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Uninterruptible Power Supply Systems

UTrain course 58423

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Unclassified: David Allen Smith 2024-05

Terminal Objective: UPS Design Engineer Electrical

- **Identify the principles of operation of uninterruptible power supply (UPS) systems, focusing on double conversion and offline/standby/backup types.**

Objectives: UPS Engineering Design

Identify	Identify the difference between double conversion and offline/standby/backup UPS systems.
Describe	Describe the advantages and disadvantages of each type of UPS system.
Identify	Identify the appropriate type of UPS system for a given application.
Explain	Explain how to install and maintain UPS systems.

Uninterruptible Power Supply Systems

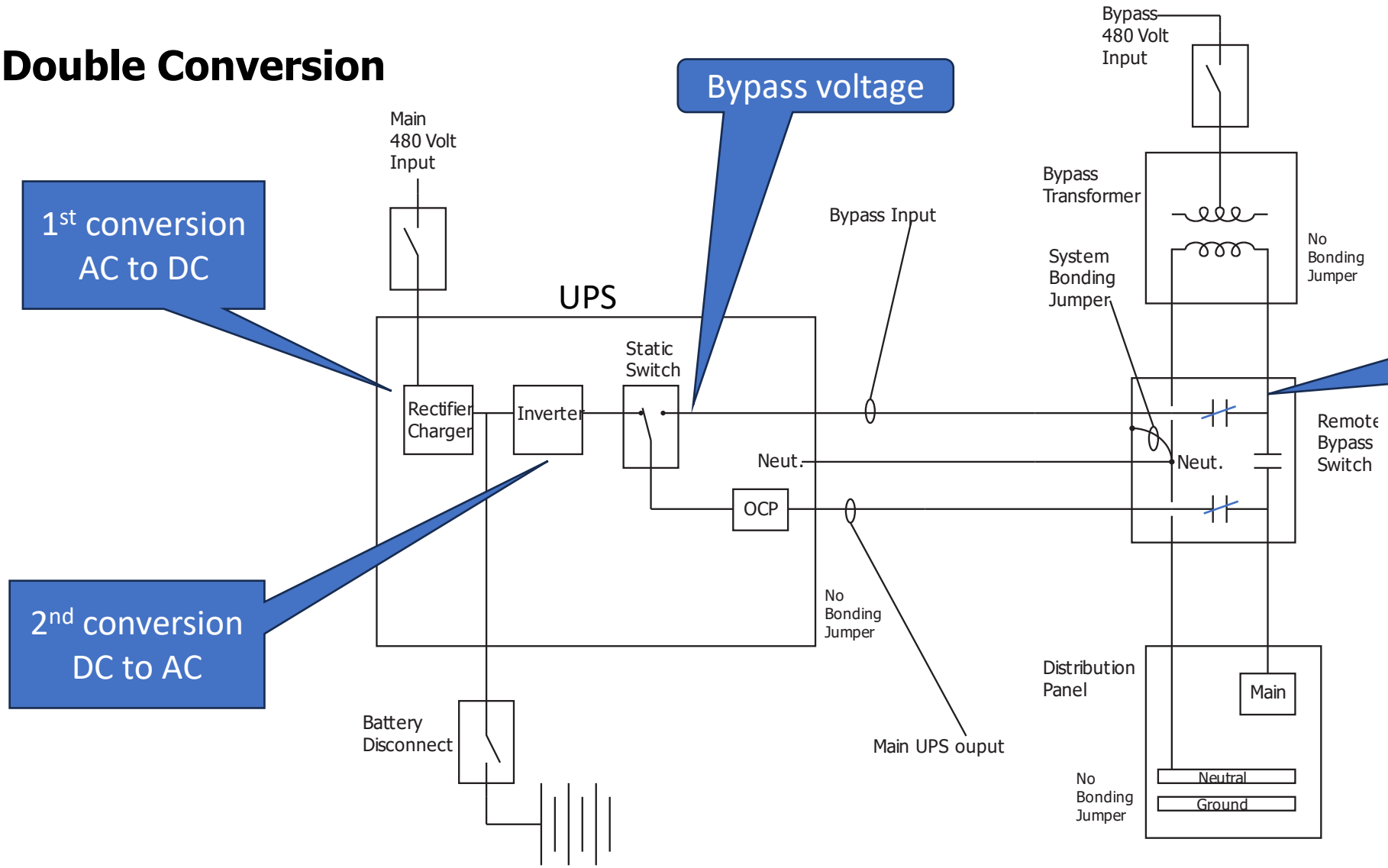
Types of UPS systems

- Double Conversion
- Offline/Standby/Backup (line-interactive is a variation of this)

Double Conversion - The traditional UPS is now referred to as a "double conversion" UPS. The AC input power is rectified into DC. The DC feeds an inverter which provides the AC output. The DC bus is also connected to batteries. It is called double conversion because the first conversion is from AC to DC and the second conversion is from DC to AC. The inverter creates the output waveform to match the bypass input. Because of this, the static bypass switch may be switched between inverter and bypass seamlessly.

Uninterruptible Power Supply Systems

Double Conversion



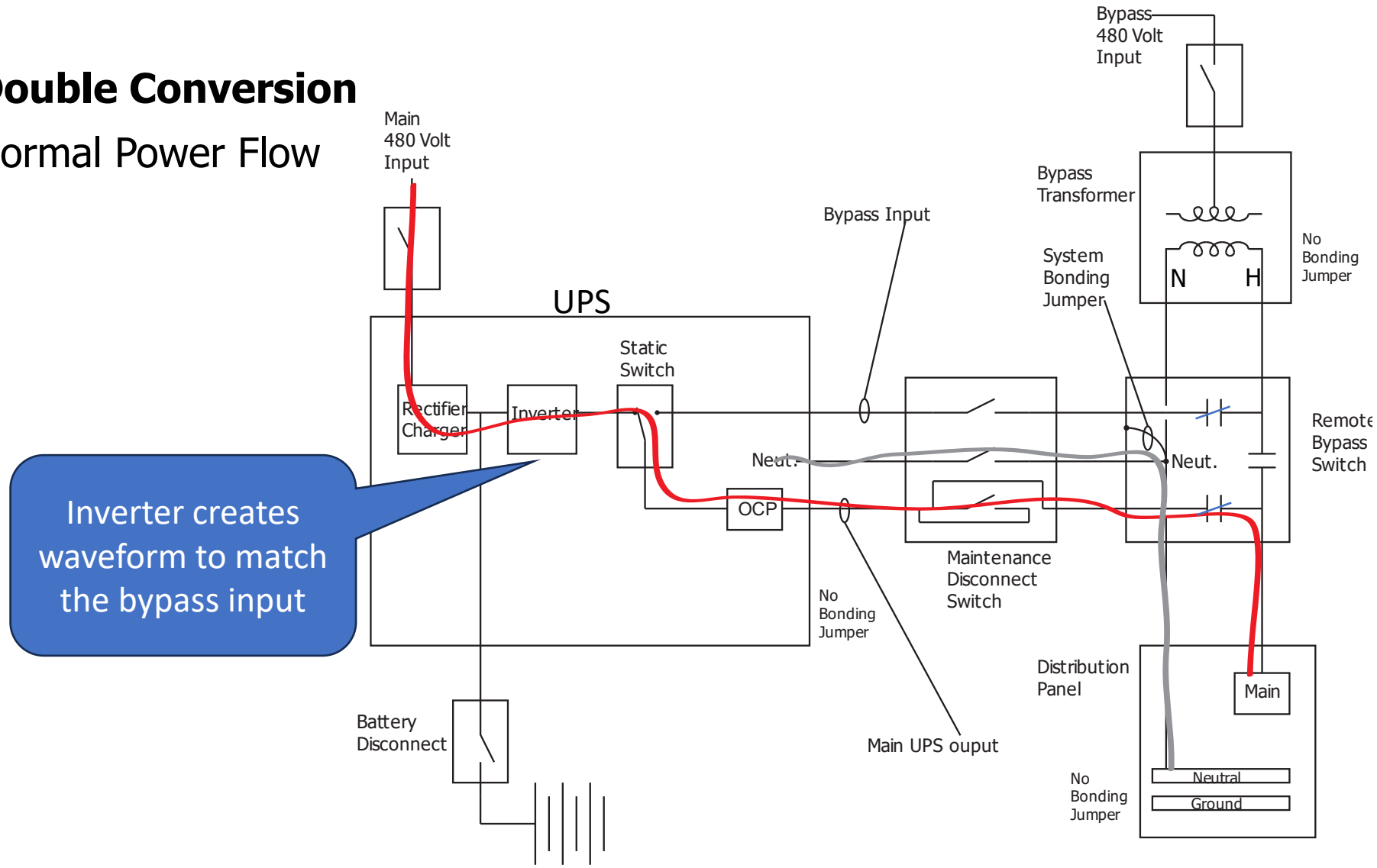
1 – Transformer secondary conductors can only be 25 ft. long (indoors)

2 – The System Bonding Jumper is in the location of the first overcurrent device.

Uninterruptible Power Supply Systems

Double Conversion

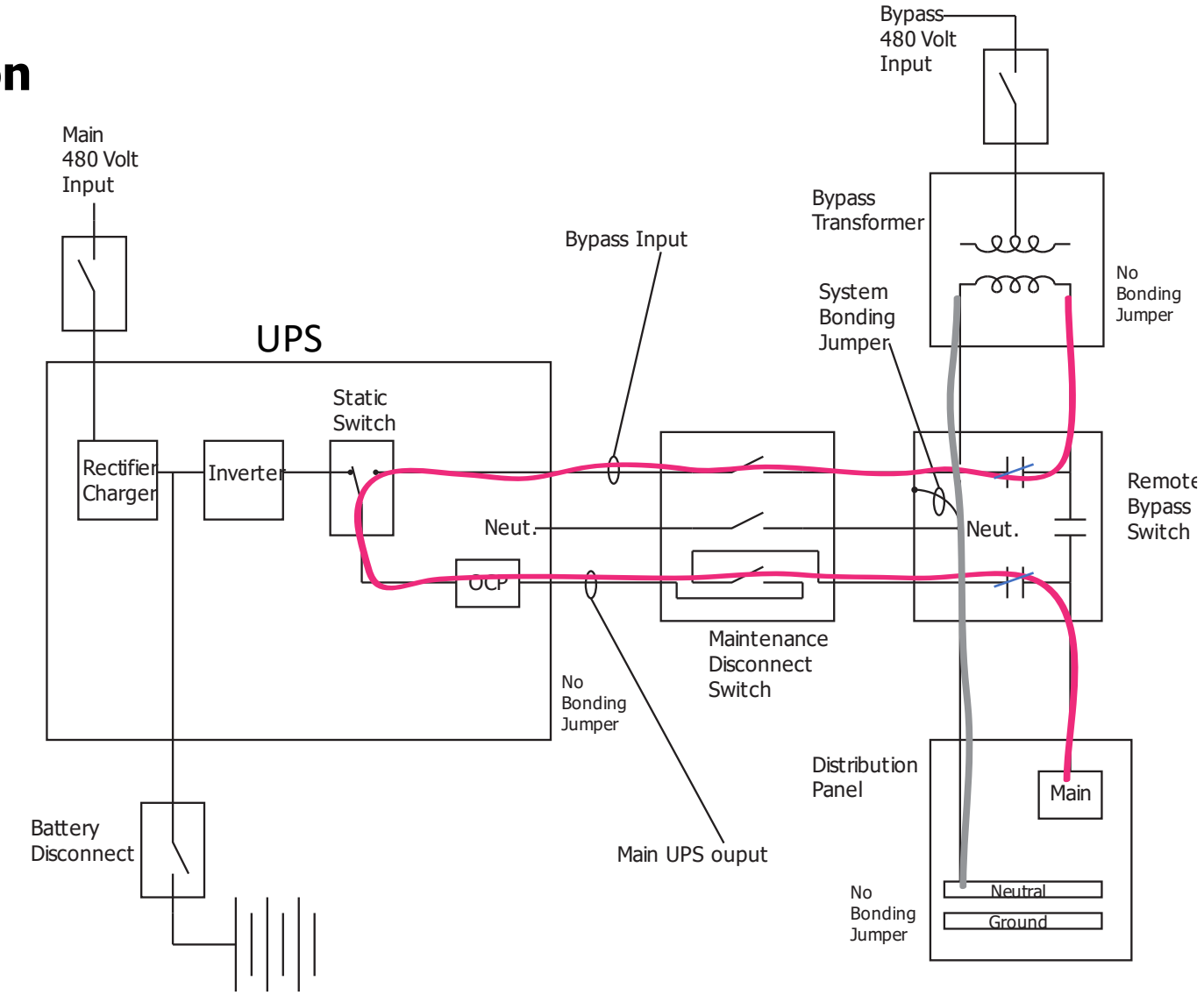
Normal Power Flow



Uninterruptible Power Supply Systems

Double Conversion

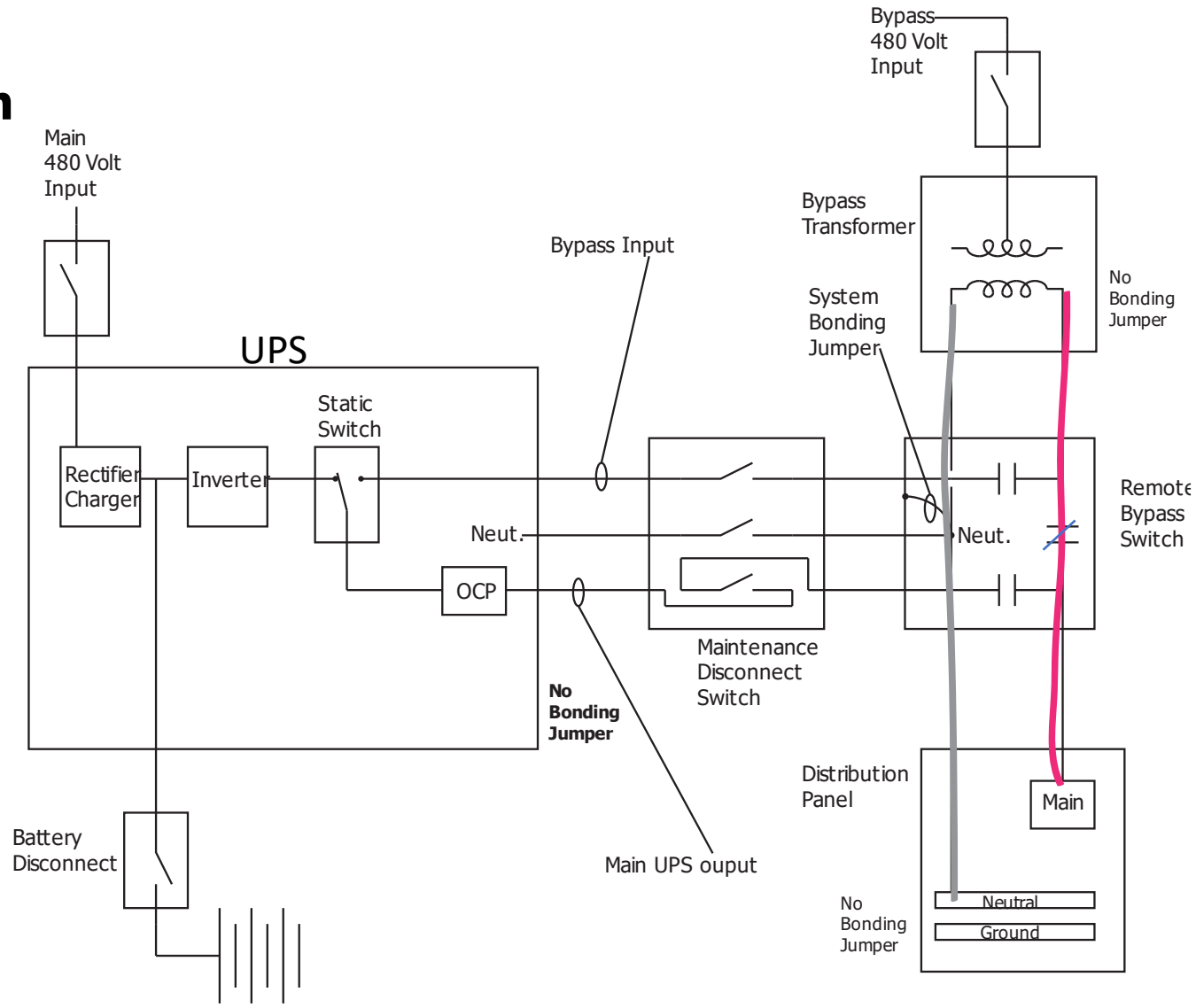
Static Bypass
Power Flow



Uninterruptible Power Supply Systems

Double Conversion

Maintenance Bypass Power Flow



Uninterruptible Power Supply Systems

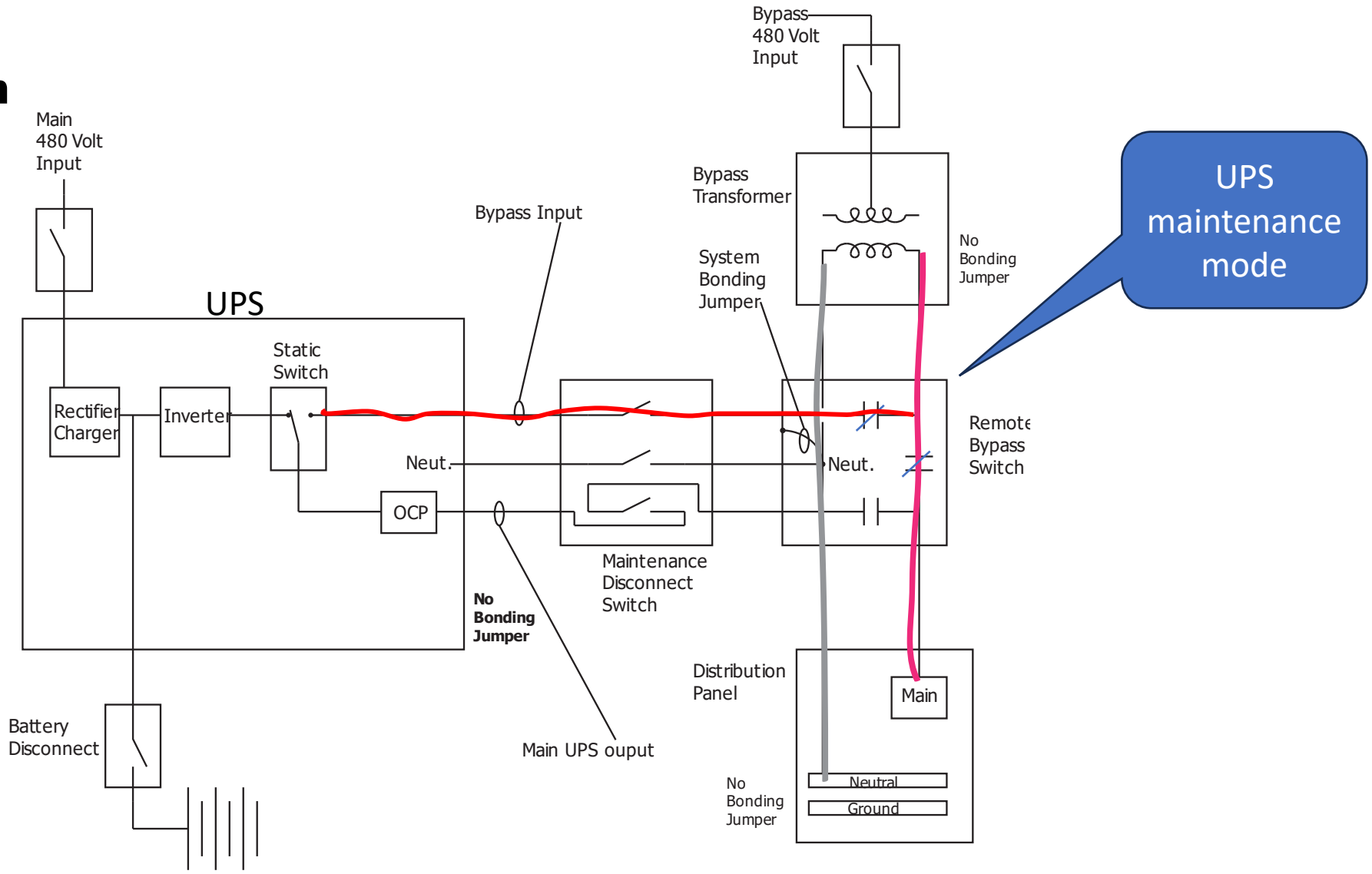
Now…

What happens when we install a new UPS and reconnect it?

Uninterruptible Power Supply Systems

Double Conversion

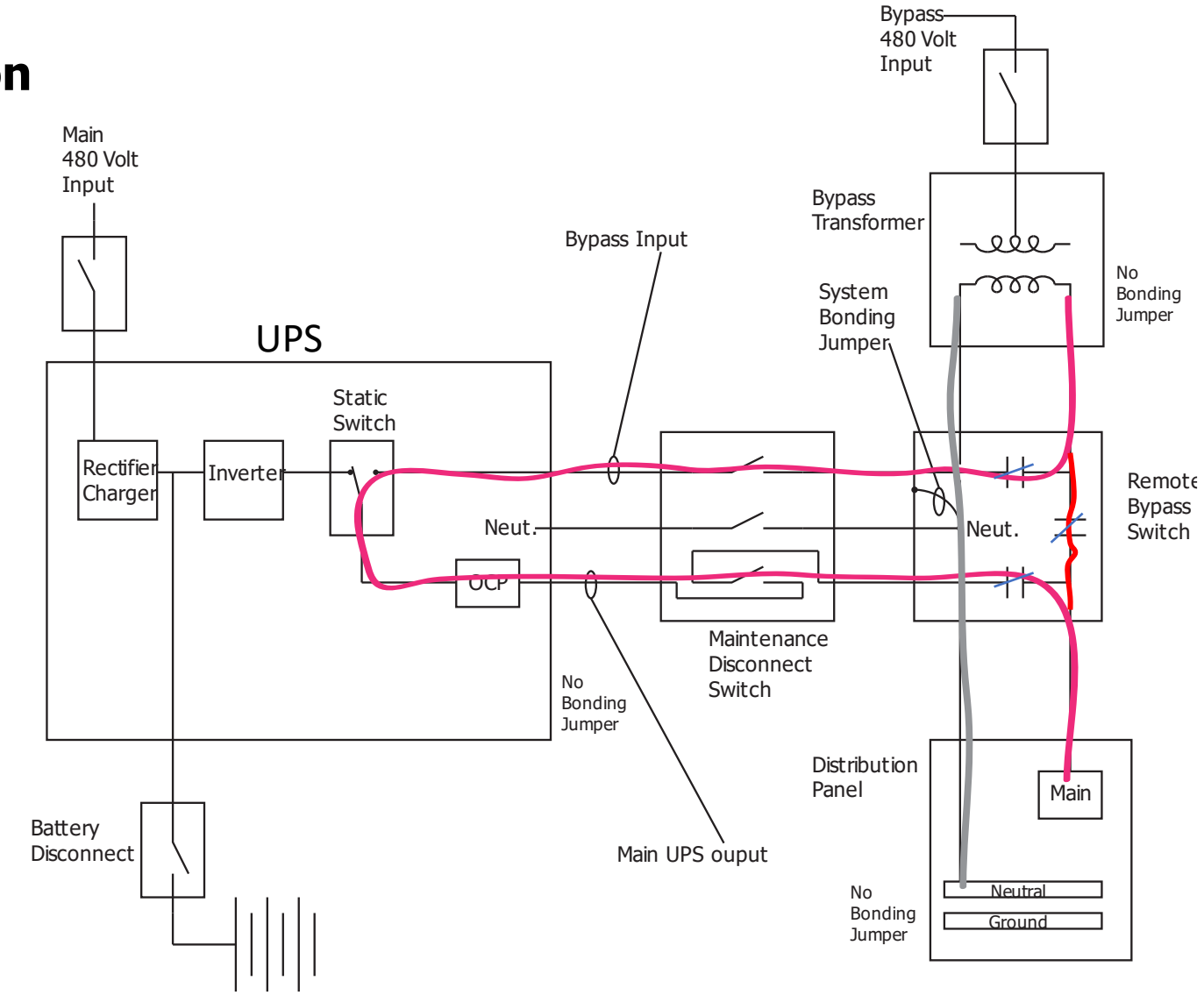
Maintenance Bypass Power Flow



Uninterruptible Power Supply Systems

Double Conversion

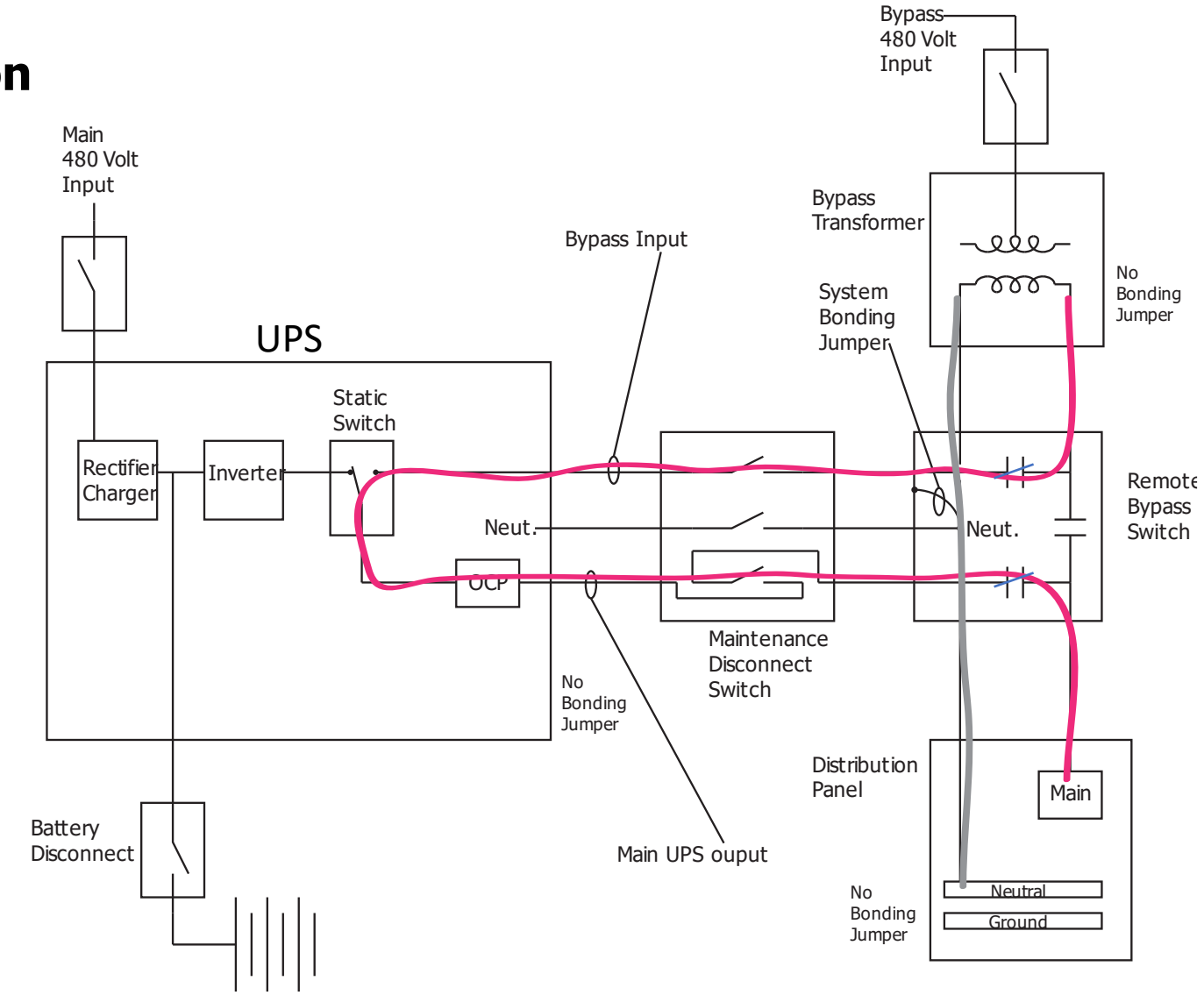
Static Bypass
Power Flow



Uninterruptible Power Supply Systems

Double Conversion

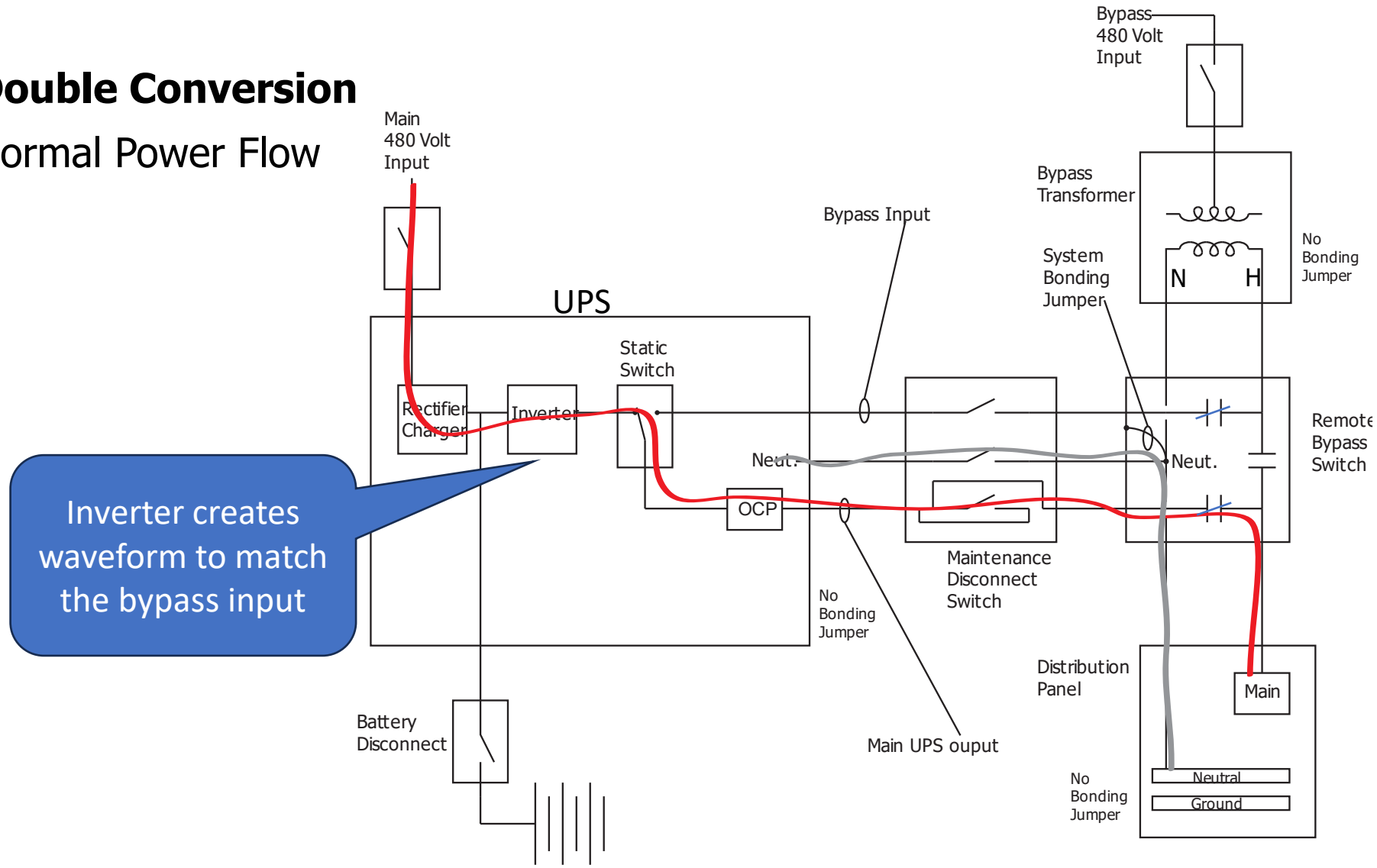
Static Bypass
Power Flow



Uninterruptible Power Supply Systems

Double Conversion

Normal Power Flow

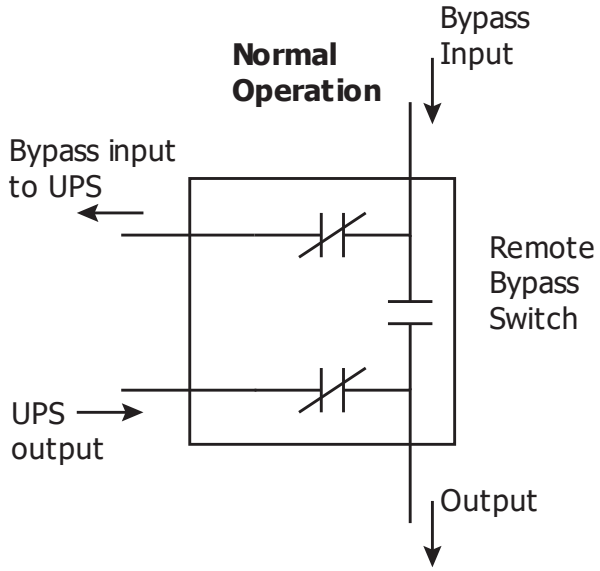


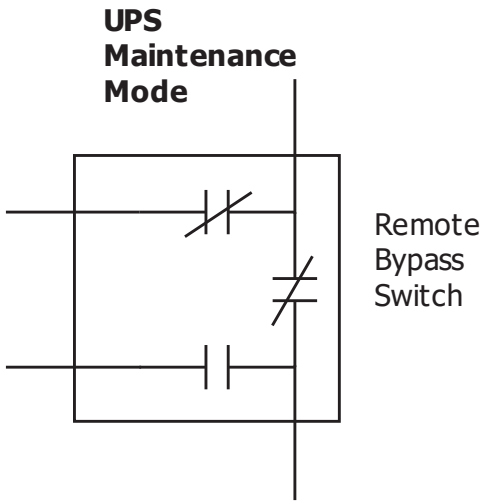
Uninterruptible Power Supply Systems

Remote Bypass Switch

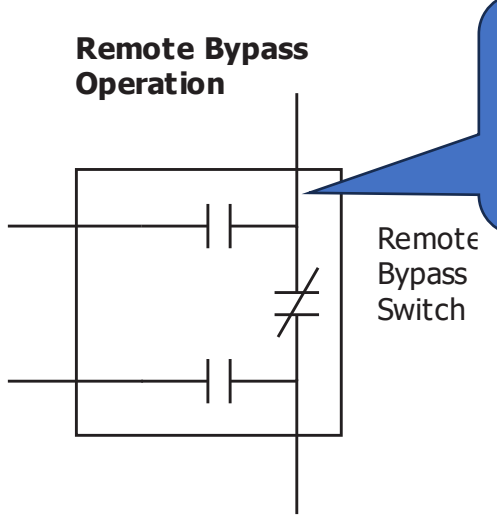
Switch positions

All of the switches in the remote bypass should be molded case switches. Not Breakers! Breakers require periodic maintenance and would require the entire system to be shut down.





In this mode, the bypass source is powering the load while the UPS is connected to the bypass input so that the inverter may be tested.



Circuit Breaker for bypass circuit should be here.

In this mode, the bypass source is powering the load and the UPS is electrically disconnected. This allows for the replacement of the UPS

Uninterruptible Power Supply Systems

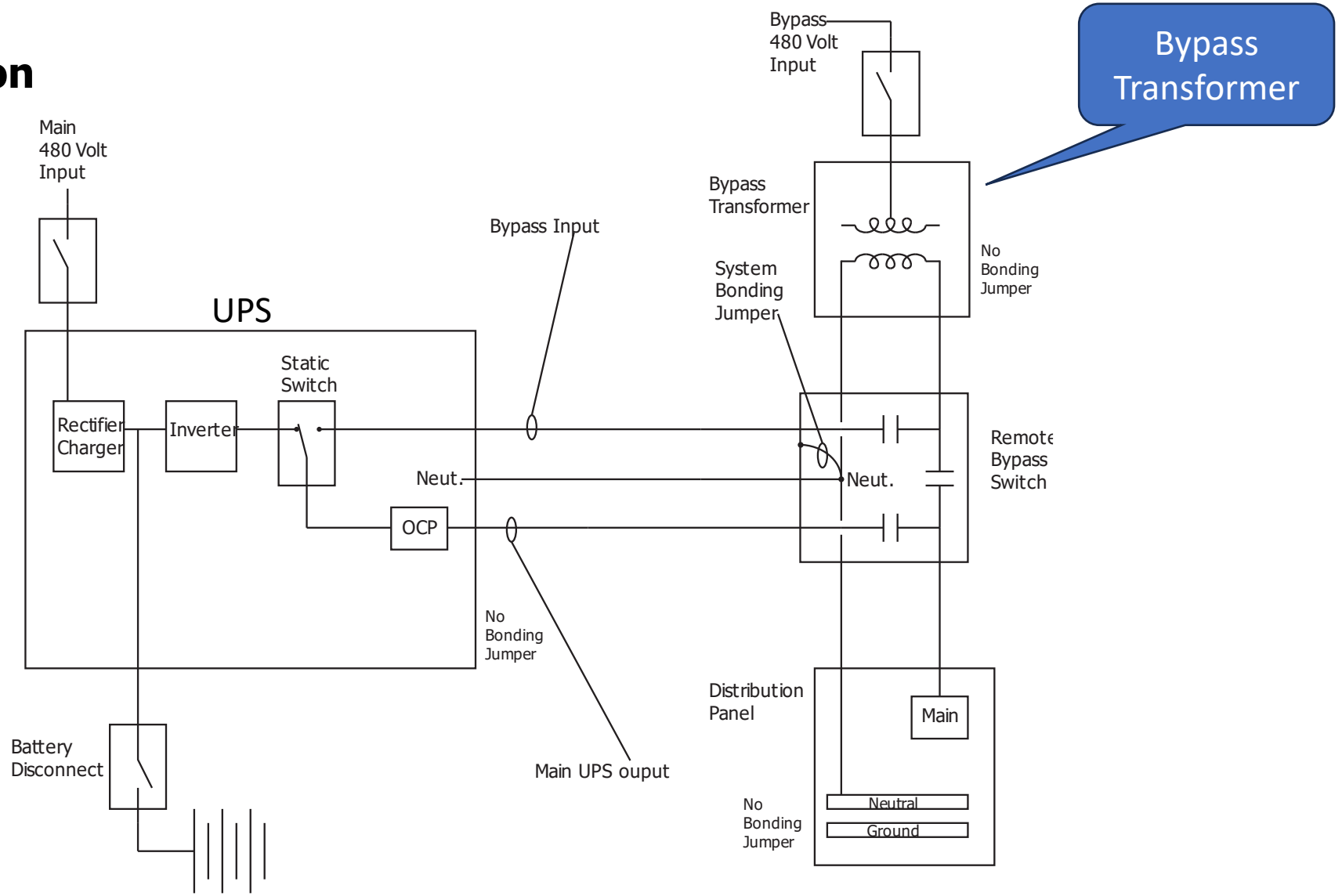
Double Conversion – *cont.*

Voltage – UPS systems with an input voltage of 480 volts and an output voltage of 208/120 should be considered. Most of the loads powered by a UPS are 208/120 and this makes it convenient to install a transformer in the bypass line. The transformer is needed for isolation so that the UPS system can be bonded appropriately.

Bypass Transformer – If the UPS has a 480 volt output and the bypass source is 480, a bypass transformer will still need to be installed.

Uninterruptible Power Supply Systems

Double Conversion



Uninterruptible Power Supply Systems

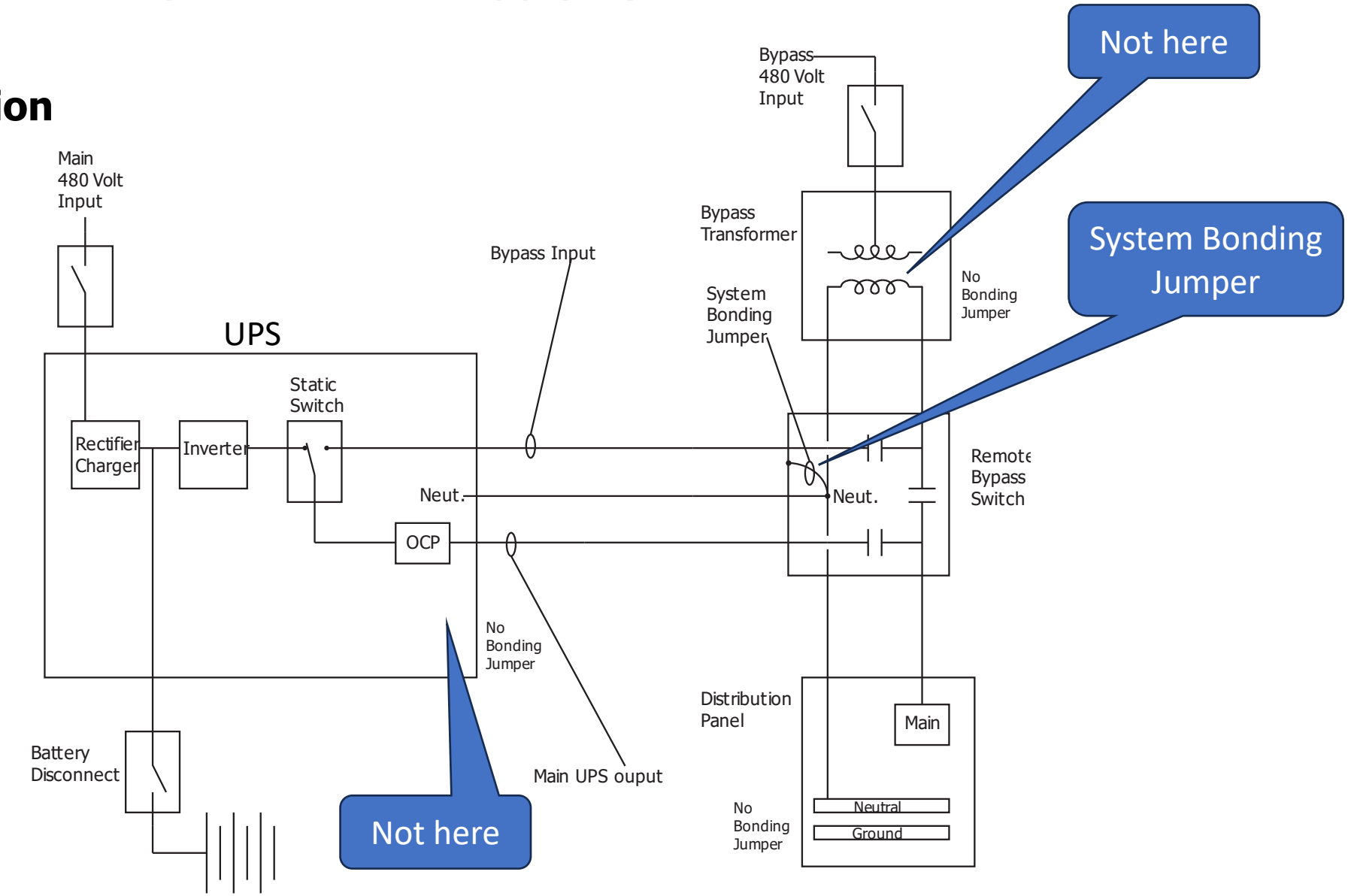
Double Conversion – *cont.*

System Bonding Jumper – Location for the system bonding jumper:

- System Bonding Jumper should be in the remote bypass
- UPS shall be labeled "No system bonding jumper at this location. System bonding jumper is in remote bypass."
- Bypass shall be labeled "No system bonding jumper at this location. System bonding jumper is in remote bypass."

Uninterruptible Power Supply Systems

Double Conversion



Uninterruptible Power Supply Systems

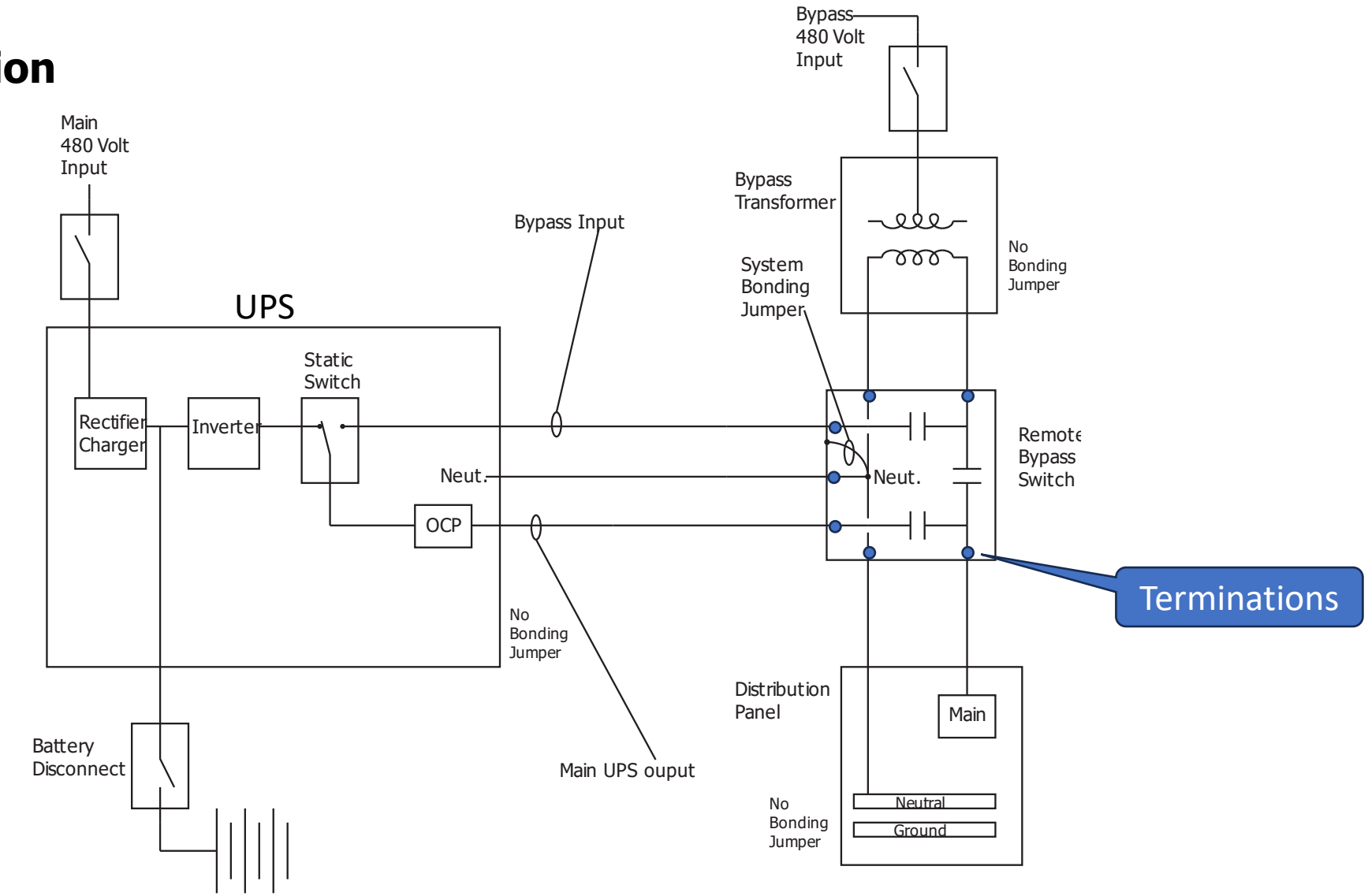
Double Conversion – *cont.*

Remote Bypass Switch – Preferably, the remote bypass switch should not be installed in the same lineup as the UPS. It should be installed remotely and connected with raceways. This is so that the UPS can be removed and replaced without disturbing the remote bypass switch.

The terminals of the remote bypass switch should be covered with a barrier so that there are no exposed terminations when the cover is removed. This is so that the conductors from the UPS can be disconnected while the bypass source is powering the load. If the terminals are not covered, additional disconnects will have to be added between the remote bypass and the UPS.

Uninterruptible Power Supply Systems

Double Conversion



Uninterruptible Power Supply Systems

Double Conversion – *cont.*

High Efficiency or Economy Mode – Some UPS systems have a high efficiency, or economy mode. This is actually just a bypass around the double-conversion components such that the load is powered directly from the line input. The double-conversion components are switched in and out depending on the quality of the line input. More of these systems are appearing in the market due to manufacturers' attempts to save energy, as there are reduced efficiencies in a double conversion UPS because the rectifier and inverter both have losses.

Uninterruptible Power Supply Systems

Types of UPS systems

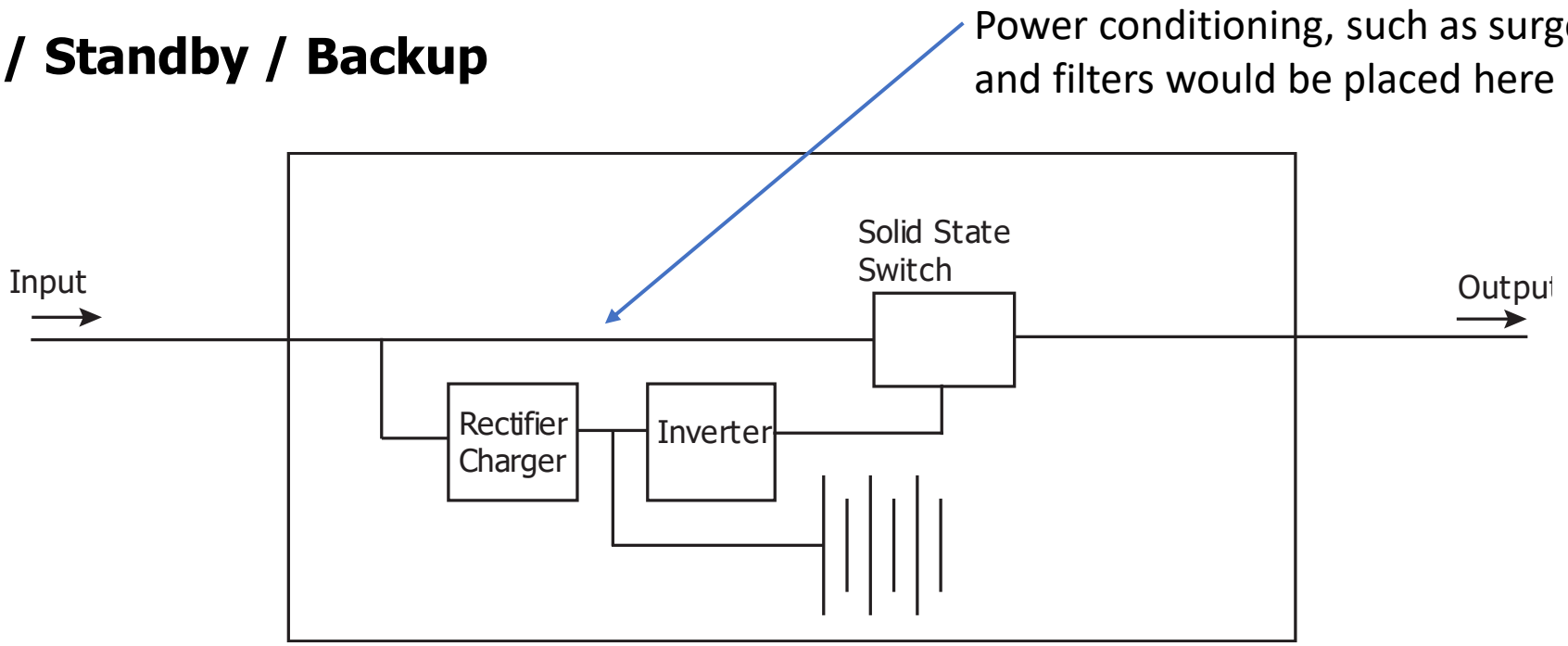
- Double Conversion
- Offline/Standby/Backup

Offline, Standby, or Backup – This system operates normally off of line power. The rectifier, charger, battery, and inverter are off to the side. The inverter creates a voltage waveform that matches the line input. When a power failure occurs, a solid-state switch transfers the load to the inverter in about 6 to 8 milliseconds.

These systems started off as the small backup power supplies that were found under desks for computer systems. They were around 1kW or so. Some larger systems are now employing this topology, so it is essential to understand the differences before ordering a system.

Uninterruptible Power Supply Systems

Offline / Standby / Backup



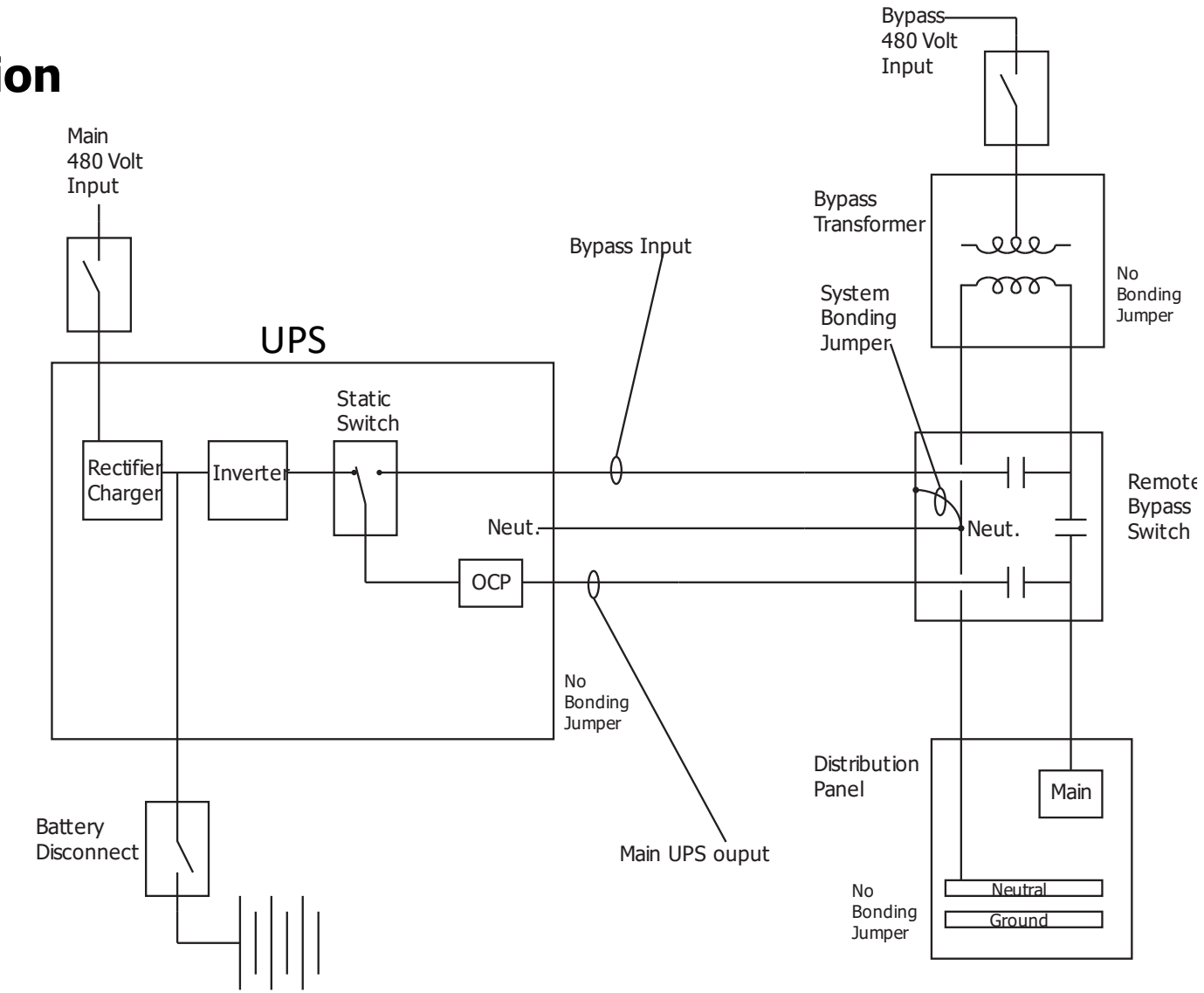
In normal mode, the load is powered by the line input. The rectifier/charger keeps the battery charged and the inverter creates a voltage output that is in sync with the line input. When the power fails, the solid state switch switches the load to the inverter. Different units have differing amounts of power conditioning on the line input.

Offline, Standby, or Backup – *cont.*

Since these systems power the load from line power, they do not provide much power conditioning. If the customer wants a UPS in order to provide clean power, a double conversion is the way to go.

Uninterruptible Power Supply Systems

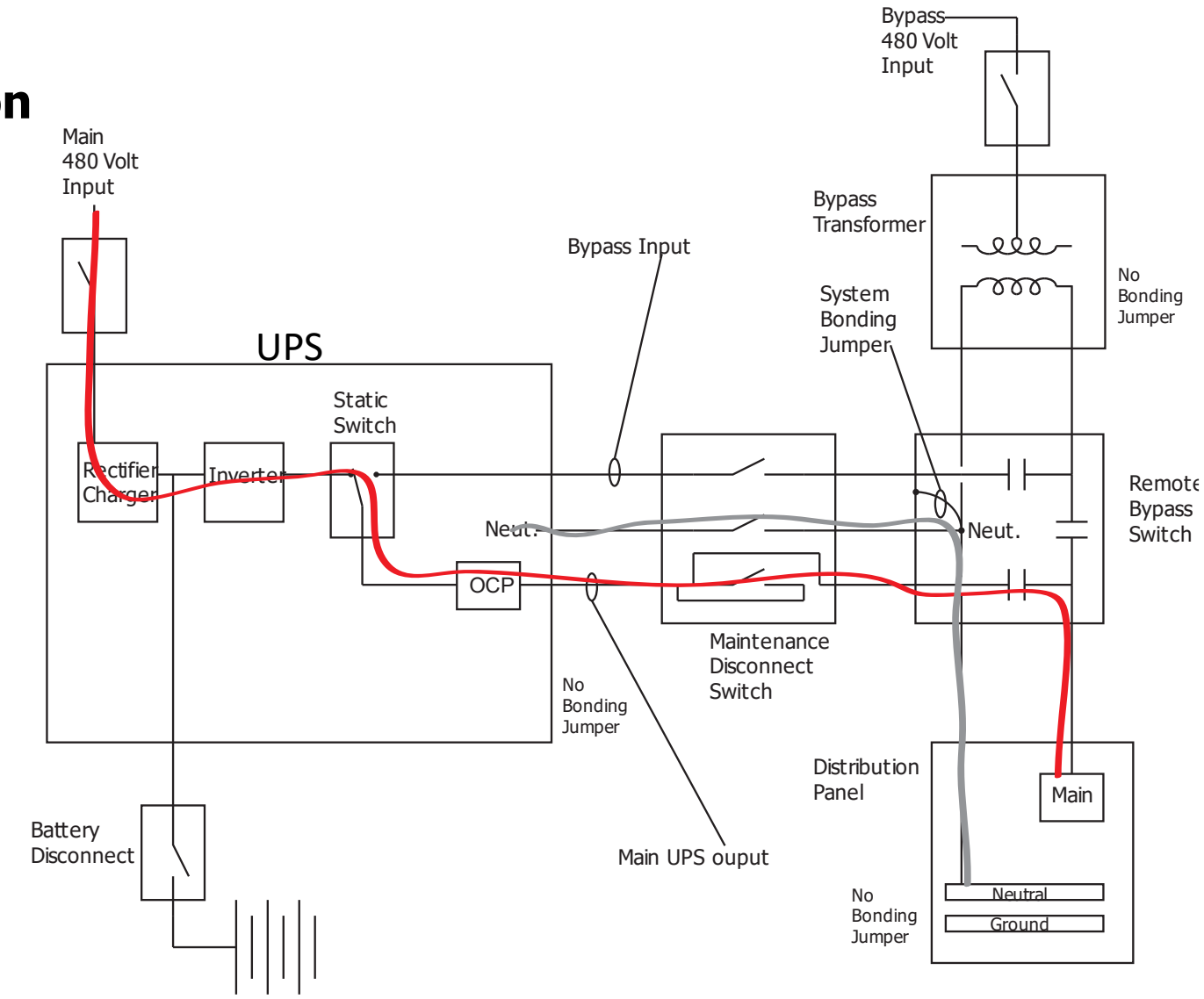
Double Conversion



Uninterruptible Power Supply Systems

Double Conversion

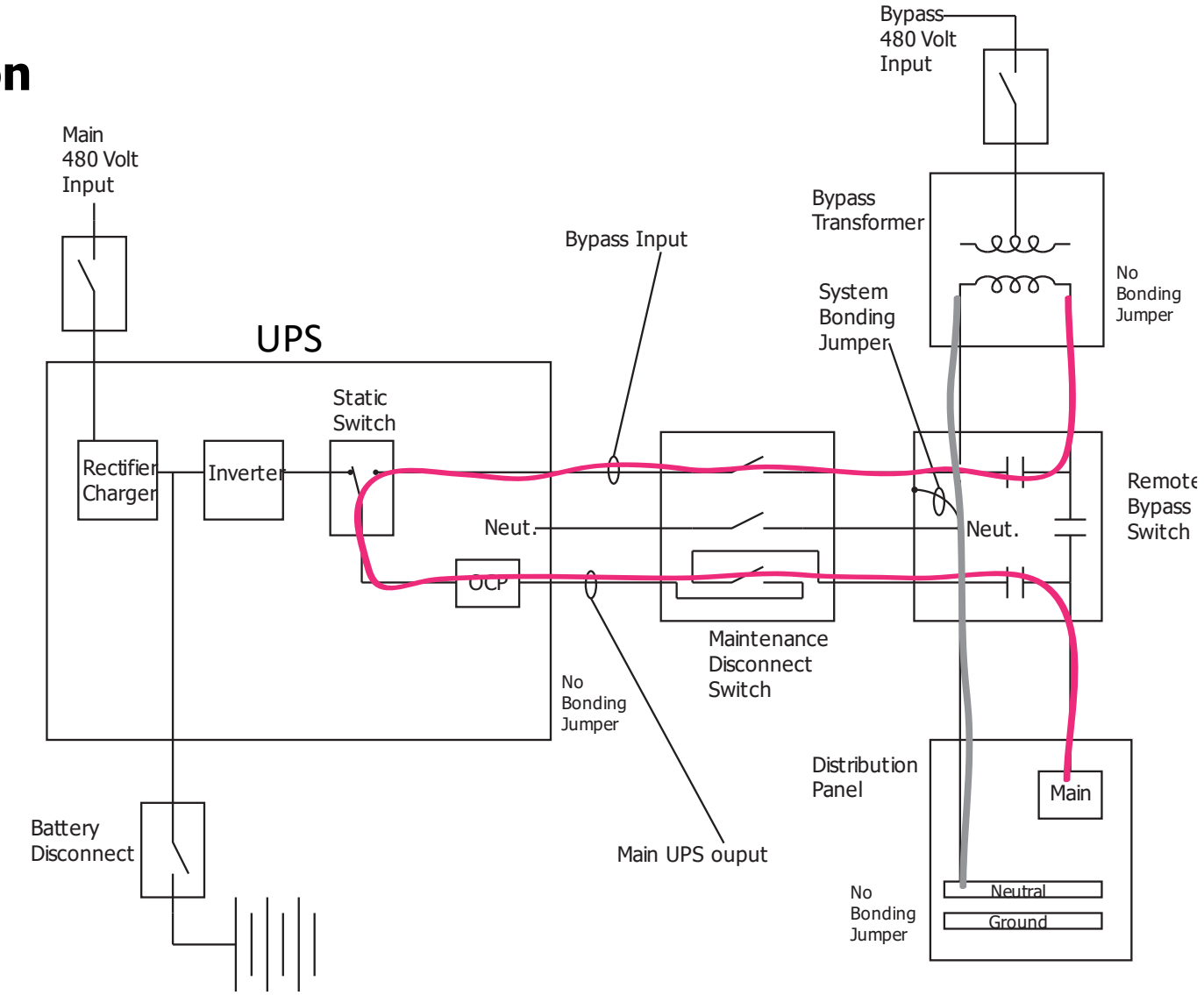
Normal Power Flow



Uninterruptible Power Supply Systems

Double Conversion

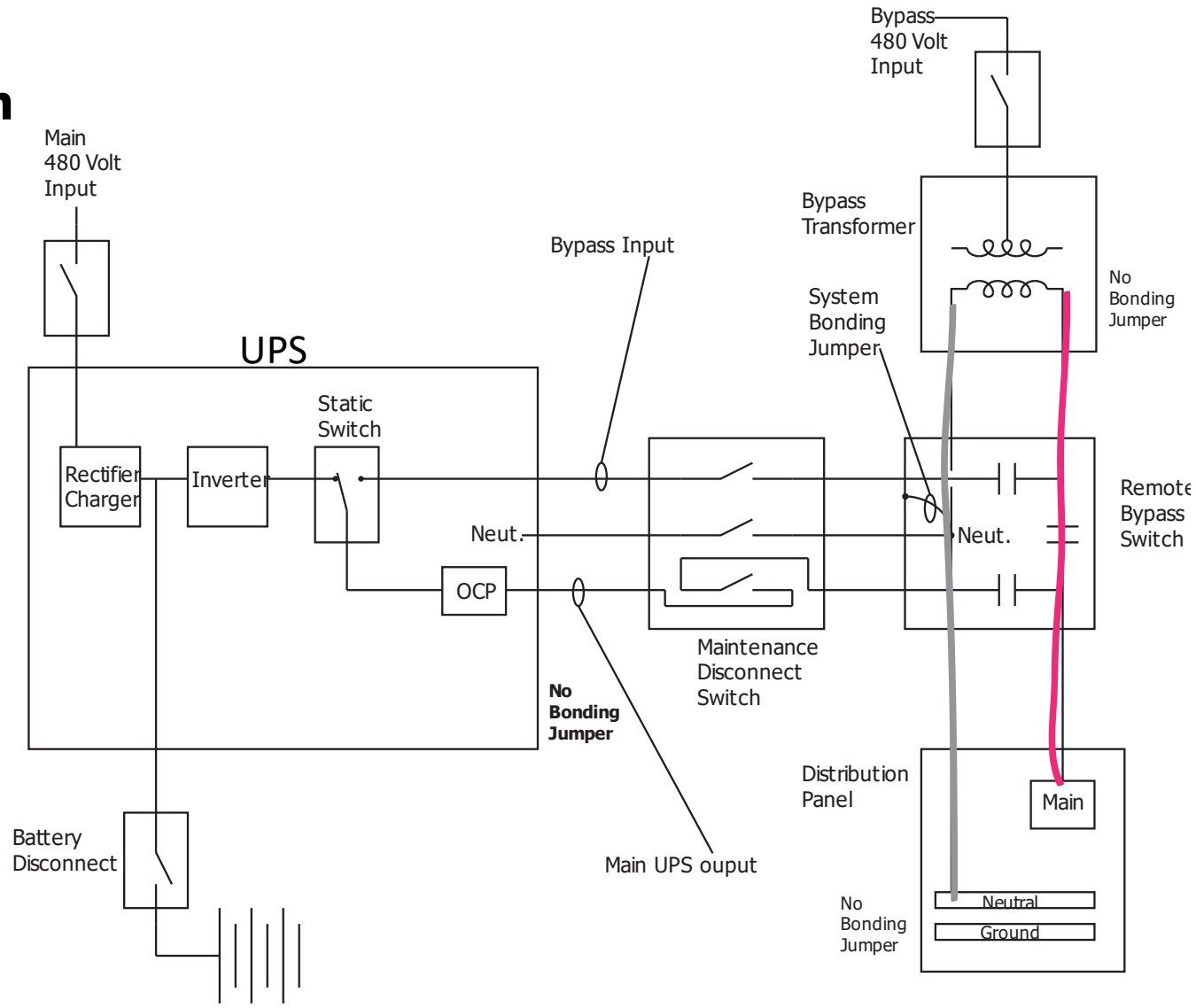
Static Bypass
Power Flow



Uninterruptible Power Supply Systems

Double Conversion

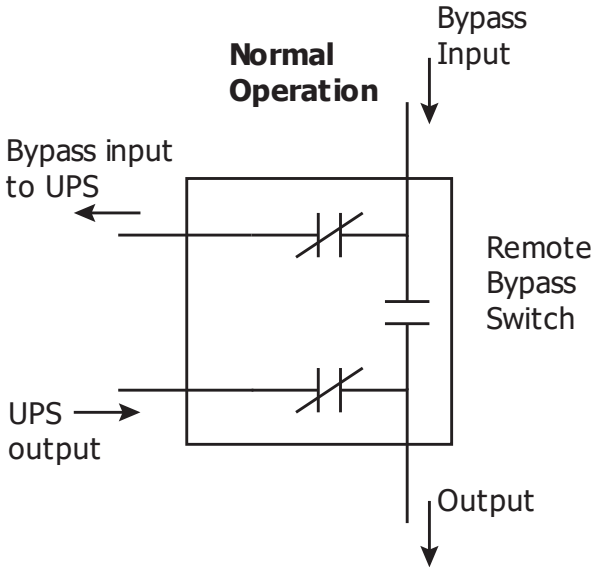
Maintenance Bypass Power Flow

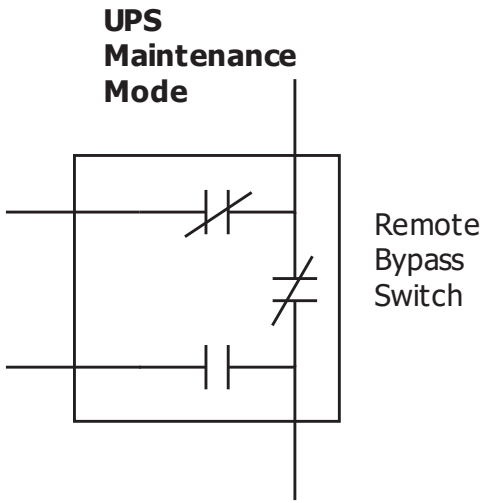


Uninterruptible Power Supply Systems

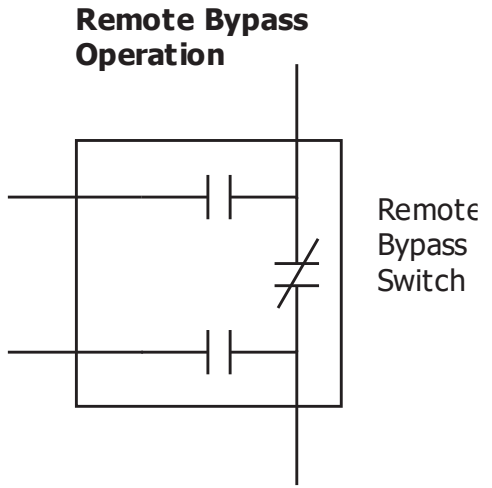
Remote Bypass Switch

Switch positions





In this mode, the bypass source is powering the load while the UPS is connected to the bypass input so that the inverter may be tested.



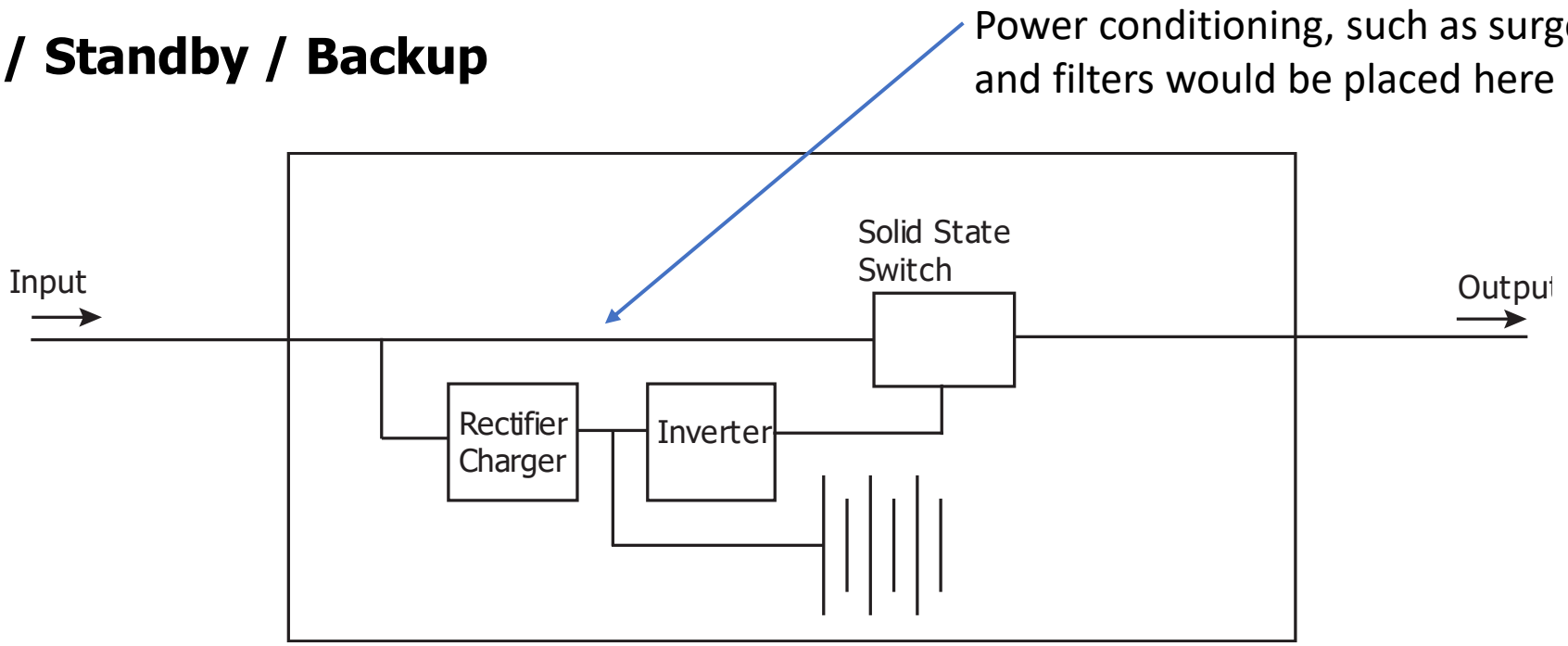
In this mode, the bypass source is powering the load and the UPS is electrically disconnected. This allows for the replacement of the UPS

Uninterruptible Power Supply Systems

- It's time to test your knowledge! Take a short 5-question quiz in the chat window to wrap up our session.

Uninterruptible Power Supply Systems

Offline / Standby / Backup



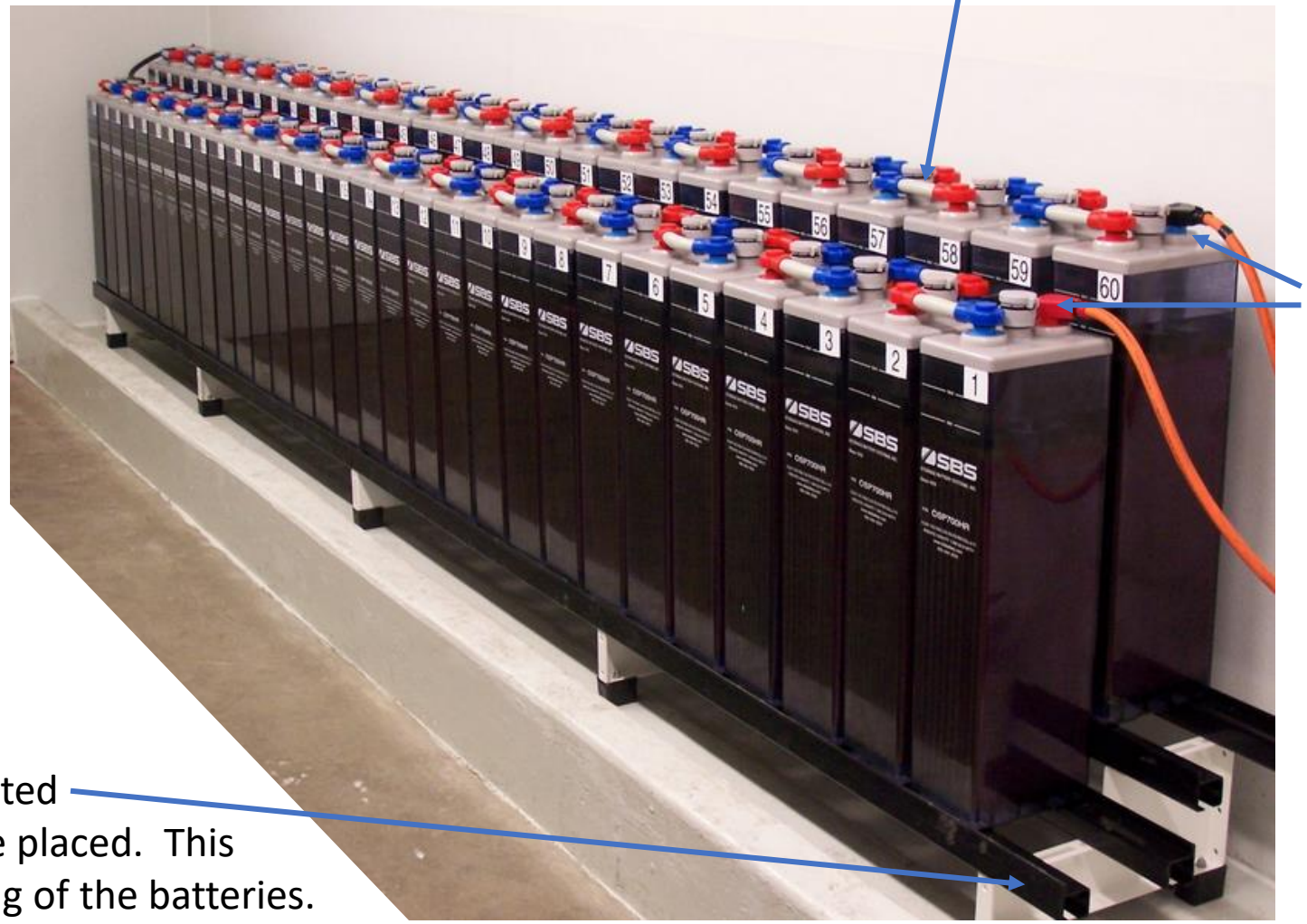
In normal mode, the load is powered by the line input. The rectifier/charger keeps the battery charged and the inverter creates a voltage output that is in sync with the line input. When the power fails, the solid state switch switches the load to the inverter. Different units have differing amounts of power conditioning on the line input.

Uninterruptible Power Supply Systems

Battery Systems

Flooded Cell

This a two-tier rack. With even numbered racks, the battery connections to the system will be on the same side. This system has 60 batteries so there is a 120 volt potential between these two points.



Note: There is usually no need to Ground battery racks

Uninterruptible Power Supply Systems

Battery Systems

VLRA

There are 24 batteries in this rack. If there is one cell per battery, this makes the total 48 volts, which is a standard size for battery systems.

Note: There is usually no need to Ground battery racks

Notes:

- Some Double-Conversion UPSs have what is called an "Economy Mode," or "High Efficiency Mode." This is simply a bypass for the Rectifier and Inverter such that the load is powered directly from the line. The Double-Conversion portion is switched in and out, depending on the quality of the line input.
- There are also UPSs called "Line Interactive." These have become popular in the telecommunications field in server racks. They are a modification of the Offline/Backup topology with more line conditioning and faster transfer times.
- Transfer times:
  - Double-Conversion None. The load is constantly on the inverter
  - Line-Interactive 2 to 4 milliseconds
  - Offline/Backup 2 to 10 milliseconds

Notes:

•The Remote Bypass Switch is almost the central focus of a UPS system. The bypass controls power flow for maintenance and normal operations. Other parts of the system can be disconnected and replaced, but the bypass remains in place. If the bypass must be replaced, the whole system will have to be deenergized.

•Battery monitoring systems are sometimes specified for the battery systems. Battery monitoring systems make more sense for individual flooded-cell batteries where each cell can be monitored. They don't make as much sense for Valve Regulated Lead Acid (VLRA: Gel-Cell or Absorbed Glass Mat) batteries because individual cells cannot be monitored. The selling point of battery monitoring systems for VLRA batteries is so that the batteries can be run longer before they have to be replaced. Some companies that use VLRA batteries do not monitor them and simply replace them at ½ the manufacturer's stated life. For installations that require highly reliable power, this is a good solution. Whatever battery system is chosen will require maintenance. The maintenance requirements should be considered in the design, along with the facility requirements for reliable power.

Items to be aware of on project reviews:

- Ensure the UPS topology chosen matches the customer requirements. If the customer is asking for a UPS because the requirement is for 'clean' power, a Double-Conversion is the right choice. In some instances, Line-Interactive may be acceptable. This will have to be decided with the customer.
- The Remote Bypass Switch, also called an External Maintenance Bypass, should not be in the same lineup as the UPS. If it is, the cabinet should not be bolted to the UPS as this would inhibit disconnecting the UPS and replacing it.
- The Bypass input to the UPS system must be transformer isolated.
- The system bonding jumper for the UPS system must be in the Remote Bypass Switch. The UPS shall not have a SBJ and the Bypass transformer shall not have a SBJ.
- Some Remote Bypass Switches come with isolation transformers built in. This is rare, but it is worth checking.

Items to be aware of on project reviews:

- The Remote Bypass Switch must have terminals that are covered. This is so conductors can be removed/replaced from some terminals while other terminals remain energized. The Bypass switch has four sets of terminals:
  - Bypass Switch input from bypass source
  - Bypass Switch output to UPS
  - Bypass Switch input from UPS output
  - Bypass Switch output to the load
- If a Remote Bypass Switch with covered terminals is not available, disconnects will have to be added between the UPS and the Remote Bypass Switch to facilitate maintenance.
- Strong preference is for a 480 volt input and a 208/120 volt output.
- Plug-in type batteries should be considered. These batteries are not interconnected with wire jumpers. Plug-in type batteries reduce the possibility of shock exposure to the workers.

Items to be aware of on project reviews:

- If batteries with wire jumpers are used, a quick disconnect should be added in the battery strings such that the batteries can be separated into groups of less than 100 volts each. Battery racks and configurations should be designed such that terminals that have a large potential difference between them should not be close together.
- Battery rack systems should be reviewed by someone who is familiar with electrical safety standards.