

## APP NOTE: Using the TSW4048 in 3 Phase Applications

### OVERVIEW:

This App Note explains how to use the Apollo Solar TSW (True Sine Wave) Inverter / Chargers in 3 phase systems.

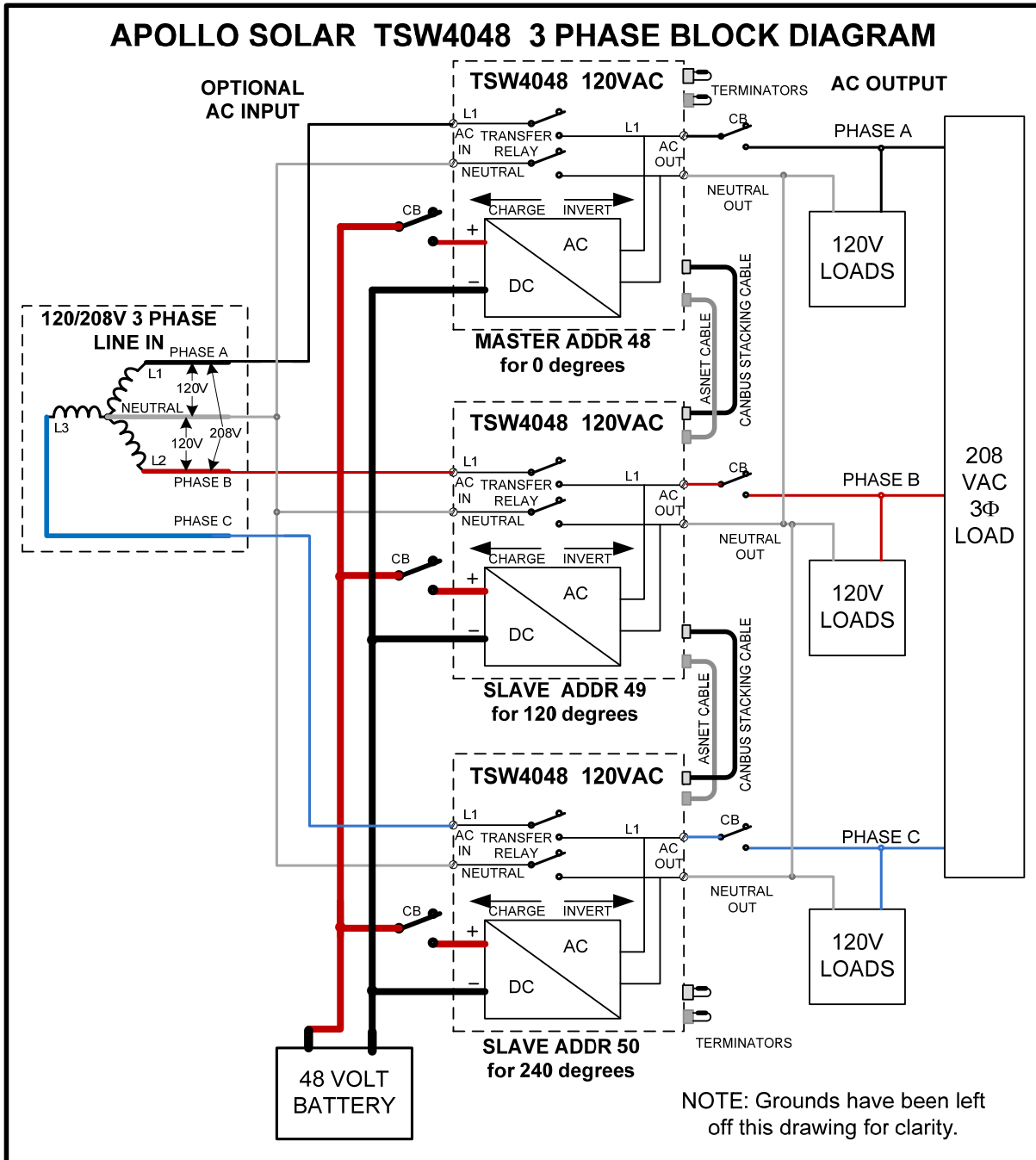


Figure 1 – Block diagram showing the basic connections for 3 phase operation.

**BLOCK DIAGRAM:**

Figure 1 above shows that the each of the 3 phase legs uses a separate, single-phase TSW Inverter / Charger. This is very similar to the way that the 3 phase power is generated in the first place by the electric utility company with 3 windings on a generator. See the Utility Source circuit on the left side of Figure 2 below. The TSWs, just like the generator windings, are connected together in a “Wye” or “Y” connection with Neutral at the common center point and a 120 volt leg at the other end of the 3 phase legs. When a volt meter is used to measure the AC voltage between any phase leg to Neutral, you will read 120 volts AC. Measuring from any phase leg to the any other phase leg, the voltmeter will read 208 volts AC. If you put 3 scope probes across all the phase legs with their ground clips all attached to neutral, you will see the 3 sine waves that are offset from each other by 120 degrees which is 5.55mS at 60 Hz or 6.667mS at 50Hz as depicted in the sketch on the right side of Figure 2 below.

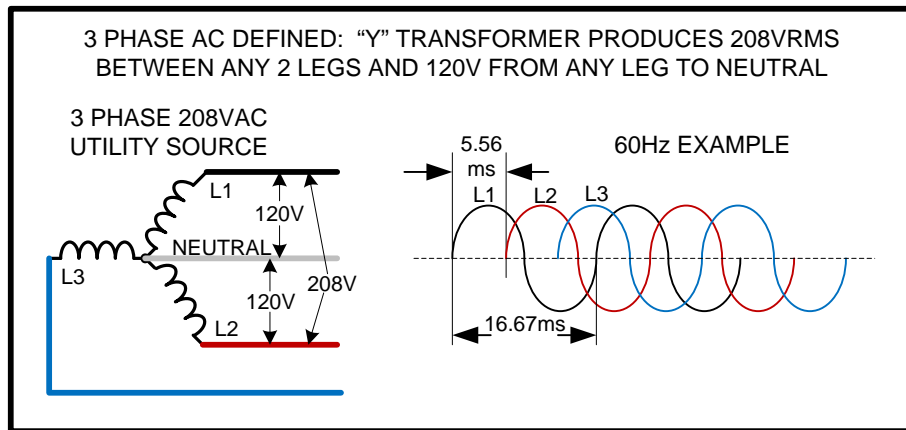


Figure 2 – Generating 3 phase AC

One nice feature of 3 phase wiring is that one can use any single phase, or 2 phases or all 3 phases for different loads at the same time. So a 120/208 VAC feeder can be used to power 120 volt appliances and larger 208 volt 3 phase equipment. And many 240 volt loads will function at 208 volts although we are not recommending this.

**AC CONNECTIONS:**

The AC Input and Output connections are made to the barrier strip at the top of the TSW as shown in the photo below. The alternative 230 volt connections are called out below.



AC INPUT / OUTPUT CONNECTIONS					
SUITABLE FOR USE WITH 90°C COPPER CONDUCTORS					
TORQUE CONNECTOR SCREWS TO 30 in-lbs / 3.4N-m					
AC OUTPUT TO LOAD			AC INPUT FROM LINE OR GENERATOR		
230VAC 50Hz			230VAC 50Hz		
ACTIVE	NEUTRAL	EARTH	EARTH	ACTIVE	NEUTRAL

**HIGHER VOLTAGES:**

The TSW is designed to work at 230 and 240 volts as well as 120 volts, and therefore they can be used in systems at 230/400 volts or 240/415 volts. The only difference is that each of the individual TSWs must be wired for the higher voltages inside then the dip switch on the DSP control board must be set to either 230 or 240 volts. Make sure that the 50/60 Hz switch is set properly depending on the location of the installation. Of course, the circuit breakers and the wire insulation must be rated for the higher voltages. If you are using the Apollo Solar Inverter Switchgear Modules, the AC circuit breakers are rated for 277 VAC so they will work at the 230 or 240 volts that each circuit breaker sees.

**POWER AVAILABLE:**

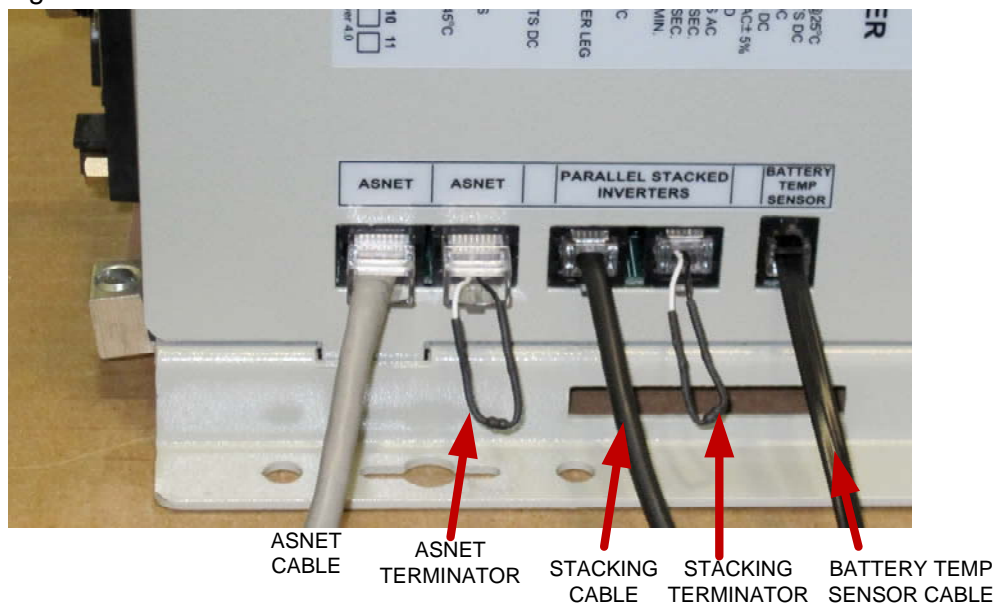
Three TSW4048s stacked together can produce up to 12,000 watts continuously. The nature of 3 phase sine waves add up to more power which means that 3 TSWs in 3 phase can deliver up to 15,000 VA continuously. For 10 seconds they can produce 200% of that.

**SYNCHRONIZING THE PHASES:**

In invert mode, the 3 independent TSWs must generate the 3 phases in the proper 120 degree relationship to each other. The Master TSW sends out commands to the 2 slave TSWs to start their sine wave at the zero crossing point at the proper time delayed precisely from the Master. This command is sent over the CANBUS.

The CANBUS Stacking Cable supplied with each TSW is connected from TSW to TSW. The end of this daisy chain must be terminated with a termination plugs which are also supplied. The ASNET cables must also be installed in the same daisy chain arrangement and terminators plugged in to fill all empty jacks. See Figure 4 below.

Figure 4 –ASNET and STACKING Cable connectors on a TSW



**PROGRAMMING THE TSW:**

Setting up the Master and Slave addresses may be done from the front panel or by using the Apollo Inverter Manager (AIM). See the TSW Installation manual for a description of the steps.

**ORDERING THE EQUIPMENT:**

Apollo Solar manufactures the Inverter / Chargers. We also make the special AC and DC circuit breaker box called an Inverter Switchgear Module (ISM) which makes the installation neat and is already UL certified. We offer the complete system on a back plate and pre-wire it so the installation is fast and trouble free. Ask for our Pre Wired Panel (PWP) UPS products. We don't make batteries, but we can recommend good manufacturers and we can supply them if you like.

Call us at (203) 790-6400 or email us at [Sales@ApolloSolar.com](mailto:Sales@ApolloSolar.com)

Our website is [www.ApolloSolar.com](http://www.ApolloSolar.com)

For an in-depth explanation of the much broader subject of 3 phase power in general, look at [www.3phasepower.org](http://www.3phasepower.org).

**SAFETY CONCERNS:**

Any inverter is going to produce lethal AC voltage. Make sure all wiring meets the NEC rules for wire size, insulation, conduit and connections. Dropping a wrench across the terminals of batteries will produce a very large arc which could cause a fire after the wrench is vaporized. Please be very careful. All the wires must be large enough to handle the current and every connection must be tightened to the torque specified on the equipment or it will get very hot. The systems will easily have 100 Amps of DC flowing through the battery terminals. Just 0.1 ohm of resistance on any connection will release 1000 watts of power in a very small area which is more than enough to melt the battery post or cause a fire in the wire insulation or both. The batteries must have adequate ventilation. They will produce hydrogen gas when they are being charged. If hydrogen builds up to a concentration of only 4% by volume in air, it is potentially explosive. If the batteries are in an enclosure, fans must be provided to make sure that hydrogen gets outside into fresh air. It is lighter than air and it moves very fast, so once it is outside, it will dissipate safely.