-400A: about 1 ft. from rail ends and maximum 5 ft. between hangers.



#### 4.8 STEP 2: Hang the Starter Rail and Standard End Feed

Typically the Starter Rail is hung first, but some customers prefer to hang the Standard End Feed before the Starter Rail, for these reasons:

- The Standard End Feed is a large box and may be cumbersome to install when overhead cable trays are close. An already installed Starter Rail can make installation more difficult.
- Customers may want conduit and power already run to the power feed before installing the bus run structure.

Regardless of which is installed first, both the power feed and Starter Rails should be installed together before the rest of the bus run.

### 4.8.1 Hang the Starter Rail

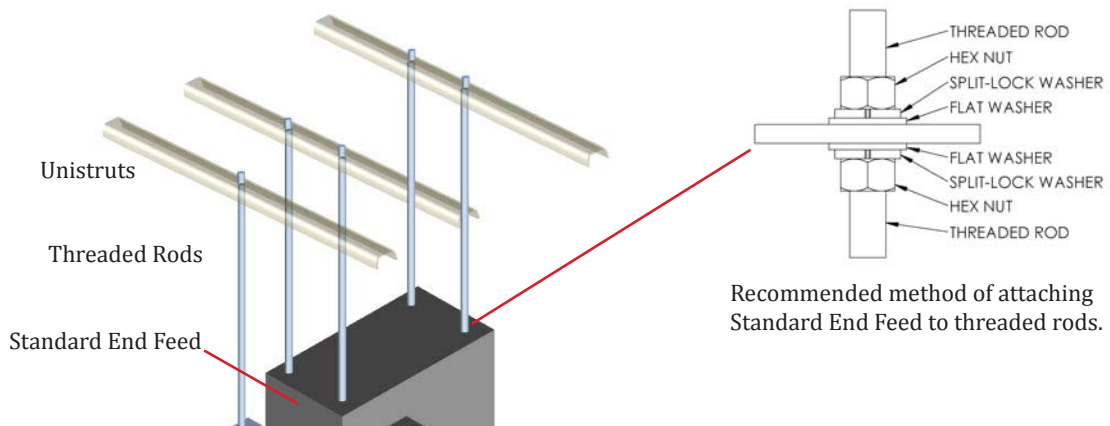
Attach the Starter Rail to the overhead support structure using customer supplied hardware and the number of hangers appropriate to the length of the rail. (See 4.7 **Installing Vertical Hangers**.) Check that the Starter Rail is level. Neutral must be on the top side of the rail.

### 4.8.2 Hang the Standard End Feed

There are no hangers for power feeds. Standard End Feeds are attached to overhead support structures using customer-provided hardware.

Before hanging the Standard End Feed, installers must make their own cutouts for conduit and cutouts should have grommets installed. There are no pre-punched knock-outs.

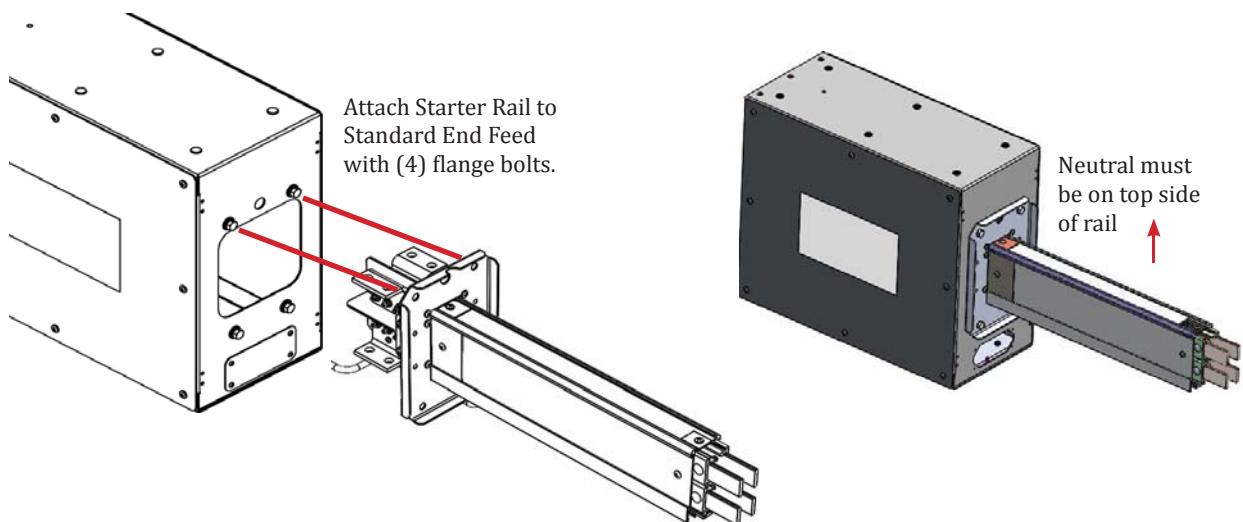
The recommended method for mounting the enclosure is using (4) or (6) 3/8 threaded rods (depending on enclosure size) to secure the enclosure to the ceiling or to Unistruts.



### 4.8.3 Attach Starter Rail to the Standard End Feed

Remove (4) bolts from the Standard End Feed and use them to attach the Starter Rail flange.

Starter Rail and Standard End Feed should be aligned and leveled to each other so that the Standard End Feed is completely level after installation

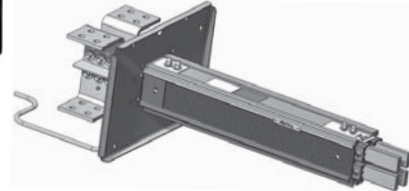


#### 4.8.4 Installing an 800A Starter Rail and Standard End Feed

The 800A Standard End Feed is installed in the same way as the 250-400A systems but the components are larger. More bolts are used to connect the Starter Rail flange to the Standard End Feed.



(8) bolts for connecting 800A Starter Rail flange

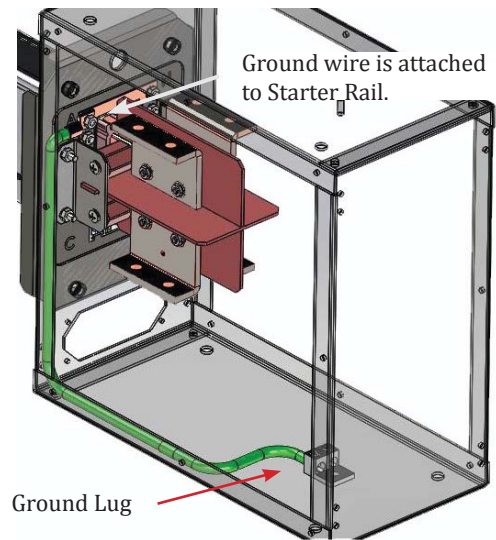


#### 4.8.5 Attach Ground Wire to Enclosure Lug

The Starter Rail has a ground wire that is always connected to the rail on the Neutral side.

Connect the ground wire to the ground lug on the bottom of the Standard End Feed.

Check that the ground wire is tightly connected to both the Starter Rail and the ground lug.

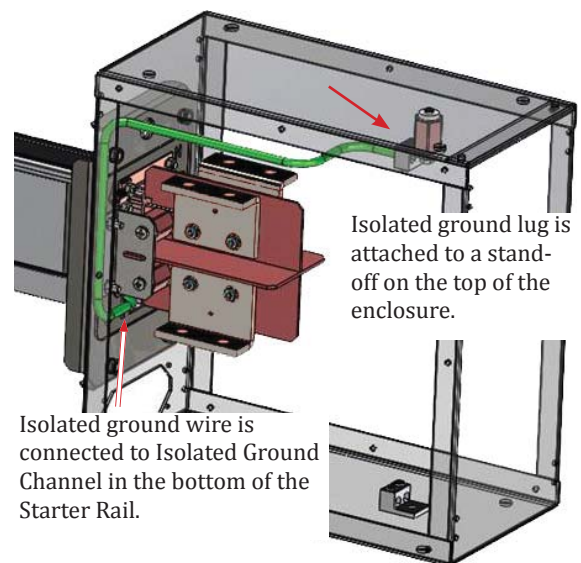


#### 4.8.6 Attach (Optional) Isolated Ground Wire

If the Isolated Ground Option is selected, the Starter Rail has an isolated ground wire attached to the Isolated Ground Channel on the bottom of the rail on the opposite side as the Neutral.

Connect the isolated ground wire to the stand-off ground lug on the top of the Standard End Feed.

Check that the isolated ground wire is tightly connected to both the Starter Rail and the isolated ground lug.



## 4.9 STEP 3: Complete the Bus Run Structure

### 4.9.1 Install Standard Rails

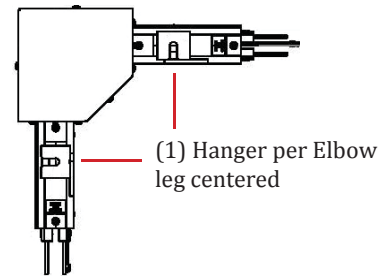
Usually the bus run is extended beyond the Starter Rail with Standard Rails. Attach Standard Rails to the overhead support structure using customer supplied hardware and the number of hangers appropriate to the length of the rail. (See topic **4.7 Installing Vertical Hangers.**) Check that Bus Rails are level and that the conductors on adjacent rails are aligned and nearly touch (leave 1/8" gap between conductors).

### 4.9.2 Install Elbows and Tees

If your bus run is not a straight run, install an Elbow or Tee according to your bus run design. Use (1) Vertical Hanger on each leg. Leave 1/8" gap between conductors in adjacent bus rails.

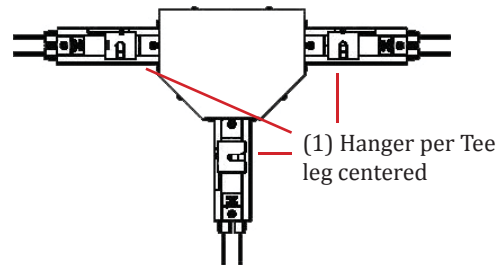
#### Hanging Elbows

Elbows should be hung with (2) hangers, each one centered on a leg.



#### Hanging Tees

Tees should be hung with (3) hangers, each one centered on a leg.

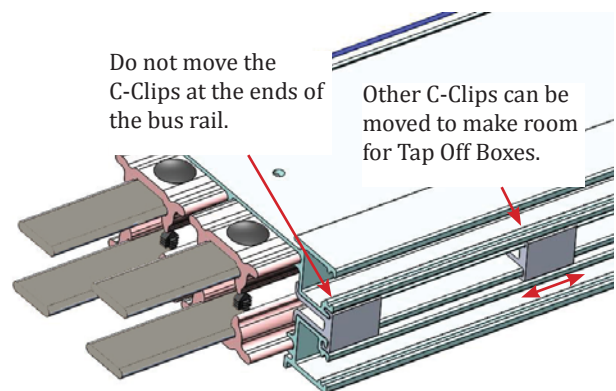


### 4.9.3 Adjust Bus Rail C-Clips

Bus Rails have C-clips along the mast channel to stiffen the channel.

A C-clip should be positioned at each end of the rail and should not be moved.

Other C-clips should be evenly spaced along the Bus Rail. You can slide these other C-clips along the mast channel to make room for Tap Off Boxes. Adjust the C-clip spacing only enough to make room for Tap Off Boxes.



#### 4.9.4 Install End Cap

##### End Cap 250-400A

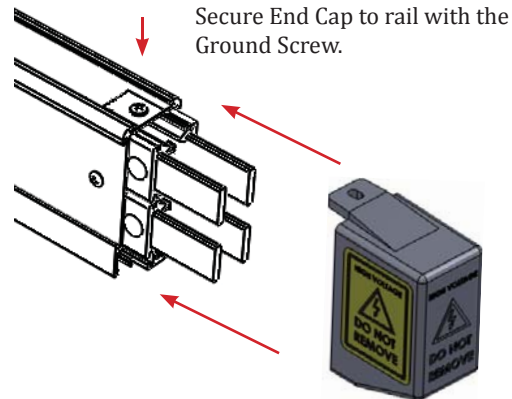
An End Cap must be installed to the exposed end of each bus run leg.

Remove the Ground Screw from the end of the bus rail.

Attach the End Cap to the bus rail, making sure it is snug and completely covers the exposed end.

Secure the End Cap to the rail with the Ground Screw.

If an extra leg has been forked off with a Tee, you will need an extra End Cap for this leg.



##### End Cap 800A

Every exposed bus rail (or other component) end must be covered by an End Cap.

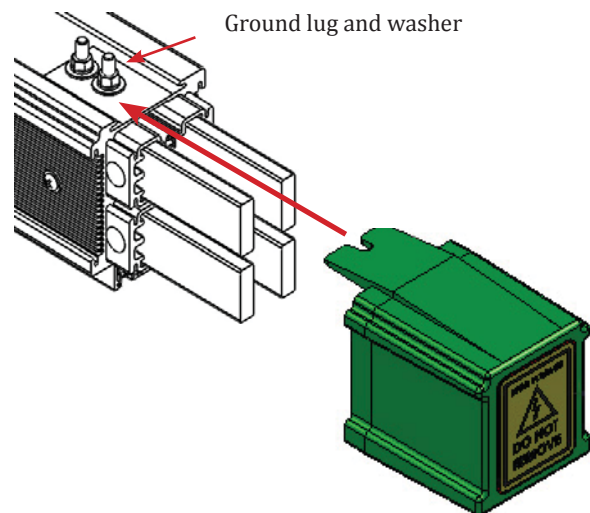
Loosen lug and washer from outer ground bolt.

Slide End Cap over the exposed conductors so that the notch is under the washer and snug against the ground bolt.

Tighten the lug and washer over the End Cap lip.

You should not be able to pull the End Cap off.

For each Tee that you have in the bus run, you will need an extra End Cap to cover the forked leg.



**Danger! High voltages and amperages!**

**Risk of electrical shock and electrocution causing injury or death!**

**Do not remove End Cap while the bus run is powered on!**

**All exposed bus run conductors must be covered by an End Cap!**

## 4.10 STEP 4: Install Couplers

Bus run sections are joined by Couplers. A Coupler can be installed at least (10) ten times while maintaining conductivity.

### 4.10.1 Installing a 250-400A Coupler

The following steps describe Coupler installation for 250-400A bus systems. Coupler installation is simple and requires no special tools, only an Allen wrench, included in the Coupler kit.

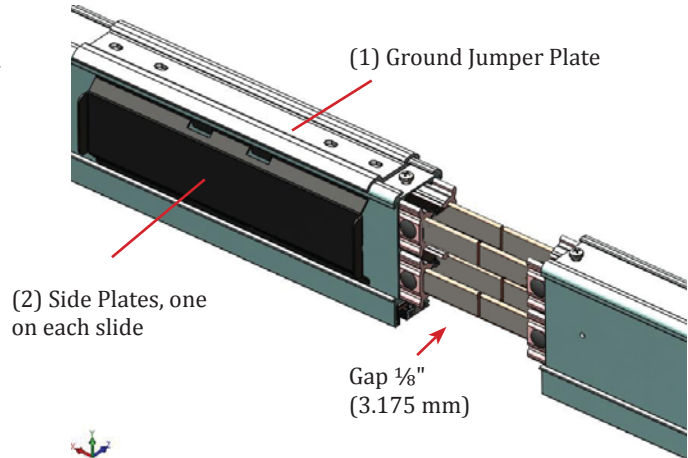
800A bus systems have a different Coupler and installation is described in the next topic **4.10.2 Installing an 800A Coupler**.

#### Coupler Step 1: Position Bus Rails

Hang (2) Bus Rails (or (1) Bus Rail with Elbow or Tee) so that both Rails are level and conductors aligned.

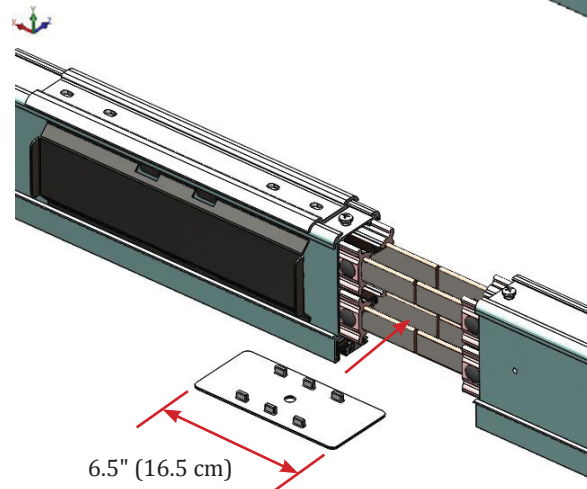
Each Bus Rail has (1) Ground Jumper Plate and (2) Side Plates that slide along the rail. Slide them to one side of the exposed conductors.

The conductors should be separated by a gap of  $\frac{1}{8}$ " (3.175 mm).



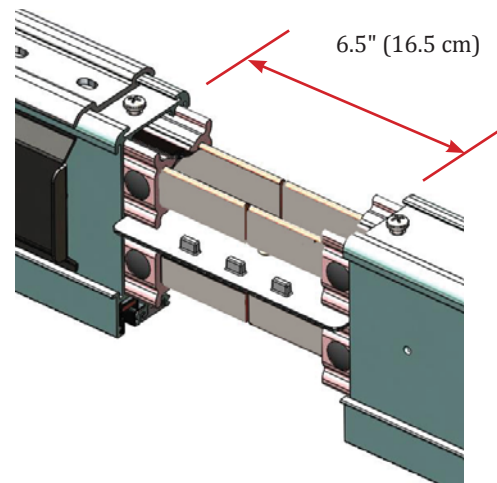
#### Coupler Step 2: Insert Divider

**2A:** Insert the **Divider** between the conductors, as shown.



**2B: Important!** Slide Bus Rails together until the fit between the Bus Rails and **Divider** is snug.

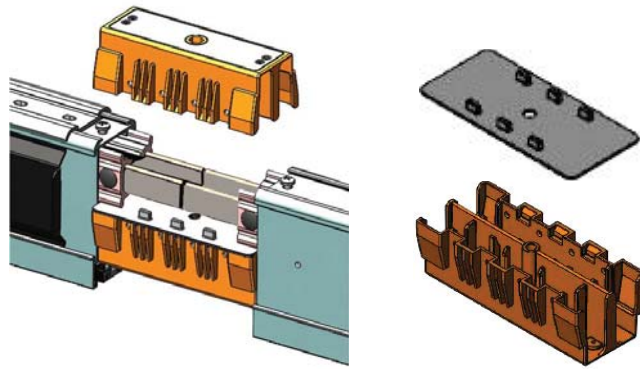
Note: The **Divider** maintains the correct spacing for the Coupler. Space between the housing of the Bus Rails should be 6.5" (16.5 cm), the width of the **Divider**. There should be a  $\frac{1}{8}$ " (3.175 mm) gap between conductors.



### Coupler Step 3: Attach Coupler Housing

Clamp the top and bottom halves of the **Coupler** over the top and bottom conductors.

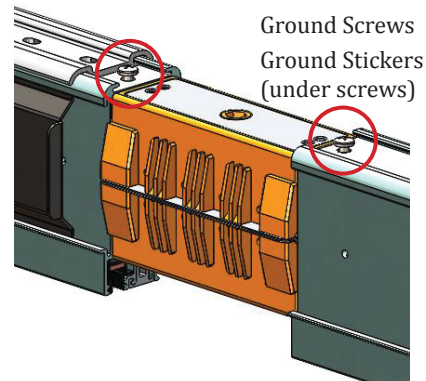
Mate the **Coupler** halves with the (6) tabs on each side of the **Divider**.



### Coupler Step 4: Secure Ground Jumper Plate

**4A:** Remove and retain (2) Ground Screws from the top ends of the Bus Rails.

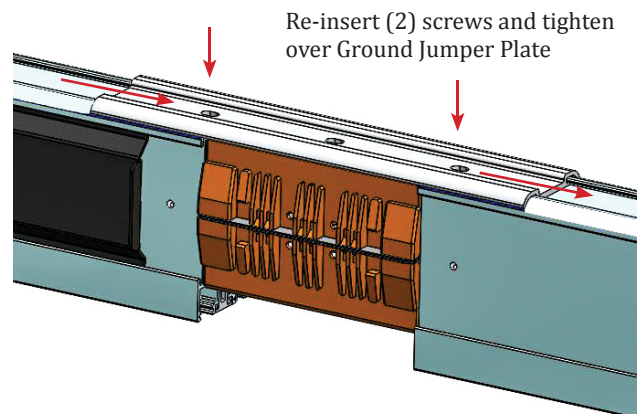
Remove Ground Stickers from the bus rail if present. (If present, the Ground Stickers are under the Ground Screws.)



**4B:** Slide the **Ground Jumper Plate** over the Coupler and center.

Reinsert (2) retained screws and tighten. The **Ground Jumper Plate** must be securely attached to the Bus Rails on both sides.

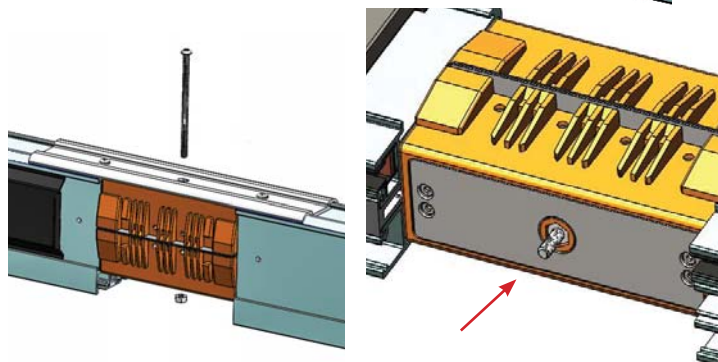
**This is essential to the grounding of the bus run!**



### Coupler Step 5: Secure Coupler Halves

**5A:** Insert the enclosed bolt into the top center hole of the **Ground Jumper Plate** all the way through both **Coupler** halves.

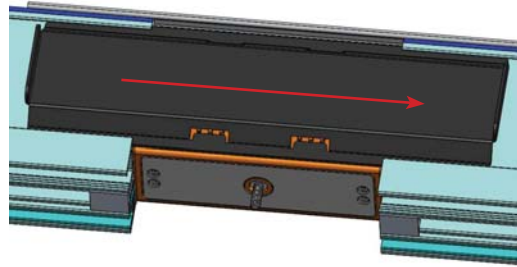
**5B:** Insert the enclosed nut onto the bottom of the bolt so that the nut rests in the recessed hole. Screw the bolt and nut tightly using the enclosed Allen wrench. The bolt protrudes allowing the bottom cover to be attached in **Step 7**.





**Coupler Step 6 : Side Plates**

Slide the (2) Side Plates (one each side) over the Coupler and center.



**Coupler Step 7: Connect Optional Features**

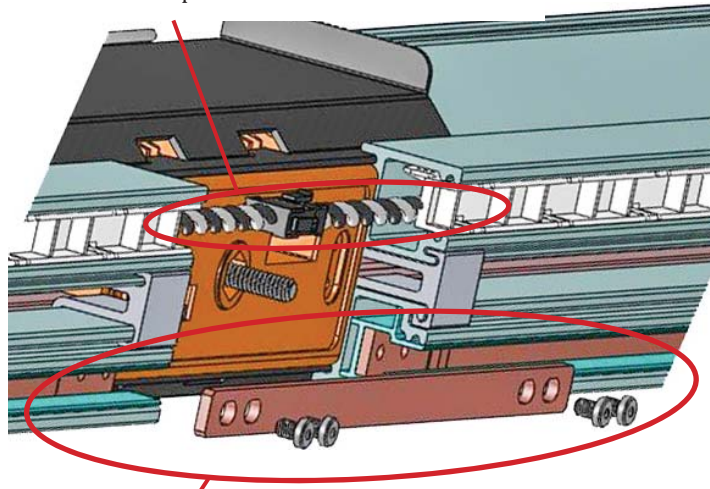
**7A:** If **BCMS Monitoring for Tap Off Boxes** is installed, a communications cable will be installed in Bus Rails, Elbows, and Tees in the bottom channel on the neutral side.

Snap together the communications cables from each side of the Coupler.

**7B:** If the **Isolated Ground Option** is installed, a copper grounding strip will be installed in the Bus Rails, Elbows, or Tees in the other bottom channel.

Attach the enclosed copper connecting strip to the isolated ground strips on both sides of the Coupler using (4) enclosed screws. Tighten with the enclosed Allen wrench.

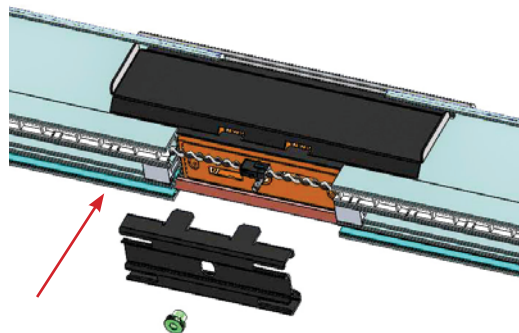
Step 7A: Connect (optional) monitoring cable across the Coupler.



Step 7B: Connect (optional) copper strip connecting Isolated Ground strips across the Coupler.

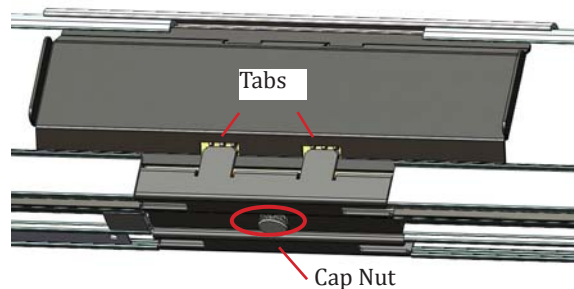
**Coupler Step 8: Install Bottom Coupler Cover**

**8A:** Insert the **Bottom Cover** under the **Coupler**. Make sure that the communications cable is not pinched, if installed.

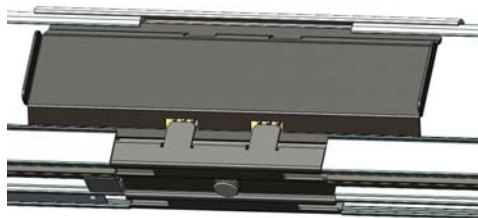
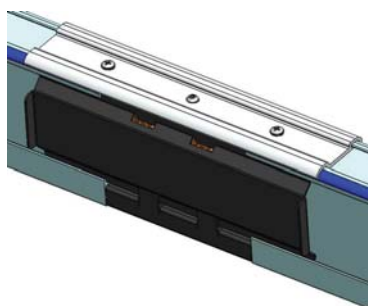


**8B:** The tabs on the **Bottom Cover** lock into the tab openings on the **Side Plates**.

Screw the enclosed cap nut onto the bolt and tighten with the Allen wrench.



**Completed Coupler Installation 250-400A**



### 4.10.2 Installing an 800A Coupler

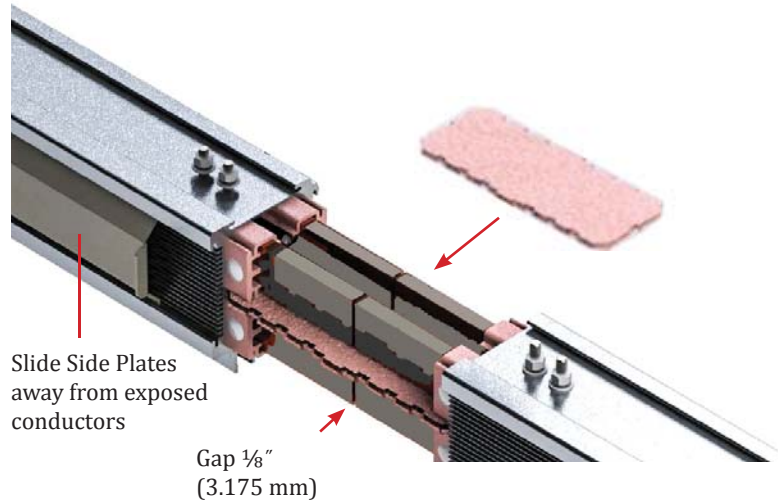
The 800A Coupler has a similar structure to the 250-400A Coupler and installation is also similar.

Position (2) Bus Rails or Bus Rail and Elbow or Tee so that conductors are separated by 1/8".

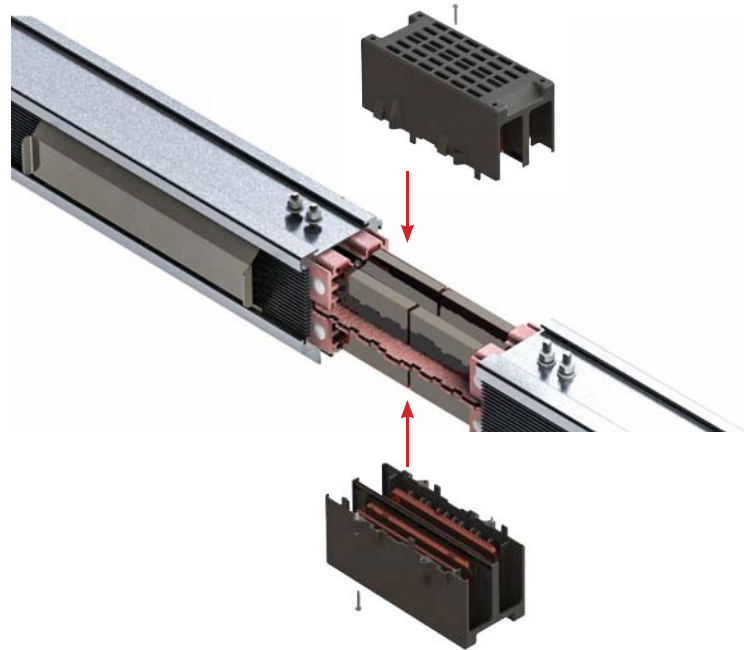
Slide Side Plates away from conductors.

Insert 800A Divider between the top and bottom conductors.

**Important!** Slide Bus Rails together until the fit between the Bus Rails and Divider is snug. The Divider maintains the correct spacing for the Coupler. There should be a 1/8" (3.175 mm) gap between conductors.



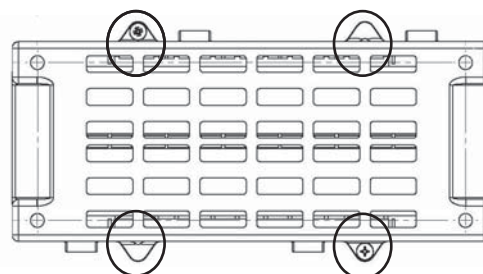
Insert the bottom Coupler section onto bottom two bus bar conductors and use a rocking motion to slide it onto the bus bars. (Note: the action of securing the Coupler may be difficult because of the strong contact needed to ensure a good connection.)



Insert the top Coupler section onto top two bus bar conductors using similar rocking motion.

Secure top and bottom halves of Coupler with enclosed (4) 8-16 x 3/4" Phillips pan-head plastic thread forming screws.

(2) screws face up, (2) screws face down.

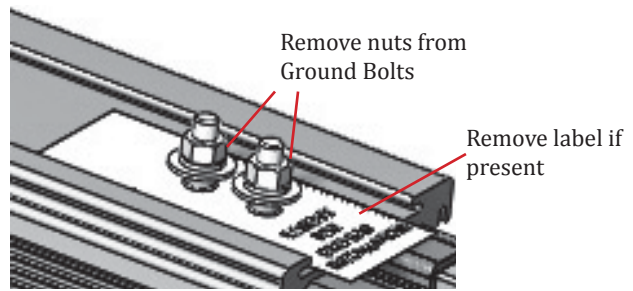


Bottom half of Coupler shown.

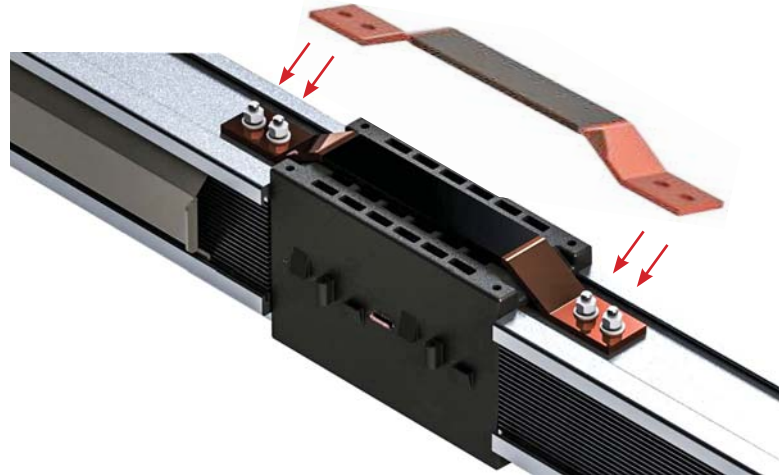
**Install Ground Strap across Coupler:**

Remove (4) nuts from Ground Bolts on the ends of the Bus Rails, Elbow, or Tee.

If present, remove labels around Ground Bolts. (This is important for making a good ground connection.)

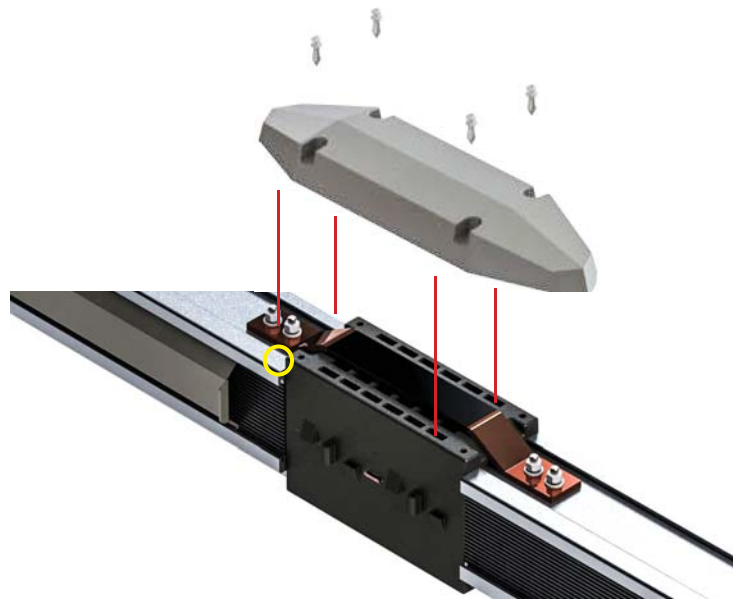


Using a 5/16 wrench, attach the **Ground Strap** across the top of the Coupler with the (4) Ground Nuts. Tighten securely.



Attach the **Drip Cover** to top of the Coupler using four (4) pop-screws.

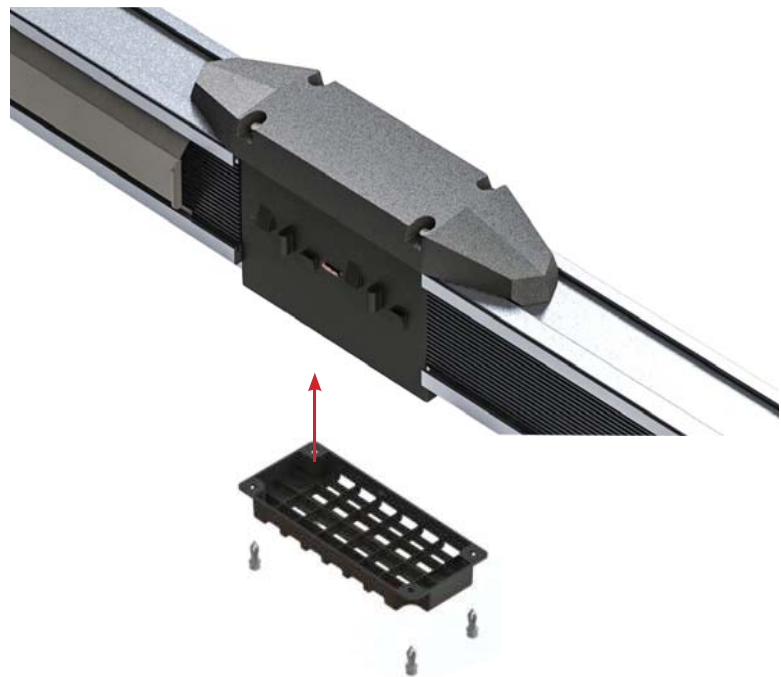
(Note: to remove Drip Cover, pop-out the screws rather than unscrew them.)



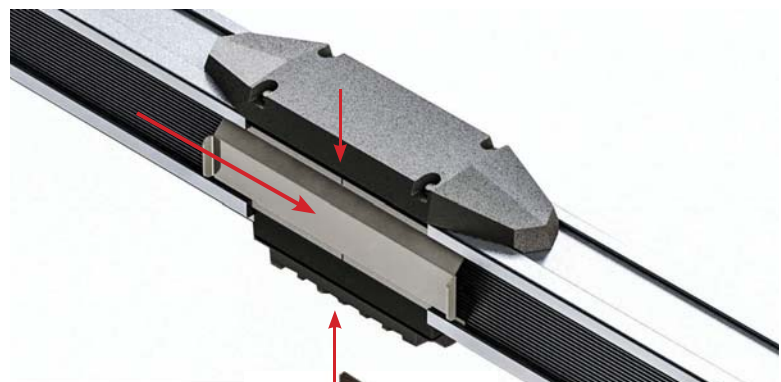
If BCMS (monitoring) is installed for Tap Off Boxes, a communications cable is installed in the communications channel. Connect the communications cable as shown for **4.10,1 Installing a 250-400A Coupler Coupler Step 7: Connect Optional Features.**

Similarly, if the Isolated Ground Option is selected, connect the isolated ground channels with the copper grounding strip.

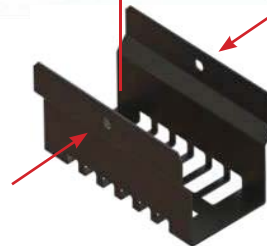
Attach the **Cable Harness Protector** to the bottom half of the Coupler using four (4) pop-screws.



Slide the (2) **Side Plates** across the Coupler and line up hole with the center line of Coupler (where Bus Rail housings meet).



Slide the **Support U-Channel** over Side Plates and secure to pem nuts on either side of the Side Plates using (2) Phillips head screws (enclosed).



Secure both sides of U-Channel to pem nuts on Side Plates.

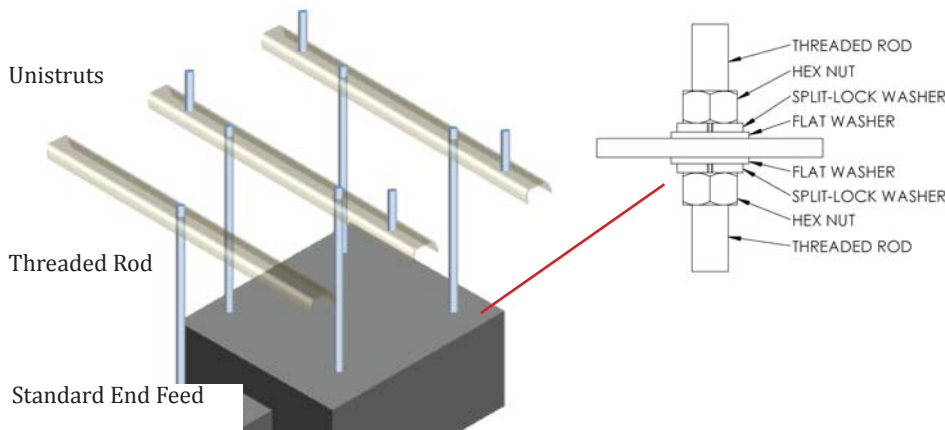
### 4.11 Horizontally Oriented Bus Runs (250-400A)

250-400A bus runs can be horizontally oriented:

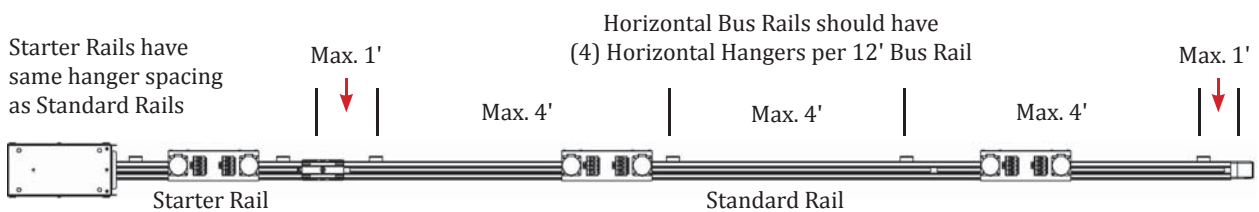
- Standard End Feed and bus rails are rotated 90°. (Center Feed not available for horizontal orientation.)
- Bus rails are hung with Horizontal Hangers.
- There are no Elbows or Tees for this orientation.

Mounting a Standard End Feed horizontally is similar to vertical mounting. The enclosure is rotated 90° and is supported by (4) 3/8" threaded rods (or (6) on 400A enclosures) to secure the enclosure to the ceiling or to Unistruts. Top side of the enclosure should be a panel. A Comm Box for monitoring must be on the bottom side.

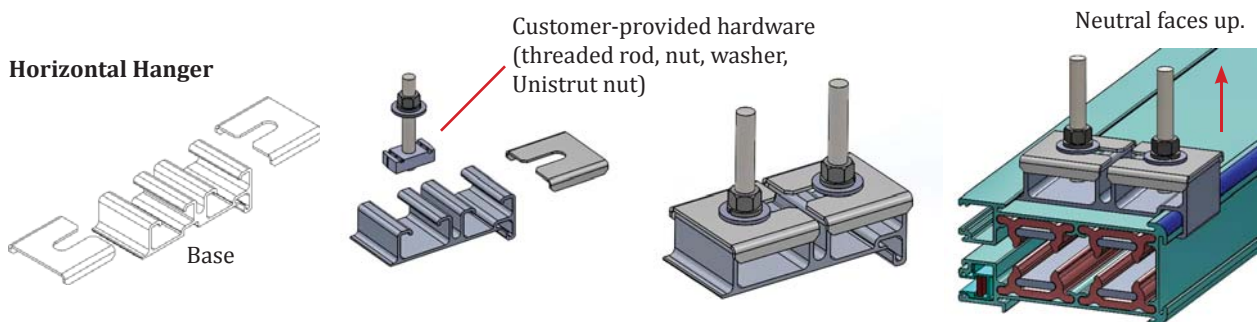
The Starter Rail is supported by (1) or more Horizontal Hangers. The Standard End Feed and Starter Rail must be aligned and leveled to each other so that the Standard End Feed is completely level after installation.



On horizontal layouts, the neutral conductor should be on the top side. Like Vertical Hangers, there should be a Horizontal Hanger no more than 1' from the center of the Coupler or End Cap, but Hangers should be spaced no more than 4' apart. A 12' bus rail should have at least (4) Horizontal Hangers.



Slide the base section of a Horizontal Hanger onto the side of the bus rail as shown below. Assemble the Hanger with customer-provided hardware and attach to overhead support rods.



## 5 Power Connections

Customers provide their own wiring and conduit to power feeds. Power feeds (Standard End Feeds and Center Feed) do not have knock-outs. Customers should create cable entry cut-outs before hanging a power feed. All cable entry cut-outs should have grommets.

### 5.1 Lugs, Wires, and Torque

Customer power connection lugs by power feed type:

- Standard End Feed (250-400A): 2-hole lugs (3/8-in), one wire or two parallel wire connections
- Center Feed (250-400A): 2-hole lugs (3/8-in), one wire or two parallel wire connections
- Standard End Feed (800A): 2-hole lugs (1/2-in), one wire, or two parallel wire connections

The following table gives wire-size recommendations. However, the customer's installers are responsible for selecting wiring that is both appropriate for their installation and compliant with electrical codes.

Busway Amperage	Phase Wiring, Single Wire	Phase Wire, (2) or (3) Parallel Wires	Neutral Wire, Single Wire	Neutral Wire, (2) Parallel Wires	Ground Wire, Single Wire
250A	250 MCM	(2) x 1 AWG	250 MCM (N=100%) 500 MCM (N=150%)	1 AWG (N=100%) (2) x 3/0 AWG (N=150%)	6 AWG
400A	600MCM	(2) x 3/0 AWG	600MCM (N=100%) N/A <sup>1</sup> (N=150%)	(2) x 350MCM (150%) (2) x 3/0 AWG (N=100%)	2 AWG
800A	N/A <sup>1</sup>	(4) x 3/0 AWG (3) x 300MCM	N/A <sup>1</sup>	(3) x 300MCM (N=100%) (4) x 350MCM (N=150%)	1/0 <sup>2</sup>

<sup>1</sup> Single wire not recommended.

<sup>2</sup> 800A Standards End Feed has (2) 1/0 ground wires connected separately to (2) ground lugs.

Isolated Ground: Use Ground Wire, Single Wire size from above table.

BCMS Control Wiring Ground: Use 18 AWG wire for control (BCMS) ground connections from BCMS Comm Box to single-point ground lug.



**Important!**

**Wiring must comply with NEC and local electrical codes!**

Torque power connections as follows:

- Standard End Feed (250-400A): 3/8"-16 screws; torque 350 in-lbs, tolerance (-15)-in.-lbs.: Power connections to customer input power cables
- Standard End Feed (800A): 1/2"-13 screws; torque 875 in-lbs, tolerance (-30)-in.-lbs.: Power connections to customer input power cables

Torque specifications are also given on a label in each power feed:

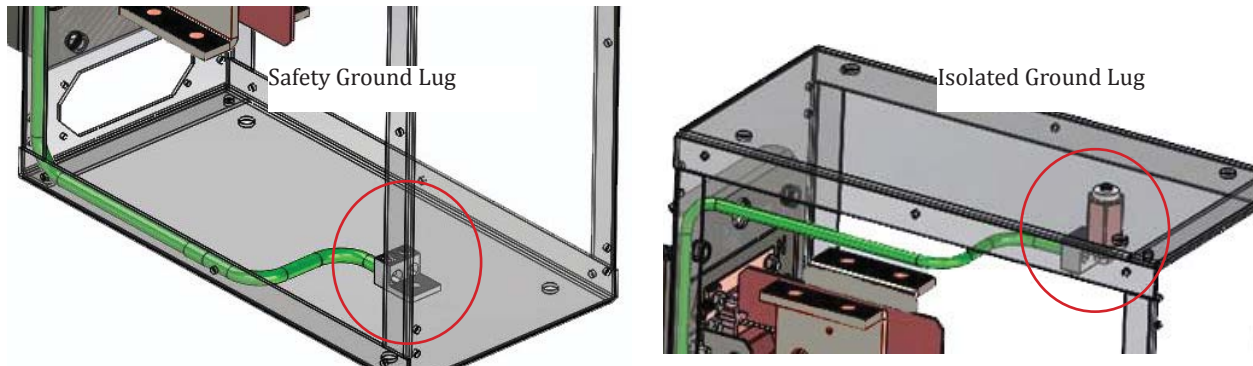
TORQUE SPECIFICATIONS		
HARDWARE BOLT SIZE	IN*LBS	N*M
1/4-20	85	
M6 X 1		10
5/16-18	201	
M8 X 1.25		23
3/8-16	350	
M10 X 1.5		40
7/16-14	575	
M12 X 1.75		65
1/2-13	875	
M14 X 2		100

## 5.2 Power and Ground, Standard End Feed, 250-400A

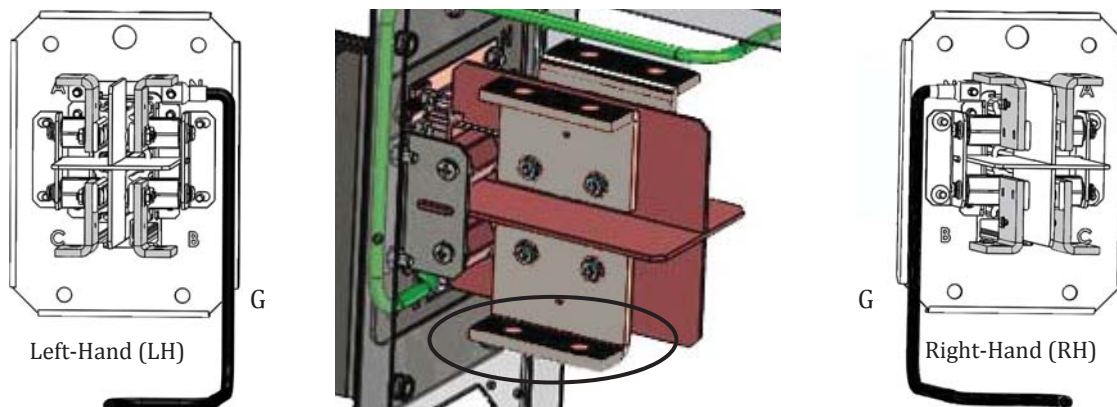
Connect ground wires before connecting power wires.

Connect site safety ground wire to ground lug on bottom of power feed enclosure.

Connect (optional) site isolated ground wire to lug on stand-off on the top of the enclosure. (If Isolated Ground Feature is not selected, Isolated Ground Lug will not be present.)



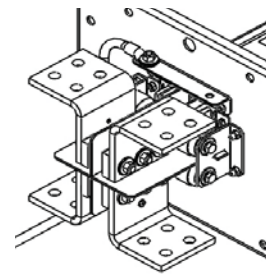
Site power connections (ABCN) are made directly to double-lug terminals in the Starter Rail. Connections are labeled for ABCN. LH and RH orientations have mirror-image layouts. If the BCMS source monitoring option is selected, run power cables through CTs as shown in 5.4.2





### 5.3 Power and Ground, Standard End Feed, 800A

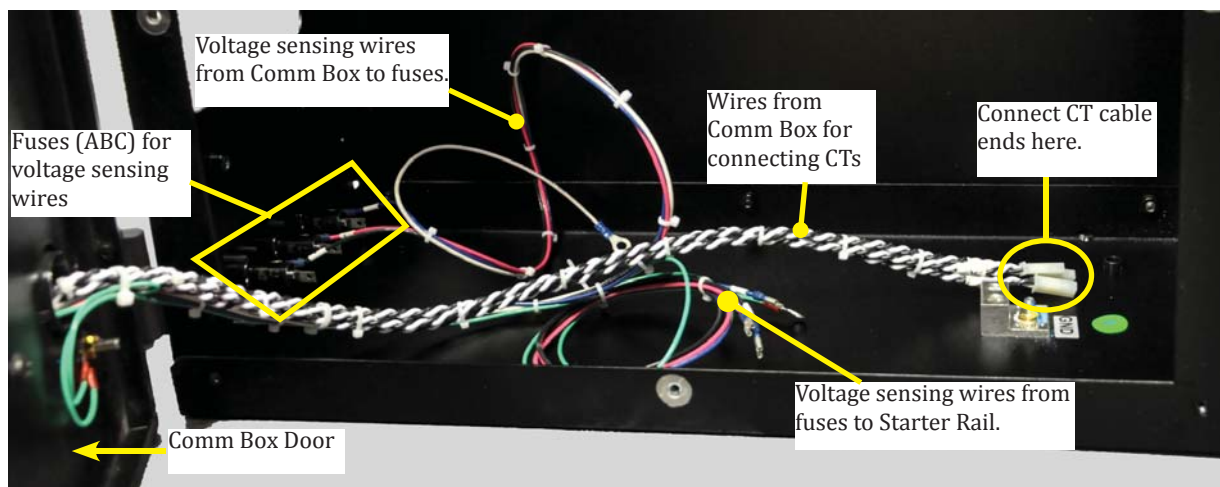
Power and ground connections for 800A Bus Systems are the same as 250-400A Bus Systems except that 800A Starter Rails allow (2) x 2-holes compression lugs.



### 5.4 Connections for Monitoring Source Power

#### 5.4.1 Comm Box Wiring

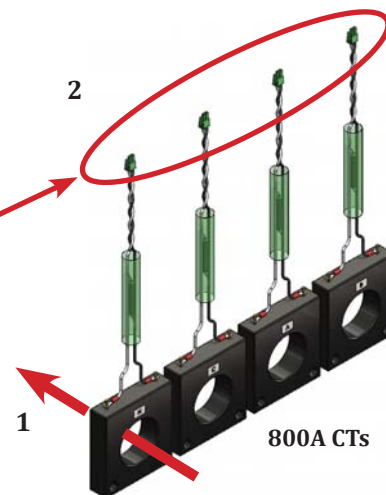
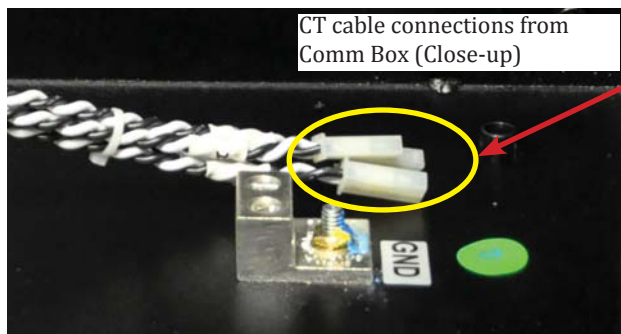
When BCMS is selected for Source Power Monitoring or Tap Off Box Monitoring, a Comm Box is installed on the power feed enclosure (Standard End Feed or Center Feed). Control wiring extends from PCBs in the Comm Box and must be connected when installers connect customer power cables.



#### 5.4.2 Install CTs on Phase Cables

CTs are provided in a separate package with the power feed enclosure.

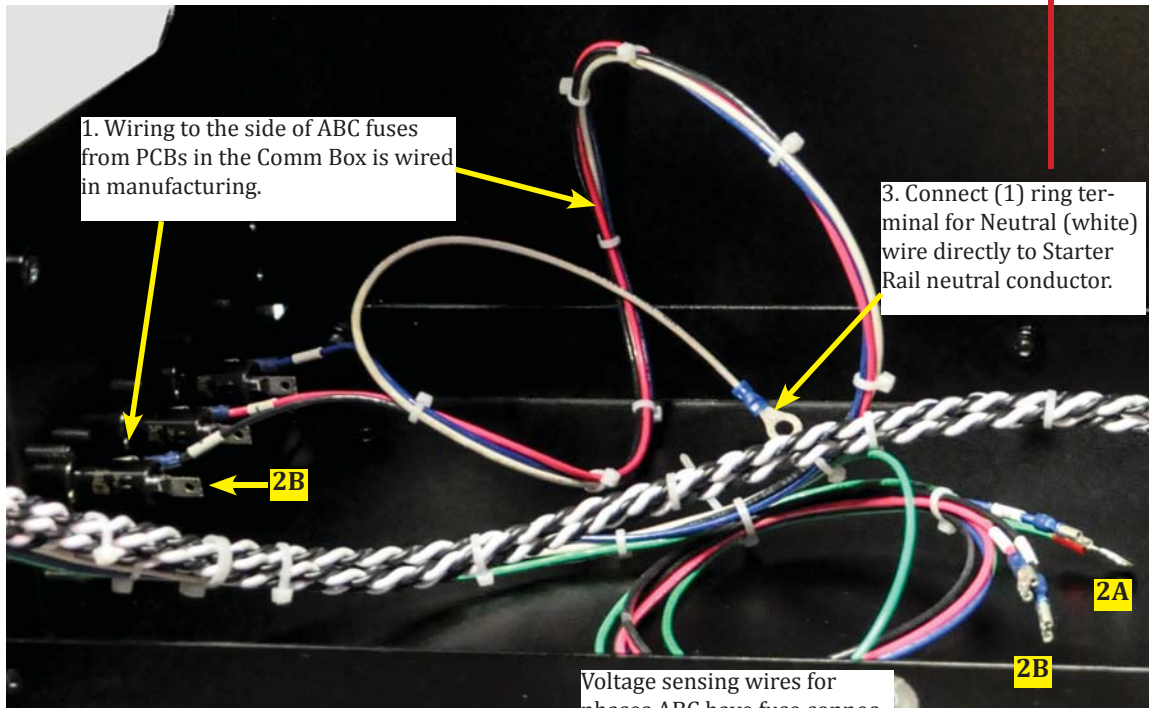
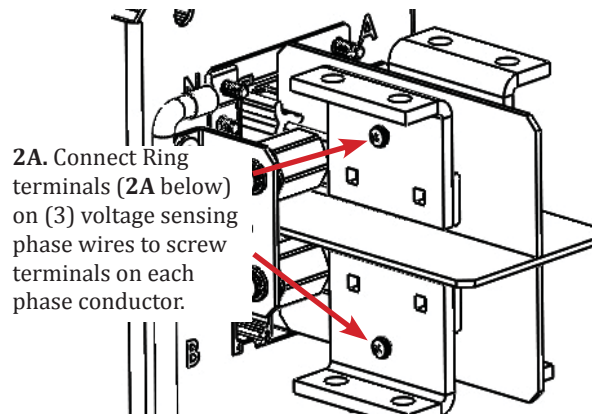
1. String customer ABCN power cables through the ABCN CTs respectively before connecting cables to the Starter Rail. CTs are labeled by conductor.
2. Connect CTs to Comm Box cables with mated connectors.



### 5.4.3 Connect Voltage Sensing Wires

Connect Voltage sensing wires as follows:

1. Wiring from Comm Box to fuses (ABC only, neutral is not fused) is pre-wired in manufacturing.
2. Wire Voltage Sensing wires from fuses to Starter Rail:
  - A. Connect ring terminals to Starter Rail voltage sensing screw terminals for phases ABC.
  - B. Connect other end of the same wire to fuses for phases ABC.
3. Connect (1) Neutral ring terminal directly to Starter Rail neutral conductor without fusing.

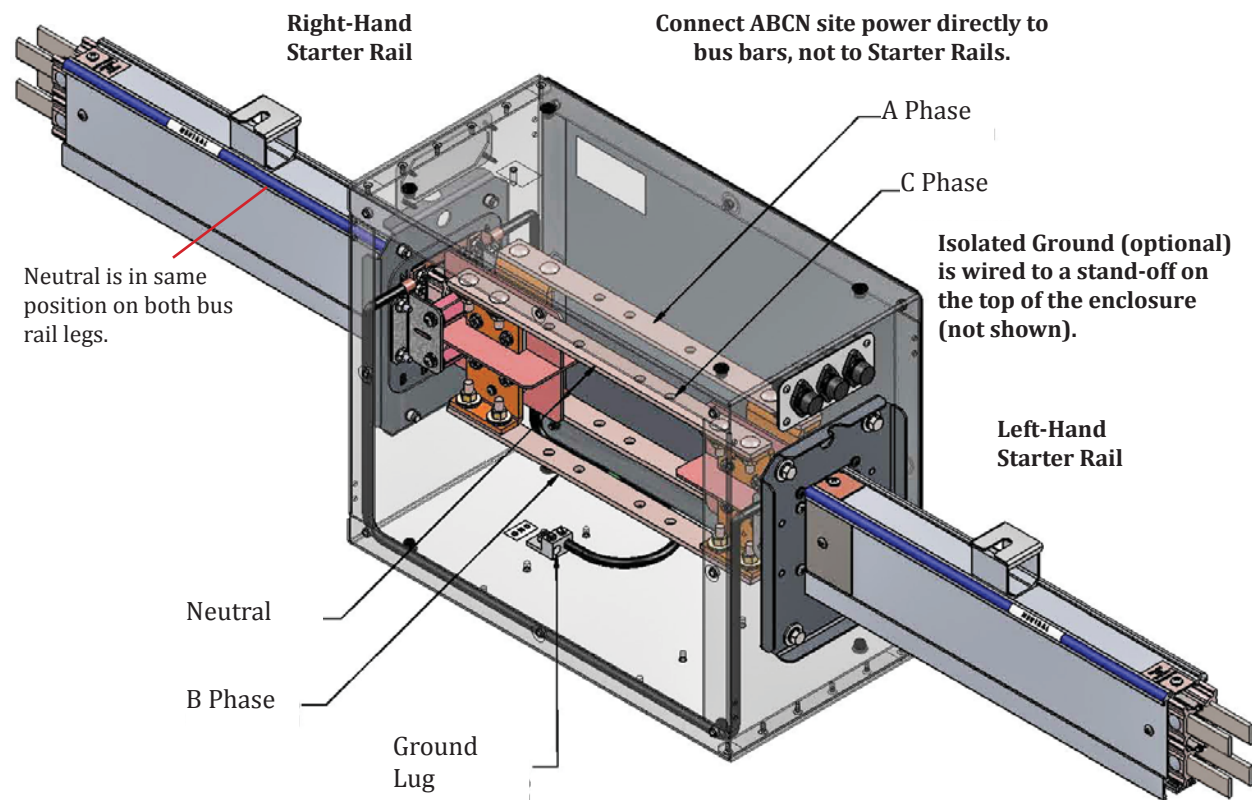


Voltage sensing wires for phases ABC have fuse connectors on one end (A) and ring terminals (B) on the other.

## 5.5 Power and Ground, Center Feed, 250-400A

Center Feeds are pre-assembled with Starter Rails. Because Neutral must be in the same position throughout the bus run, one Starter Rail is Right-Hand and the other Starter Rail is Left-Hand. Starter Rails are cross-connected by bus bars for ABCN power connections and cross-wired for ground and optional isolated ground.

Power (ABCN) connections are made to the bus bars, not to the Starter Rails. Ground and Isolated Ground connections are made to lugs in the bottom and top of the enclosure, just as for the Standard End Feed.



## 6 Tap Off Box Installation

Both Quick Connect Tap Off Boxes and Tap Off Boxes with Universal U-Channel can be installed nearly anywhere along a PowerWave 2 bus run. Both types of Tap Off Box can be installed in the same bus run. Both Tap Off Box types can also connect to and use the bus run's monitoring cable if the bus run and the Tap Off Boxes are configured for monitoring. The bus run should be tested before installing all Tap Off Boxes. See Chapter 7, "Start-Up Procedure."

### 6.1 Tap Off Box Safety

PowerWave 2 Bus Systems have an IP2X finger-safe rating (IEC60529). Tap Off Boxes are also ETL-rated for inserting into a bus rail with energized conductors.

Tap Off Boxes are inserted into Bus Rails in a safe two-stage process:

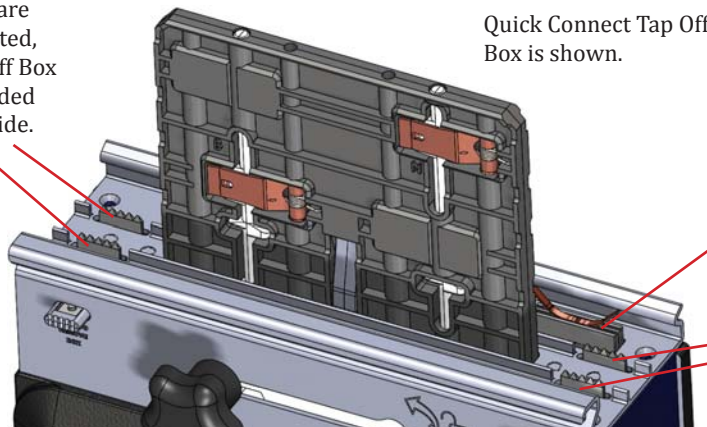
1. Ground and optional isolated ground connections are automatically made when the Tap Off Box is inserted into the Bus Rail.
2. Contact is then made with conductors when you slide the Contact Engagement Knob all the way to the right.



**Warning: Do not insert tools into the Bus Rail central mast channel! Risk of shock or fatal injury from high voltages and amperages.**

(2) Ground Clips on each side are cross-connected, so that Tap Off Box can be grounded from either side.

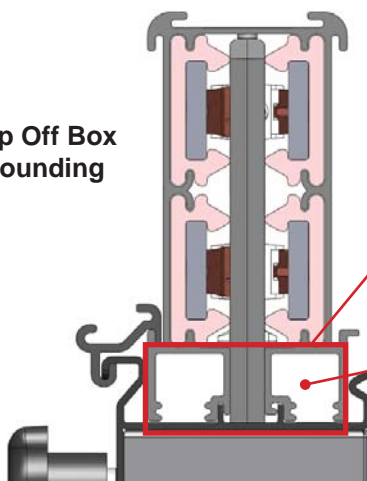
Quick Connect Tap Off Box is shown.



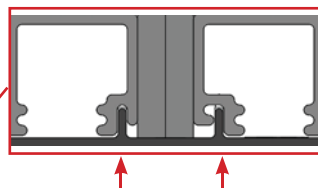
(1) Isolated Ground Clip (optional) on right side only.

(2) Ground Clips on each side.

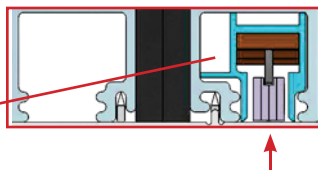
**Tap Off Box Grounding**



Tap Off Box with Universal U-Channel is shown.



Ground Clips are grounded to the Bus Rail when Tap Off Box mast is fully inserted into the Bus Rail.



If the Isolated Ground Clip is installed, it is grounded to the Isolated Ground Channel in the Bus Rail when Tap Off Box mast is fully inserted.

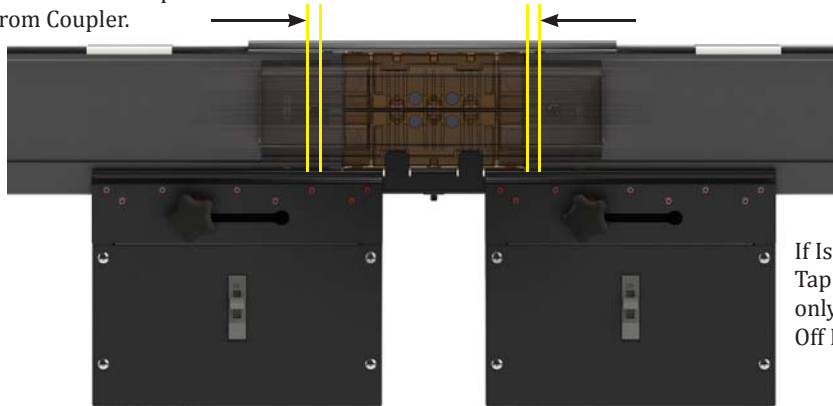
## 6.2 Coupler Overlap 250-400A

Because ground clips on the left and right side of the Tap Off Box are cross-connected, a Tap Off Box can overlap a Coupler on one side while being grounded on the other side in 250-400A bus systems. The mast on a Tap Off Box can come up to ½" from a Coupler (up to the C-Clip at the end of the Bus Rail).

A Tap Off Box with isolated ground can overlap a Coupler only on its left side to avoid masking the single isolated ground clip on the right side of the Tap Off Box.

No Tap Off Box overlap with Couplers is possible on 800A Bus Systems.

Mast can come up to ½"  
from Coupler.



If Isolated Ground is installed, the Tap Off Box can overlap a Coupler only on its left side as with the Tap Off Box shown on the right.

## 6.3 Inspect Tap Off Boxes Before Installing

**Inspect Step 1.** Inspect the Tap Off Box enclosure for dents, bent edges, cracks, and missing components. Inspect all contacts for bent contacts, bent contact springs, or missing springs.

If the Tap Off Box appears to be defective, DO NOT INSTALL THE Tap Off BOX!  
Contact PDI Service Department at

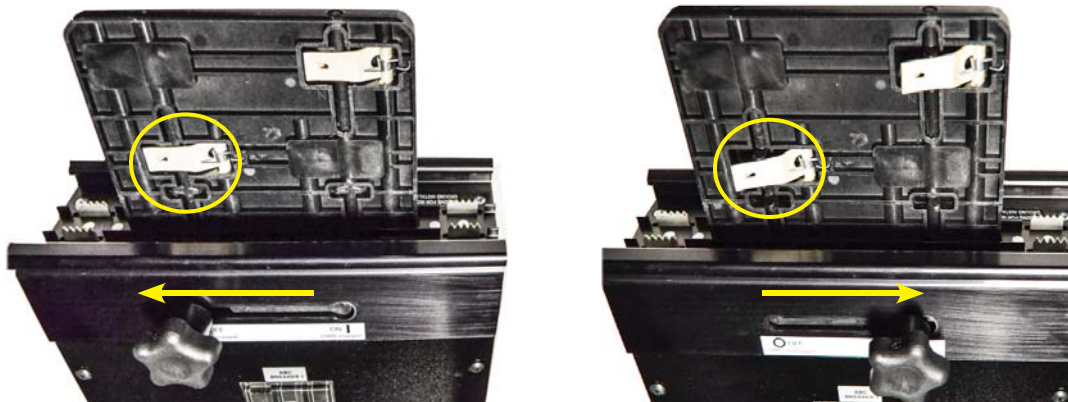
- service@pdicorp.com OR
- 804.737.9880

**Inspect Step 2.** Test Conductor Contacts Movement

**2A.** Move the Contact Engagement Knob all the way left: Conductor Contacts on both sides of the mast should be completely recessed.

**2B.** Move the Contact Engagement Knob all the way right: Conductor Contacts should open on both sides of the mast.

**Note:** To loosen Contact Engagement Knob so that you can slide it, turn it counter-clockwise. To tighten again, turn clockwise.



## 6.4 Quick Connect Tap Off Box

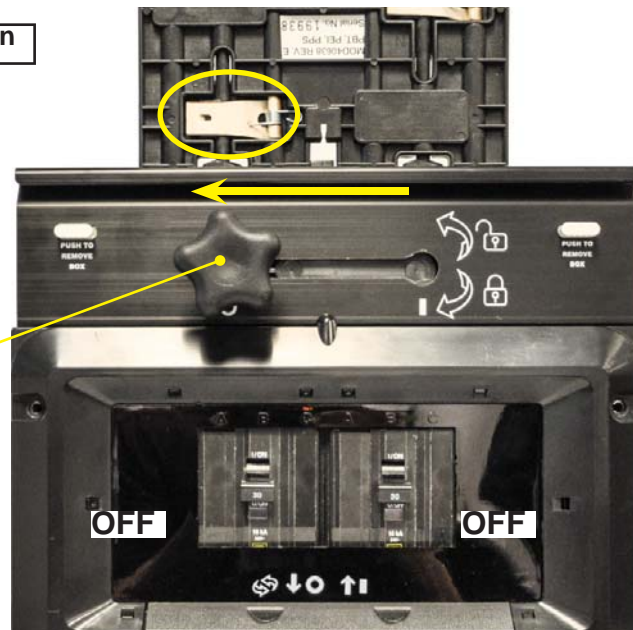
### 6.4.1 Installing a Quick Connect Tap Off Box

#### Step 1. Prepare Tap Off Box for Installation

**1A.** Set Contact Engagement Knob all the way left (CAMS disengaged). Verify that all four Conductor Contacts are completely recessed.

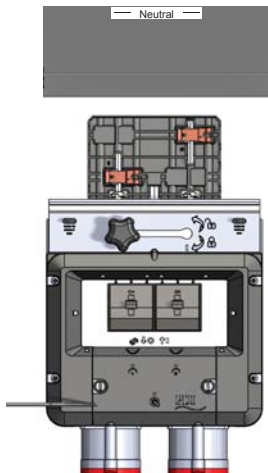
**Note:** To loosen Contact Engagement Knob so that you can slide it, turn it counter-clockwise. To tighten again, turn clockwise.

**1B.** Turn Tap Off Box circuit breaker(s) OFF.

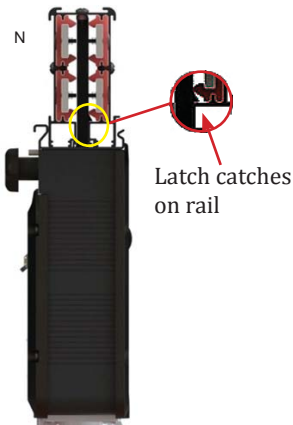


#### Step 2. Insert Tap Off Box into Bus Rail

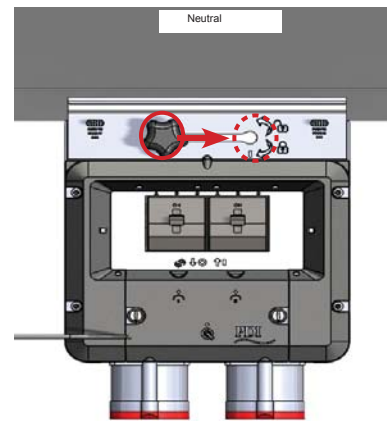
**3A.** Position the Tap Off Box front on the neutral side of the Bus Rail and align the mast with the central channel.



**3B.** Insert Tap Off Box mast completely into the Bus Rail. The latch on the rear of the mast catches on the Bus Rail to hold the Tap Off Box in place.



**3C.** Slide Contact Engagement Knob all the way right into its keyhole and tighten knob. Tap Off Box is now installed.



#### Step 3. Connecting BCMS Monitoring Cable

When Tap Off Box Monitoring is selected, the BCMS cable must be connected to the bus rail monitoring channel. However, this should be done as part of BCMS Setup to correctly assign a Modbus address to the Tap Off Box.

See companion manual, *PowerWave 2™ Bus System, Branch Circuit Monitoring System, Setup and Operation*, PM375107, which can be downloaded from the PDI web site PowerWave 2 product page:

<http://www.pdicorp.com/products/distribute/powerwave-2-bus-system>

### 6.4.2 Removing a Quick Connect Tap Off Box

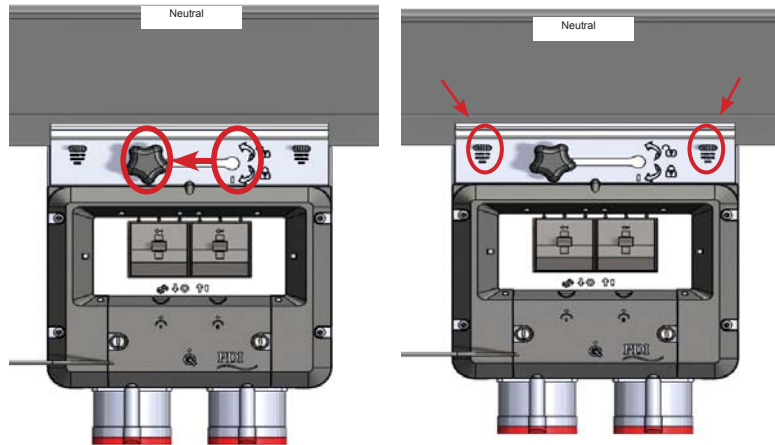
To remove a Quick Connect Tap Off Box from the bus rail, do the following:

1. Disconnect the BCMS Monitoring cable from the bus rail channel, if installed.

2. Slide Contact Engagement Knob all the way left and tighten knob.

3. Holding the Tap Off Box at the sides, press remove buttons with your thumbs until the latch unhooks from the rail.

4. Still holding the Tap Off Box, carefully remove it from the bus rail.



## 6.1 Tap Off Box with Universal U-Channel

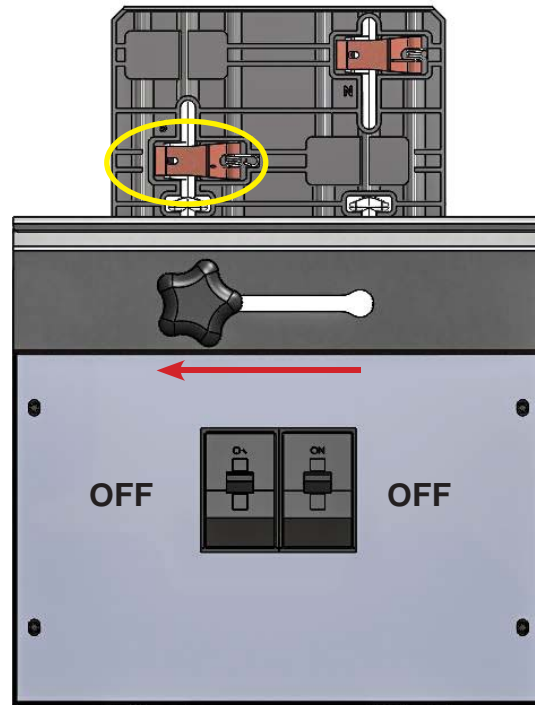
### 6.1.1 Installing a Tap Off Box with Universal U-Channel

#### Step 1. Prepare Tap Off Box for Installation

1A. Set Contact Engagement Knob all the way left (CAMS disengaged).

Verify that all (4) Conductor Contacts are completely recessed.

1B. Turn Tap Off Box circuit breaker(s) OFF.



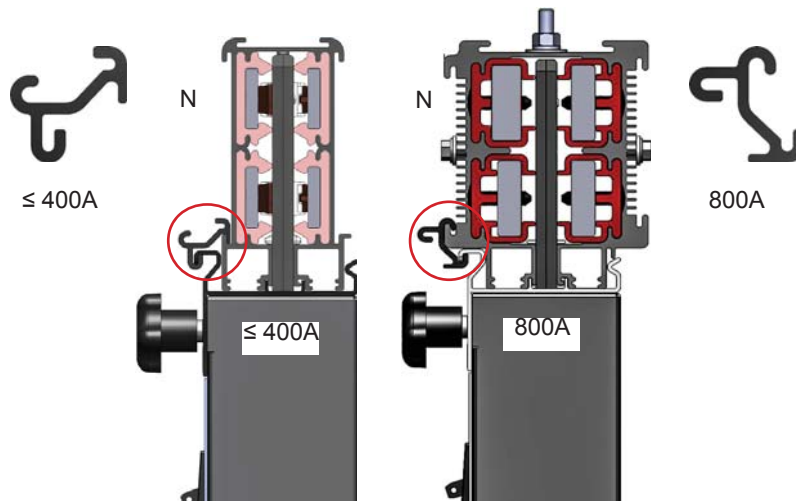
#### Step 2. Install Retainer Clips on the Bus Rail.

Two Retainer Clips are included with each Tap Off Box to secure the Tap Off Box to the Bus Rail. Retainer Clips have two different orientations depending on Bus Rail amperage ( $\leq 400A$  or  $800A$ ).

Retainer Clips must be installed on the neutral side of the Bus Rail.

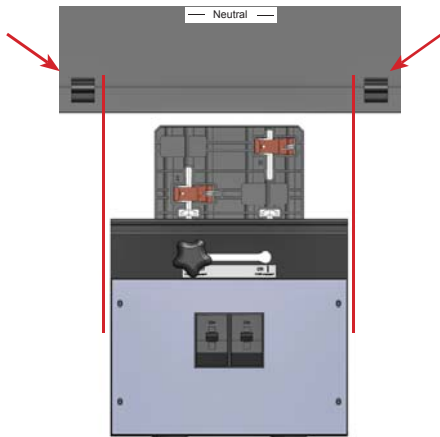


(2) Retainer Clips are included with each Tap Off Box.



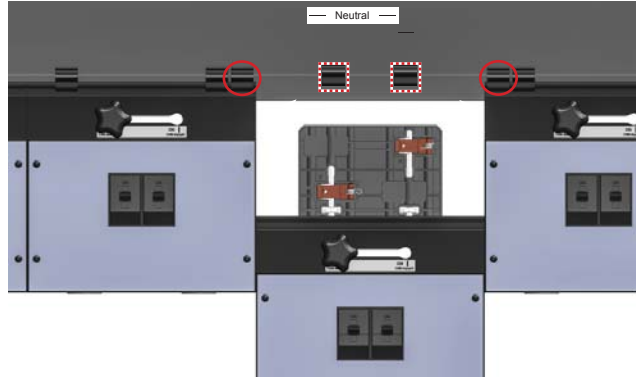


Clip the two Retainer Clips onto the Bus Rail just outside the left and right sides of the Tap Off Box.



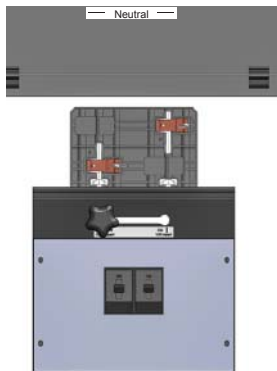
Tap Off Boxes can be installed adjacent to one another (touching) if BCMS is not installed for Tap Off Boxes.

If Tap Off Boxes are butted together, clip Retainer Clips onto Bus Rail above the Tap Off Box and slide Clips onto adjacent Tap Off Boxes.

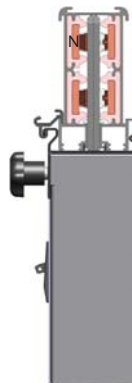


**Step 3. Insert Tap Off Box into Bus Rail**

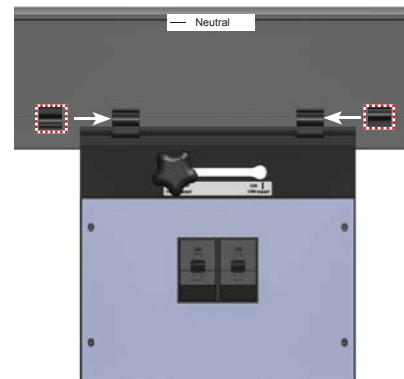
3A. Position the Tap Off Box front on the neutral side of the Bus Rail and align the mast with the central channel.



3B. Insert Tap Off Box mast completely into the Bus Rail and hold in place.



3C. Slide Retainer Clips over the Tap Off Box lip about 1" in from the sides.



3D. Slide Contact Engagement Knob all the way right into its keyhole and tighten. Tap Off Box is now installed.



**Step 4. BCMS Monitoring Cable**

When Tap Off Box Monitoring is selected, the BCMS cable must be connected to the bus rail monitoring channel. However, this should be done as part of BCMS Setup to correctly assign a Modbus address to the Tap Off Box.

See companion manual, *PowerWave 2™ Bus System, Branch Circuit Monitoring System, Setup and Operation*, PM375107, which can be downloaded from the PDI web site PowerWave 2 product page:

<http://www.pdicorp.com/products/distribute/power-wave-2-bus-system>

### 6.1.2 Removing a Tap Off Box with Universal U-Channel

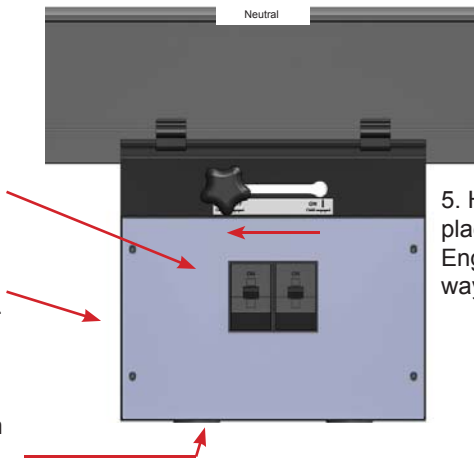
#### Removing Tap Off Boxes

1. Power down servers or other load equipment connected to Tap Off Box according to manufacturers' or site procedures.

2. Turn OFF Tap Off Box circuit breaker(s) to receptacle(s).

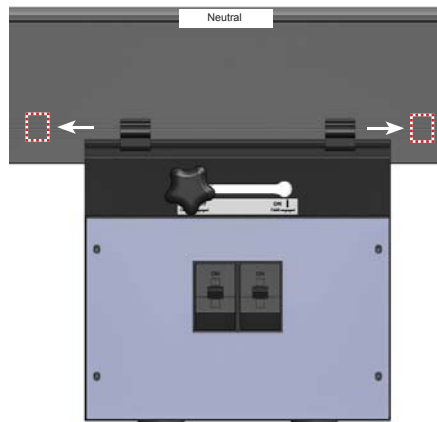
3. If installed, detach BCMS monitoring cable from bus rail and Tap Off Box side.

4. Disconnect server or load whips from power receptacle(s).



5. Holding Tap Off Box in place, slide the Contact Engagement Knob all the way left.

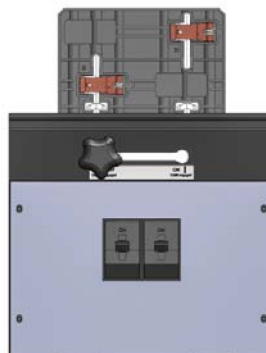
6. Still holding Tap Off Box in place, slide retainer clips away from sides.



7. Carefully pull the Tap Off Box away from the Bus Rail.



8. Remove Retainer Clips from Bus Rail and save.



## 7 Start-Up Procedure

### **DANGER!**

**This product must be installed and inspected by licensed electricians or by PDI-authorized technicians. This document should not be viewed as sufficient by otherwise non-qualified personnel to operate, service, or maintain this equipment.**



**Severe or fatal injury can result from electrical shock during contact with high voltage conductors, monitoring PCBs, or similar equipment!**

- **Disconnect power before drilling holes, making cutouts, attaching conduit, or connecting to PDUs, RPPs, or other power distribution equipment.**
- **Use Lock Out/Tag Out procedures.**
- **Wear suitable personal protective clothing and use protective equipment for performing mechanical and electrical installations.**
- **Leave ample space for attaching and routing wires.**

### 7.1 Power-Up Checklist

A PDI Certified Technician or the installer should execute the following checklist to verify correct operation before applying loads to Tap Off Boxes.

Verify the upstream circuit breaker and optional power feed circuit breaker are “OFF” or OPEN and locked out prior to adjusting electrical connections or initial system start-up.

1. Inspect the power feed (Standard End Feed or Center Feed) enclosure.
  - A. Verify that the power feed enclosure is secure with correct mounting hardware.
  - B. Verify that input cabling routed into the power feed enclosure avoids sharp edges.
  - C. Verify that power input cables are correctly connected to corresponding voltage connection on the Starter Rail for Standard End Feeds or, for Center Feeds, to the power bus bars that are connected to the Starter Rails.
  - D. Verify that the color code of each input cable correctly matches power feed connections.
  - E. (Optional for BCMS) Verify that voltage sensing wires are secured to correct power feed connections per 6.x .....
  - F. (Optional for BCMS) Verify each phase CT is installed and its wire is routed correctly per 6.x .
  - G. Verify that the grounding connections in the power feed enclosure are securely tightened.

Note: A Torque Specification label can be found inside each power feed (Standard End Feed or Center Feed).

2. (Optional for BCMS) Inspect the installed BCMS cards in the Comm Box:
  - A. Verify that the three (3) installed BCMS PCBs are secured.
  - B. Verify that all control wire connections at each PCB are correctly connected and secured.
  - C. Verify that all cables in the Comm Box are connected.
  - D. Verify that the customer Modbus cable is routed correctly (if installed).

3. Inspect the bus run:
  - A. Verify that the **neutral** label is facing the same direction on all installed bus system components. For bus run legs with Elbows or Tees, verify that **neutrals** face correctly per bus run design.
  - B. Verify that power feed enclosure mounting brackets and bus run hangers are spaced evenly to secure the bus run.
  - C. Ensure that all protective devices (upstream circuit breaker and disconnects in power feed enclosure) are correctly rated with respect to the loads supplied, or in accordance with project specifications, and that they are in the OFF position.
  - D. Verify that neutrals align along the bus run and that all incoming power feed cables are phased correctly to the bus system.
  - E. Verify that all connection phasing (across Couplers) within the bus run is correct.
4. Inspect each Coupler:
  - A. Verify that the Coupler connection is installed correctly per this manual.
  - B. Verify that the side plates at each Coupler are positioned correctly so that they symmetrically overlap both sides of the Coupler.
  - C. Verify that the Ground Jumper Plate (250-400A) on top of the each Coupler is secure with all (3) screws tight or that the Ground Strap (800A) is securely bolted on with nuts on all (4) bolts tightened down. Verify that the labels under the Ground Jumper Plates or Ground Straps have been removed.
5. Inspect all Tap Off Boxes:
  - A. Verify that all installed Tap Off Boxes are facing forward to the front (**neutral** side) of the bus run.
  - B. Verify Tap Off Boxes are installed properly with ON/OFF Contact Engagement Knobs secured and locked in the ON (engaged) position.
  - C. Verify all Tap Off Box circuit breakers are in the open (OFF) position.
  - D. (Optional for BCMS) Verify that each Tap Off Box communication cable is connected the Tap Off Box.  
**NOTE: IMPORTANT!** Tap-Off Box communications cable should be disconnected from the bus rail during Start-up. The Tap Off Box cable is connected during BCMS Setup when the Tap Off Box Modbus address is assigned.
6. Perform resistance testing on the bus run:
  - A. Use a digital meter and verify that there are no direct shorts at the Starter Rail from each phase connection to ground.

## 7.2 Power Up

1. The bus run should have no electrical load connected or all devices connected to the busway (Tap Off Boxes, monitoring equipment) should have their circuit breakers open or OFF.
2. Perform the following:
  - A. Turn ON the upstream power source to the bus system and optional power feed enclosure circuit breaker. Verify that voltage is present at the Starter Rail.
  - B. Turn on circuit breakers for a Tap Off Box located at the end of the bus run. Verify that the Tap Off Box is receiving power.
3. Perform a load bank test. (PDI has a Load Bank End Feed (load bank adapter) available for rental for 250A and 400A systems. Contact PDI Service for rental information.)
4. After power to the bus run is verified, turn on circuit breakers to each Tap Off Box one by one to verify

that power is present.

5. At this point if inspections and tests are successful, loads can be applied to each Tap Off Box.
6. (Optional for BCMS) If BCMS for Source Power and/or Tap Off Boxes is an installed option, perform BCMS Setup according to instructions in the companion manual, *PowerWave 2™ Bus System 250–800A, Branch Circuit Monitoring System, Setup and Operation (Cntl Number: PM375107 Rev 002)*. See **Bibliography** for download instructions for this and other manuals.

## 8 Maintenance

### **DANGER!**

This product must be installed and inspected by licensed electricians or by PDI-authorized technicians. This document should not be viewed as sufficient by otherwise non-qualified personnel to operate, service, or maintain this equipment.



Severe or fatal injury can result from electrical shock during contact with high voltage conductors, monitoring PCBs, or similar equipment!

- Wear suitable personal protective clothing and use protective equipment for performing mechanical and electrical installations.
- Use the same safety precautions as for startup. Power and circuit breakers must be off and locked out to perform the following tests.

PowerWave 2 Bus Systems require only nominal maintenance. Inspect the busway annually or after any short circuit or ground fault.

### 8.1 Annual Inspection

Visually inspect the entire busway.

(Recommended) Use a thermal scanning device to record the temperature rise for each termination in the end feed. Record this information for year over year comparison.

### 8.2 Procedure After Short Circuit or Ground Fault

1. Carefully inspect the entire busway.
2. Check power feed terminations, Bus Rails, and Tap Off Box contacts for discoloration, corrosion, or pitting. Replace affected components with new components.
3. Check that all mechanisms and mechanical interlocks are in satisfactory operating condition.
4. Check the torque on all power connections using a torque wrench. The tightening torque is specified on a power feed (Standard End Feed or Center Feed) label.
5. Check the insulation resistance before re-energizing the busway. Keep a record of resistance readings.
6. Execute the procedures in Chapter 7 Start Up Procedure.
7. (Recommended) After the busway is re-energized and has reached a stable operating temperature, perform an infrared temperature test on all electrical connections.

### 8.3 IR Scanning

Connections in the Standard End Feed or Center Feed can be infrared-scanned through the optional Infrared Scanning Window.

Circuits in the Quick Connect Tap Off Box can be scanned directly through the front of the TOB. Scan circuit connections just under the circuit breakers.

### 8.4 Spares Kits

Spares kits are available for PowerWave 2 Bus Systems that are specialized for different BCMS options. Parts will be selected to match the amperage of your system.

#### PowerWave 2™ Bus System Spare Parts Kits

Qty	Spare Parts Kit Components	Options					
6	Side Plate	A	B	C	D		
6	Ground Plate (250-400A) or Ground Strap (800A)						
2	Coupler						
2	End Cap						
6	Hangers						
2	Hot Stick						
2	Power Inserter Board						
2	Input Monitor Board & GP I/O						
2	Accumulator & GP I/O						
2	End Feed Harness with Terminating Resistor						
12	Fuses						
2	Communications Cable						C
2	CT Board						
2	IBus Board & GP I/O						
4	Communication Connectors						

**Options Key:**

- A. No BCMS (Monitoring) Option selected
- B. BCMS Option for Power Feed Only
- C. BCMS for Tap Off Boxes Only
- D. BCMS for both Power Feed and Tap Off Boxes

## Glossary

1P	One phase
2P	Two phase
3P	Three phase
AWG	American Wire Gauge
BCMS	(PDI's) Branch Circuit Monitoring System
Comm Box	Communications Box, a box added to a power feed that contains monitoring PCBs and an optional protocol converter for upstream Modbus TCP/IP or SNMP. Customer networking connections are made to the Comm Box.
Coupler	A component used to join bus rails, Elbows, and Tees into a bus run.
ETL	Intertek's ETL listed mark, North American certification
IEC	International Electrotechnical Commission
IP2X	Finger-safe International Protection Marking
kAIC	Kilo amperes interrupting capacity
NEC	National Electrical Code (US)
NEMA	National Electrical Manufacturers Association
Power Feed	Standard End Feed or Center Feed. Site or customer 3-phase, 4-wire power, ground, and optional isolated ground connections are made at the power feed to provide power for the bus run.
RMS	Root mean squared
Starter Rail	The first bus rail in a bus run. Customer power is connected directly to the Starter Rail.
Standard Rail	All bus rails coming after the Starter Rail are Standard Rails.
TOB	Tap Off Box
UL	Safety certification company



# Bibliography

## PowerWave 2 Bus System Documentation

Most of the following documentation can be downloaded from the PowerWave 2 Bus System product page on the PDI web site:

<http://www.pdicorp.com/products/distribute/powerwave-2-bus-system>

### Brochures

*PowerWave 2™/The Next Generation of Flexible Power Distribution*

*PowerWave 2™/La distribution électrique flexible de la prochaine génération (French)*

*PowerWave 2™/The Next Generation of Flexible Power Distribution (Chinese translation)*

### Specifications

*PowerWave 2™ Bus System Guide Specifications (.docx and .pdf)*

See also: specifications summary in the PowerWave 2 Brochure.

See also: specifications on PowerWave 2 Bus System product web page:

<http://www.pdicorp.com/products/distribute/powerwave-2-bus-system>

### Revit Models

PowerWave 2 Revit Family Model Library (.zip file)

PowerWave 2 - User Guide -Revit Family Model Library (*PDI Revit® Model Instructions/Power Distribution Units, Remote Power Panels, Static Transfer Switches, Floor Stands, PowerWave 2™ Bus Systems, Ctrl Nr PM375127*)

### Installation and Operation Documentation

*PowerWave 2™ Bus System 250A-800A Installation and Operation PM375106 (.pdf) (this manual)*

*PowerWave 2™ Bus System, Branch Circuit Monitoring System, Setup and Operation, PM375107 (.pdf)*

*Structural Calculations for Suspended Bus System Seismic Supports, Seismic Support Guidelines*

### Videos

The following videos on PowerWave 2 Bus Systems are available from your Regional Sales Manager:

*PowerWave 2 Bus System Introductory Video*

*PowerWave 2 Coupler (250-400A) Assembly Video*

*PowerWave 2 Load Bank (250-400A) Installation Video*

### Selected Documentation for Other PDI Products

You can download the most recent version of the following product manuals from the corresponding product page on the PDI web site ([pdicorp.com](http://www.pdicorp.com)).

#### Power Distribution Units (PDUs)

*WaveStar® PowerHub 2 Power Distribution Unit 300-750 kVA, Installation and Operation Rev DOC15315*

*WaveStar® PowerPak 2 Power Distribution Unit 150-400 kVA, Installation and Operation PM375116*

*WaveStar® PowerPak Power Distribution Unit 50-300 kVA, Installation and Operation PM375118*

#### Remote Power Panels (RPPs)

*Modular Compact Remote Power Panel, Installation and Operation* PM375115

**Static Transfer Switches (STSs)**

*WaveStar® Static Transfer Switch 150A-1600A Installation and Operation* PM375111

*WaveStar® Static Transfer Switch 2000A 3-Pole Installation and Operation* DOC15139

*WaveStar® Static Transfer Switch 1000A 3-Pole Bypass Procedures* PM375117

**BCMS Monitoring Products**

*WaveStar® Color Monitor, Setup and Operation* PM375103

*JCOMM® Installation and Operation* PM375100

*Wavestar® BCMS Hub Installation and Operation* PM375108

*Branch Circuit Monitoring System, Installation and Operations Manual for BCMS Plus HV (IEC Version)*  
DOC15005