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## Technical Note

### Connecting Split-phase XW Hybrid Inverter/Chargers to 3-Phase Sources

This technical note describes the option of connecting the 60Hz XW Inverter/Charger to a three-phase source by using a transformer to convert the AC source to split-phase 240/120V.

#### INTRODUCTION: Split-phase and three-phase systems

Split-phase systems are commonly used in North America for residential and light commercial (up to 100KVA) installations. A split-phase (240/120V) power system, is a 3-wire, single-phase, mid-point neutral system, which consists of two 120V voltage sources connected out-of-phase by 180° with a neutral connection between them. The voltage between the two live conductors (L-L) is 240V, whereas the voltage between a live conductor and neutral (L-n) is 120V.

Standard 120V lighting and small appliances are connected between a live wire and the neutral. Large appliances, such as cooking equipment, space heating, water pumps, clothes dryers, and air conditioners are connected across the two live conductors and operate at 240V, requiring less current and smaller conductors than would be needed if the appliances were designed for 120V operation.

Since the current in each leg of a split-phase system is 180° out-of-phase, the neutral wire carries only the difference of current between the two lines, or zero current when loads on both legs are perfectly balanced (i.e. consuming equal amounts of power).

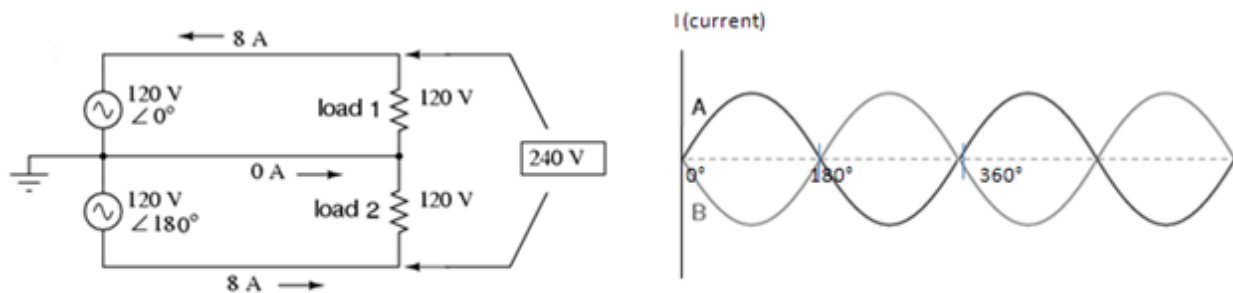


Figure. 1 - Split Phase 240/120V circuit (180° phase shift)

Because no individual conductor will be at more than 120V potential with respect to ground (earth), split-phase systems are considered safer than a 240V 2-wire system that has one leg (the neutral) earthed. In addition, it is more efficient as it requires smaller conductor size compared to a 2-wire 120V system with the same two loads connected in parallel.

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Three-phase power systems are defined by having three equal AC voltages which are out-of-phase by one third of a cycle ( $120^\circ$ ). Three-phase power is the backbone of the electrical distribution system and is used to power both three-phase and single phase loads. There are two basic configurations for three-phase systems, Wye (Y) and Delta ( $\Delta$ ).

Wye configuration is a 4-wire system with three live lines (commonly referred as phases) and a neutral point where all three phases are connected together. This configuration allows for two different supply voltages; phase-to-phase voltage (line voltage), and phase-to-neutral voltage (phase voltage). Line voltage is  $\sqrt{3}$  times the phase voltage, while line current and phase current are the same. Three-phase power is most commonly provided by the Utility companies in a Wye configuration.

Delta configuration is a 3-wire system, which also consists of three live lines. There is no neutral wire in a Delta system and thus the line voltage is equal to the phase voltage. Line current, on the other hand, is  $\sqrt{3}$  times the phase current. Delta configurations are primarily used to provide power to three-phase motor loads. Delta systems are sometimes corner grounded to protect for ground faults.

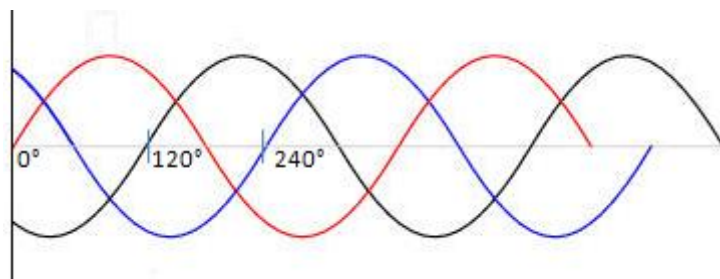
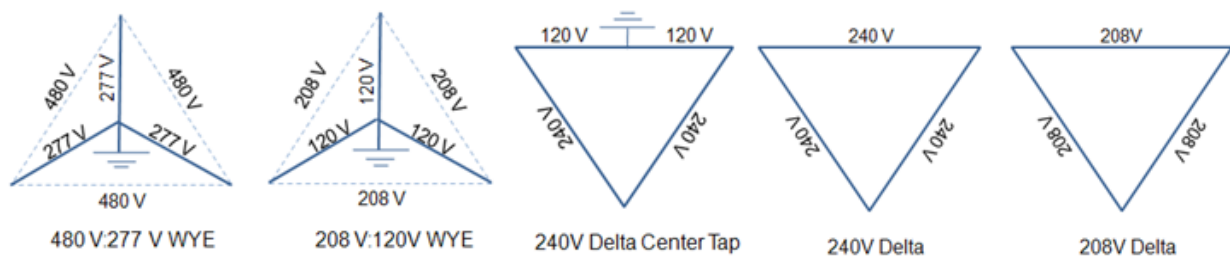


Figure 2. Most Common three-phase transformers ( $120^\circ$  phase shift)

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#### **THE XW INVERTER/CHARGER: Split phase design**

60Hz XW Hybrid Inverter/Charger models are designed to be connected to split-phase (240/120V) AC sources, where the current from each leg (L1 and L2) is 180° out-of-phase. This ensures the neutral wire never receives more current than it was designed to handle as the current from each line cancels out, leaving only the difference current between the two lines. The XW Inverter/Chargers allow a maximum current imbalance of 75% between L1-n and L2-n. This equates to:

XW6048

L-N:  $(6,000W \times 0.75)/120V = 37.5$  Amp

XW4548

L-N:  $(4,500W \times 0.75)/120V = 28.1$  Amp

XW4024

L-N:  $(4,000W \times 0.75)/120V = 25.0$  Amp

Input power to the XW Inverter/Charger cannot be simply derived from a phase or line voltage of a three phase 208:120Y or 240VΔ AC source. Instead of cancelling each other as they would with a split-phase source, each 120° out-of-phase leg effectively creates a short circuit (limited by the impedance of the transformer and the wiring), which leads to very high currents flowing on the neutral line causing imminent failure of the inverter's AC relay board.

To protect against this, the XW Inverter/Charger will sense if a non-symmetrical phase is present and will prevent the unit from connecting to the AC source. That is, the three-phase input source will not be qualified and the unit will stay in invert mode until a qualified split-phase source is present on either of the Inverter/Charger 's two AC inputs terminals.<sup>1</sup>

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<sup>1</sup> The original firmware released with the XW6048-120/240-60 (XW6048\_v1.00\_BN0011) did not check for this split-phase condition. All subsequent firmware versions do, including those for the XW4024 and XW4548 models.

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#### **THE XW INVERTER/CHARGER AND THREE-PHASE SOURCES: Use of a transformer**

All is not lost! A 60Hz XW Inverter/Charger can still be connected to a three-phase distribution system or three-phase generator by using a transformer to convert the AC input to the Inverter/Charger into split-phase 240/120VAC. The selection of the transformer depends on the size of the Inverter/Charger(s), and the AC source input voltage.

There are 3 different inverter power levels to consider for single-unit configuration: 4.0kW (XW4024), 4.5kW (XW4548) or 6kW (XW6048). A larger transformer would be required in multi-unit configurations where more than 1 unit is connected together for increased power capacity. The largest XW inverter system consists of three XW6048 inverters for a total capacity of 18kW; however, for even larger systems where there are more than one 18kW load panels, two or more 18KW XW systems can be installed sharing the same AC input (grid or generator). Consider the total power of the XW system and size the transformer accordingly.

Different types of transformers from different manufacturers can be found in the market that can convert from practically any common three-phase voltage (e.g. 208V, 277V, 380V, 416V) to split-phase 240/120V, and with power capacities available from 50VA to 750KVA. Two well known manufacturers of transformers are Mag-Tran and Hammond Power Solutions. The links to their web pages are below:

<http://www.mag-tran.com/>

<http://www.hammondpowersolutions.com/>

**EXAMPLE 1:** Connecting an XW Hybrid Inverter/Charger to a 208:120Y distribution system through a 6KVA, 120V to split phase autotransformer.

In this example, a 208:120Y distribution system is the primary AC input source to an XW6048-120/240-60 (p/n: 865-1000). A transformer is used to convert from 120V, the phase voltage of the three-phase system, to 240/120V split phase required by the XW Inverter/Charger. The transformer used is a Xantrex TX Autotransformer, TX6K (6KVA). See Figure 3.

From the Utility Distribution panel, a single hot leg wire (Phase A, for example) and Neutral (N) wire are connected as input to the transformer's 120V L1 and Neutral wiring terminal, respectively. The ground wire is connected to the transformer's ground bar.

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From the transformer's 240V output terminal, L1 and L2 wires are connected to the input side of the AC1 Breaker (60Amp 2-pole breaker) in the XW-Power Distribution Panel (XW-PDP). The neutral (N) wire is connected to the neutral bar on the XW-PDP. The input to the XW-PDP is therefore 240V Line to Line, and 120V line to neutral.

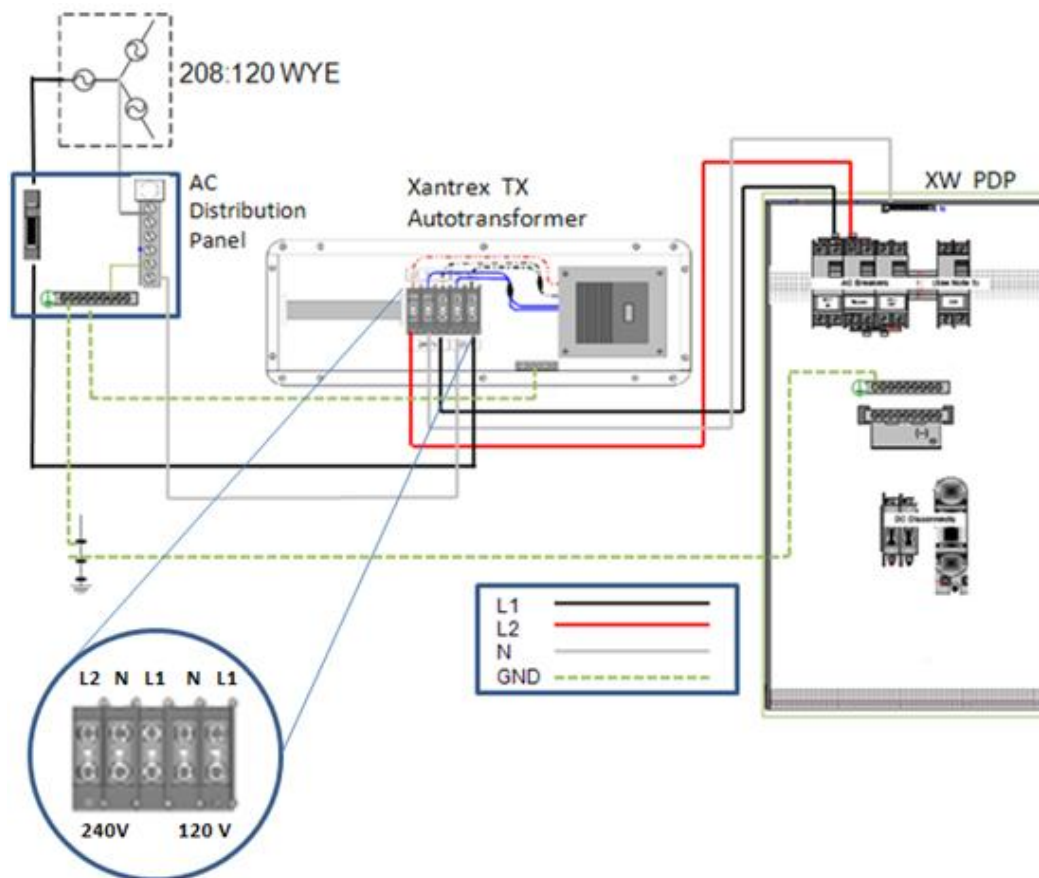


Figure 3.

Connecting the XW Inverter/charger to a three-phase source through a 120V to 240/120V split phase autotransformer

Note: Using a 120V to 240/120V transformer as described above may significantly imbalance the 208:120Y three-phase source. A better approach would be to use a 208V to 240/120V transformer to balance the load on two phases, as described in Example 2.

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### Connecting Split-phase XW Hybrid Inverter/Chargers to 3-Phase Sources

**Example 2:** Connecting an XW Hybrid Inverter/Charger to a 208:120Y distribution system through a 208V to split phase autotransformer.

In this example, a 208:120Y distribution system is the primary AC input source to an XW6048-120/240-60 (p/n: 865-1000). A transformer is used to convert from 208V, the line voltage of the three-phase system, to 240/120V split-phase required by the XW Inverter/Charger. The sketch of the primary and secondary windings of a generic 6KVA, 208V to 120/240V transformer is used for this example. See figure 4.

From the Utility Distribution panel, the line voltage wires (VAB, for example) are connected as input to the transformer's 208V L1 and L2 wiring terminal. The ground wire is connected to the transformer's ground bar.

From the transformer's split-phase output terminal, L1 and L2 wires are connected to the input side of the AC1 Breaker (60Amp 2-pole breaker) in the XW-PDP. The neutral (N) wire is connected to the neutral bar on the XW-PDP. The input to the XW-PDP is therefore 240VAC line-to-line, and 120V line-to-neutral.

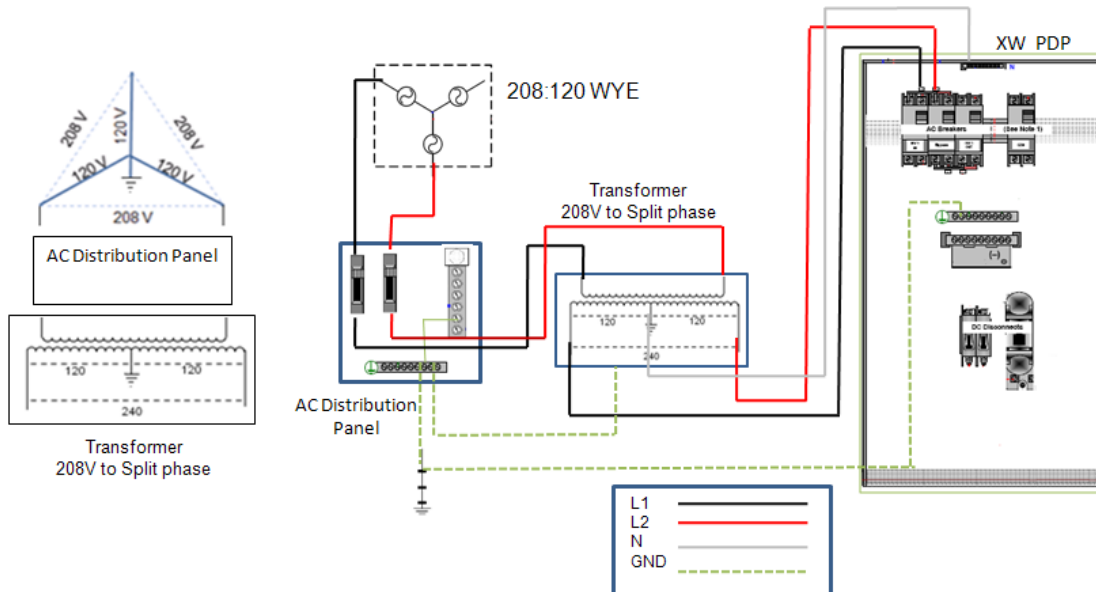


Figure 4.  
 Connecting the XW Inverter/charger to a three-phase source through a 208 to split-phase transformer