



APOLLO SOLAR

Commissioning the Apollo Solar Cabinets



Apollo Solar, Inc.

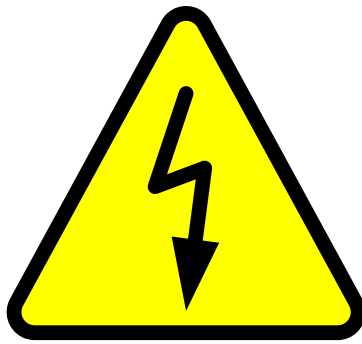
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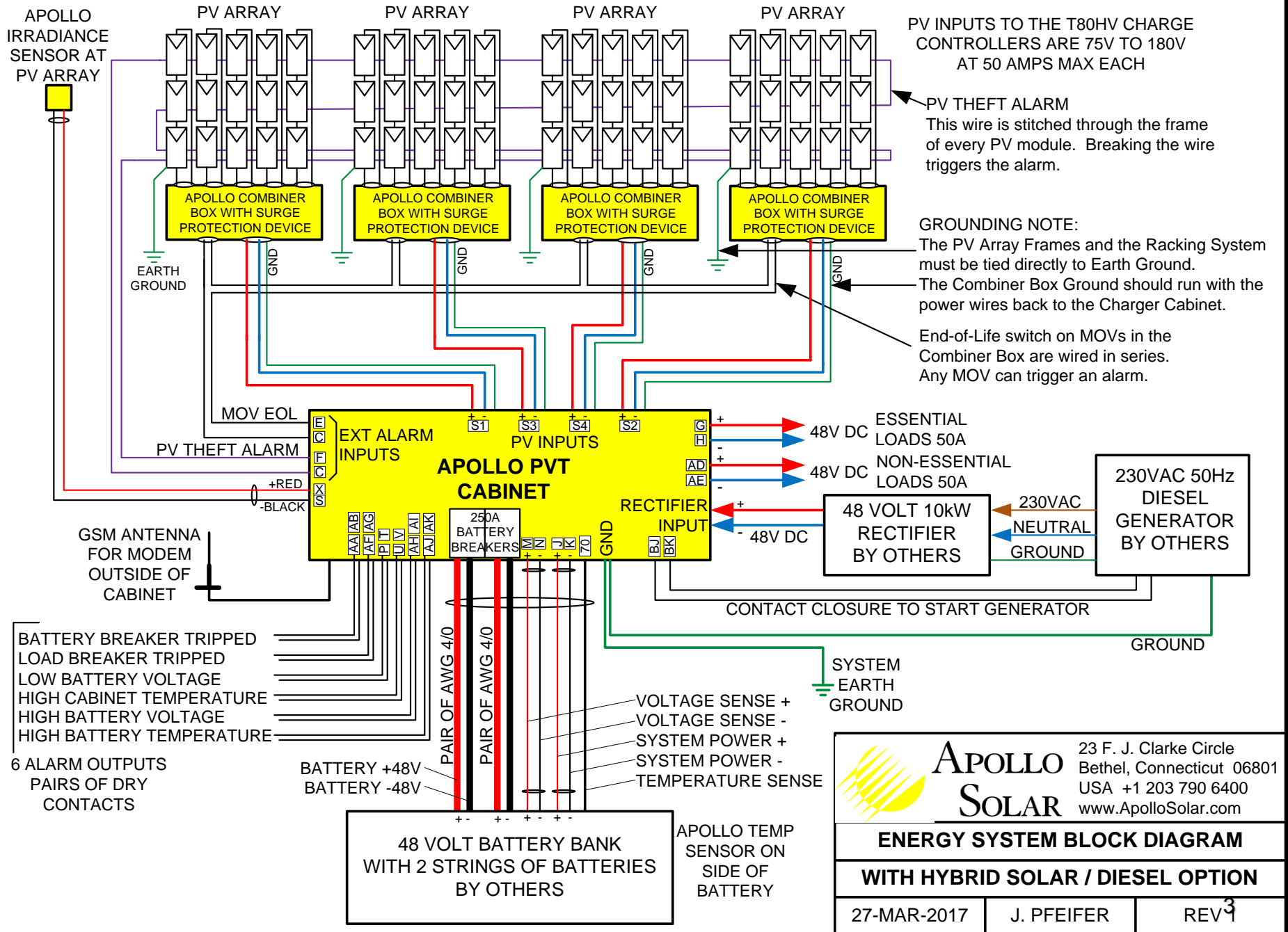
SAFETY FIRST

WARNINGS:

- **The Apollo Solar Cabinet is energized by multiple sources.**
- **Turn OFF all sources of power before working in the cabinet.**
- **Lethal Voltages inside Cabinets.**
- **Use insulated tools.**
- **Wear insulating gloves.**



APOLLO SOLAR – REMOTE ENERGY SYSTEM – SYSTEM WIRING DIAGRAM



Commissioning - Overview

THE PURPOSE OF COMMISSIONING:

- Commissioning is the final and MOST CRITICAL Quality Control step for the Installation Company.
- Thorough Commissioning assures Safety and Performance of the Tower Energy System.
- The Commissioning Report is often the key deliverable to trigger payment from the Mobile Carrier.
- The Commissioning Report establishes the baseline for all maintenance and support in the future.
- Apollo Solar reserves the right to request copies of all Commissioning Reports to help us protect the reputation of the equipment which we manufacture.

COMMISSIONING TASKS:

These major categories must be verified in addition to the detailed checklist.

1. Verify that applicable equipment and systems are installed according to the contract documents, manufacturer's recommendations and industry accepted minimum standards.
2. Verify that the energy system meets the requirements of the end-user / customer.
3. Verify that installing team performs adequate operational checkout.
4. Verify and document proper performance of equipment and systems.
5. Verify that the operations and maintenance (O&M) documentation left on-site is complete.
6. Verify that the owner's operating personnel are adequately trained.

Commissioning – Check List

Now that the Purposes and Concepts are clear, we will go over the detailed checklist.

Each Installation Company will have an established Commissioning Procedure. Apollo Solar is not trying to change that procedure, but simply highlighting details that are specific to the Apollo equipment.

1. Verify that the installation is complete, safe and done with good workmanship.
2. Verify that all components of the installation are robust and permanent.
3. Document as-built conditions including PV Module Outputs, Battery Voltages and Torques. Suggested tables for these items and photos of test point locations are included in this presentation.
4. Verify system performance against established benchmarks.
5. Verify complete and proper system operation.
6. Complete all required acceptance documentation for the system owner.

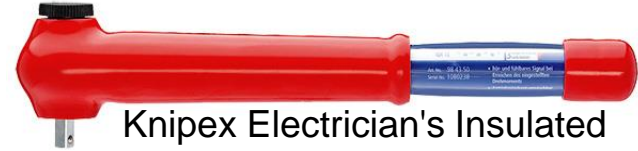
GENERAL RULES:

- The Commissioning should be done by someone other than those who wired the system.
- The Commissioning party must have the authority to ask for errors to be corrected and retested.
- Measurements of the PV Array should be done when there is irradiance of greater than 400 W/m².
- Allow enough time to do a complete job.
- Do not try to squeeze the Commissioning in at the end of the day.

Commissioning – Tools Required

A typical set of tools required for Commissioning of the Apollo Solar remote energy system includes:

- Insulated Torque Wrench (1.5 to 22 N-m) with bits to fit the following bolts or screw heads:
 - Phillips head screws
 - Slotted head screws
 - 8mm Allen head screws
 - ½” and 9/16” Socket for hex head bolts
- DC Voltmeter – Handheld digital multi-meter which can read up to 250 volts DC
- Ammeter – Handheld digital multi-meter with a clamp-on DC current probe for up to 500Amps
- Irradiance Meter – Handheld meter with readout in Watts/m² See suggested meters below. Both of these Irradiance meters are available on line from Tequipment.net.



Knipex Electrician's Insulated Torque Wrench \$480.



The Seaward Solar Survey 100
Price: \$345
In addition to Irradiance, it can be used to measure ambient temperature and PV module temperature.



The TPI Solar Irradiance Meter
Price: \$125 to \$150
Low cost meter for Irradiance.

Commissioning

SUGGESTED COMMISSIONING FORMS FOR PV ARRAYS AND BATTERIES

Verify that the polarity is correct for every voltage measurement.

APOLLO SOLAR		REMOTE ENERGY SYSTEM - COMMISSION REPORT					
DATE:		LOCATION:					
INSTALLATION BY:		COMMISSION BY:					
PV ARRAY TEST DATA							
SUB-ARRAY	STRING NUMBER	STRING VOLTAGE	IRRADIANCE VALUE	ARRAY TEMPERATURE	MODULE 1 VOLTAGE	MODULE 2 VOLTAGE	MODULE 3 VOLTAGE
1	1						
1	2						
1	3						
1	4						
1	5						
1	6						
2	1						
2	2						
2	3						
2	4						
2	5						
2	6						
3	1						
3	2						
3	3						
3	4						
3	5						
3	6						
4	1						
4	2						
4	3						
4	4						
4	5						
4	6						

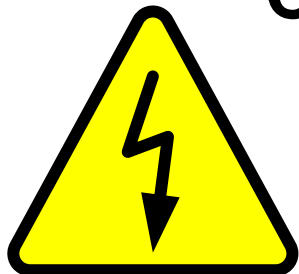
APOLLO SOLAR		REMOTE ENERGY SYSTEM - COMMISSION REPORT					
DATE:		LOCATION:					
INSTALLATION BY:		COMMISSION BY:					
BATTERY TESTING - ALL CHARGING AND LOADS DISCONNECTED FOR AT LEAST 1 HOUR							
INITIAL VOLTAGES OF CELLS							
STRING NUMBER: 1		STRING NUMBER: 2		STRING NUMBER: 3		STRING NUMBER: 4	
CELL NUM	CELL VOLTAGE	CELL NUM	CELL VOLTAGE	CELL NUM	CELL VOLTAGE	CELL NUM	CELL VOLTAGE
1		1		1		1	
2		2		2		2	
3		3		3		3	
4		4		4		4	
5		5		5		5	
6		6		6		6	
7		7		7		7	
8		8		8		8	
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11		11		11		11	
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Commissioning – Torque Values

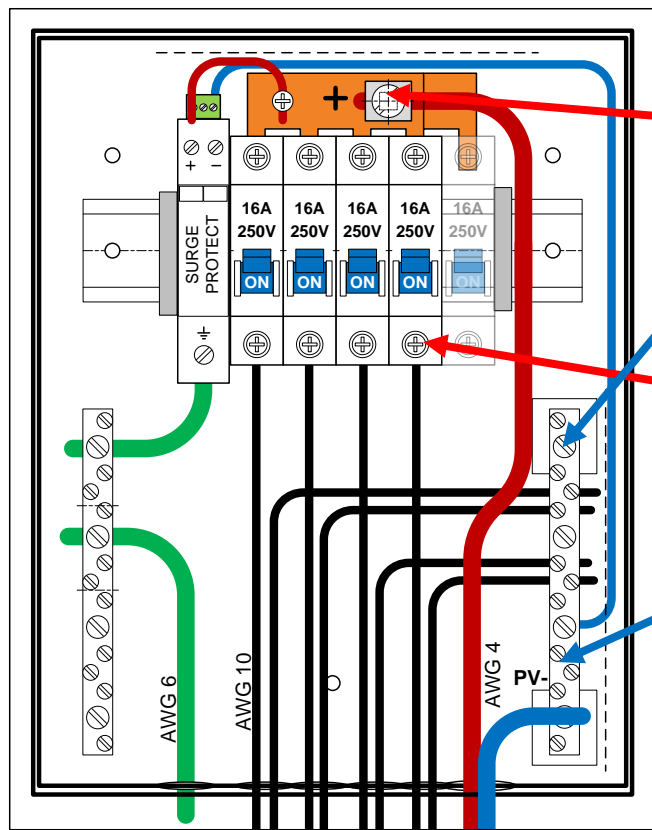
Verify that each high current terminal is tightened to the torque value specified in the chart.

APOLLO SOLAR - PVT GEN4 PANELS - PRODUCTION QUALITY ASSURANCE - CRITICAL TERMINAL TORQUE TEST								
The torque of all high current terminals are measured and must meet the specified torque +/- 10%.								
DEVICE	LOCATION	TERMINALS	TOOL	NUMBER OF TERMINALS	TORQUE N-m	TORQUE in-lbs	INSTALL BY	CHECK BY
DC Surge Protector	Bottom edge of panel	+ and -	Slotted Screw	2	1.5	13.3		
DC Surge Protector	Bottom edge of panel	GND	Slotted Screw	1	2.3	20		
T80HV Charge Controller	Master & 1 to 3 Slaves	Ground Lugs on Heat Sink	Slotted Screw	1 on each T80HV	2.3	20		
Circuit Breakers	100A and 50A, 250V	Both Ends	Slotted Screw	4 to 8	2.3	20		
Circuit Breakers	All single pole breakers	Both Ends	Phillips Screw	6 to 12	2.3	20		
T80HV Charge Controller	1 to 4 units	Gnd Wire to Chassis Ring	Phillips Screw	1 on each T80HV	2.3	20		
PV Input Terminals	Right side of panel	Top Ends	Slotted Screw	2 per PV string	4.5	40		
Earth Ground Bus Bar	Bottom edge of panel		Slotted Screw		4.5	40		
48 volt Bus Bars	Positive & Negative	Small gauge screws	Slotted Screw	Many	4.5	40		
T80HV Charge Controller	1 to 4 units	PV IN & BATT OUT Lugs	Slotted Screw	4 on each T80HV	5.6	50		
Contactors - 160A, Latching	Center of panel	M8 x 1.25 Studs	1/2" Socket	2 to 6	9.5	84		
250A Battery Circuit Breakers	Lower center of panel	8mm Hex drive box lugs	8mm Allen Hex	2, 4 or 6	20.3	180		
500Amp Shunt	Tied to Neg 48V bus bar	3/8" brass hex head bolts	9/16" Socket	2	21.7	192		
48 volt Bus Bars	Positive & Negative	3/8" brass hex head bolts	9/16" Socket	1 to 3	21.7	192		
Shunt Bus Bar	Bolted to Shunt	3/8" brass hex head bolts	9/16" Socket	up to 4	21.7	192		
		SIGNATURES	DATE	PANELS/N		DATES:		
SIGN-OFF BY PRODUCTION TECHNICIAN								
SIGN-OFF BY QUALITY ASSURANCE SUPERVISOR								

Commissioning Procedure – The PV Inputs



- **CAUTION** – During this procedure you will be working around live conductors carrying lethal voltages.



COMBINER BOX

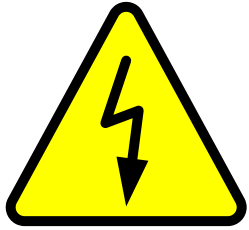
+
Measure Voltage
from each Combiner
with all Breakers ON.

-
+
Measure PV Open
Circuit Voltage for
each string with
Breakers OFF.

-
Accuracy to +/- 1 volt is
sufficient. The PV Open
Circuit Voltages must be
between 75 volts and
180 volts.

PV ARRAY COMMISSIONING

1. Measure and record the Irradiance before and after each step below.
2. In the Combiner Box, turn all the Circuit Breakers ON. Measure and record the Output Voltage of each Combiner Box.
3. Turn all the Breakers OFF. Measure the Open Circuit Voltage for each PV string at the bottom of the circuit breakers. Turn the breakers back ON.
4. In the Apollo cabinet, turn all the PV Input Breakers OFF. With sun on the PV array, carefully measure the DC voltage at the PV Input Connectors. Record each PV input separately.



Apollo Solar Gen 4 Power-Up Procedure

Warning to Prevent Damage

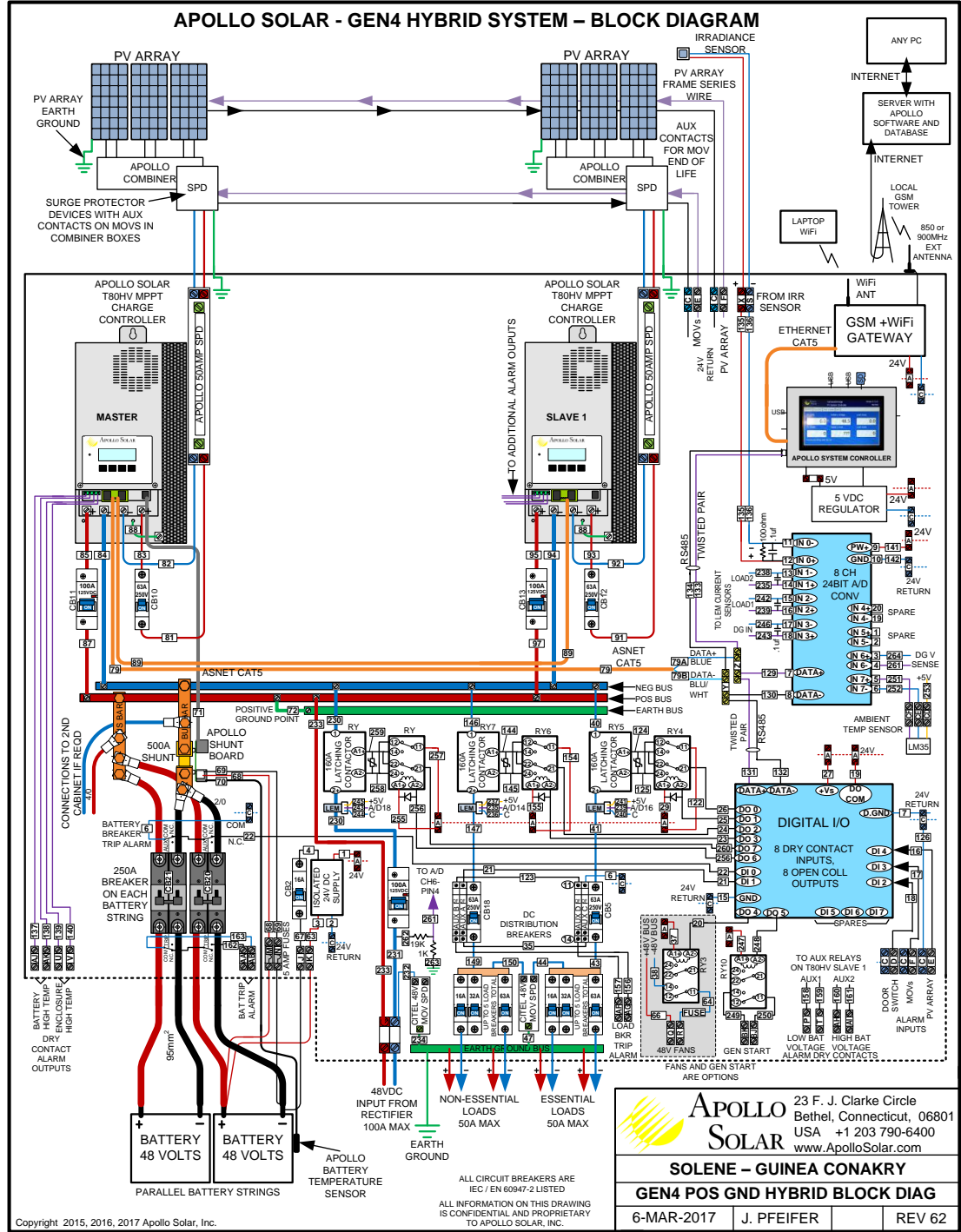
- **ALWAYS TURN THE BATTERY POWER TO THE T80HV CHARGE CONTROLLERS ON BEFORE TURNING ON THE PV INPUTS.**
- **ALWAYS TURN THE PV INPUT OFF BEFORE TURNING THE BATTERY POWER OR THE T80HV OUTPUT CIRCUIT BREAKERS OFF.**

The T80HV Charge Controllers in this product operate from the battery power. The microprocessors inside the T80HV must have voltage applied so they can control the FETs which switch power from the PV input. **If the PV input power is allowed into these FETs without the T80HV circuitry running from battery power, the FETs can be damaged.** This damage is NOT covered by the warranty.

Schematic Drawing of the Apollo Hybrid Energy Cabinet

This Schematic represents a 2X Cabinet. The 3rd and 4th T80HVs are simply added to the space between the other two.

This drawing shows the reference designators for all the parts and the numbers of each wire.



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Apollo Hybrid Energy System Assembly Drawing

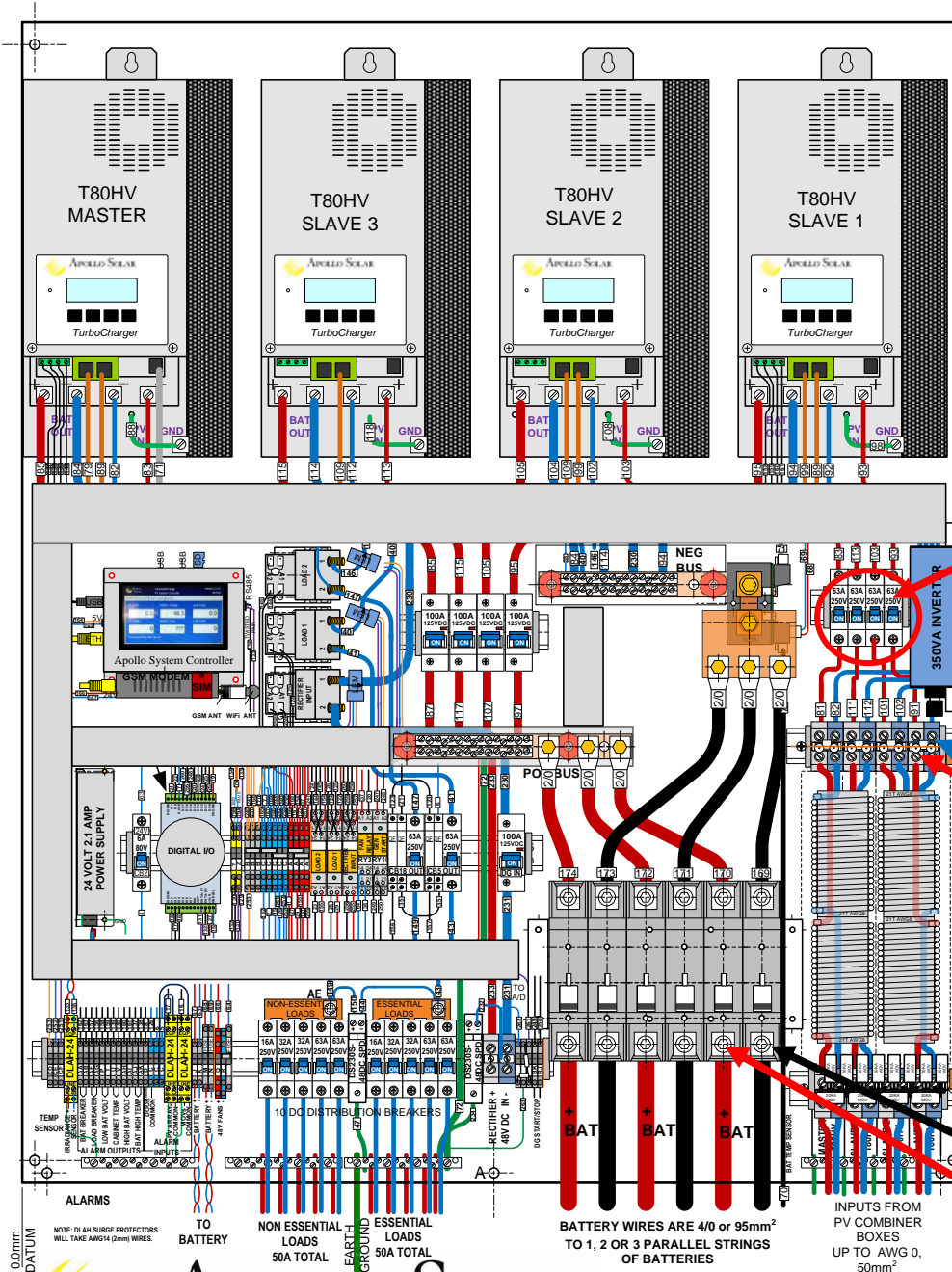
This drawing is the Panel in the Gen4 Cabinet showing all available options. Your panel may be simplified.

The key Voltage Measurement points are called out.

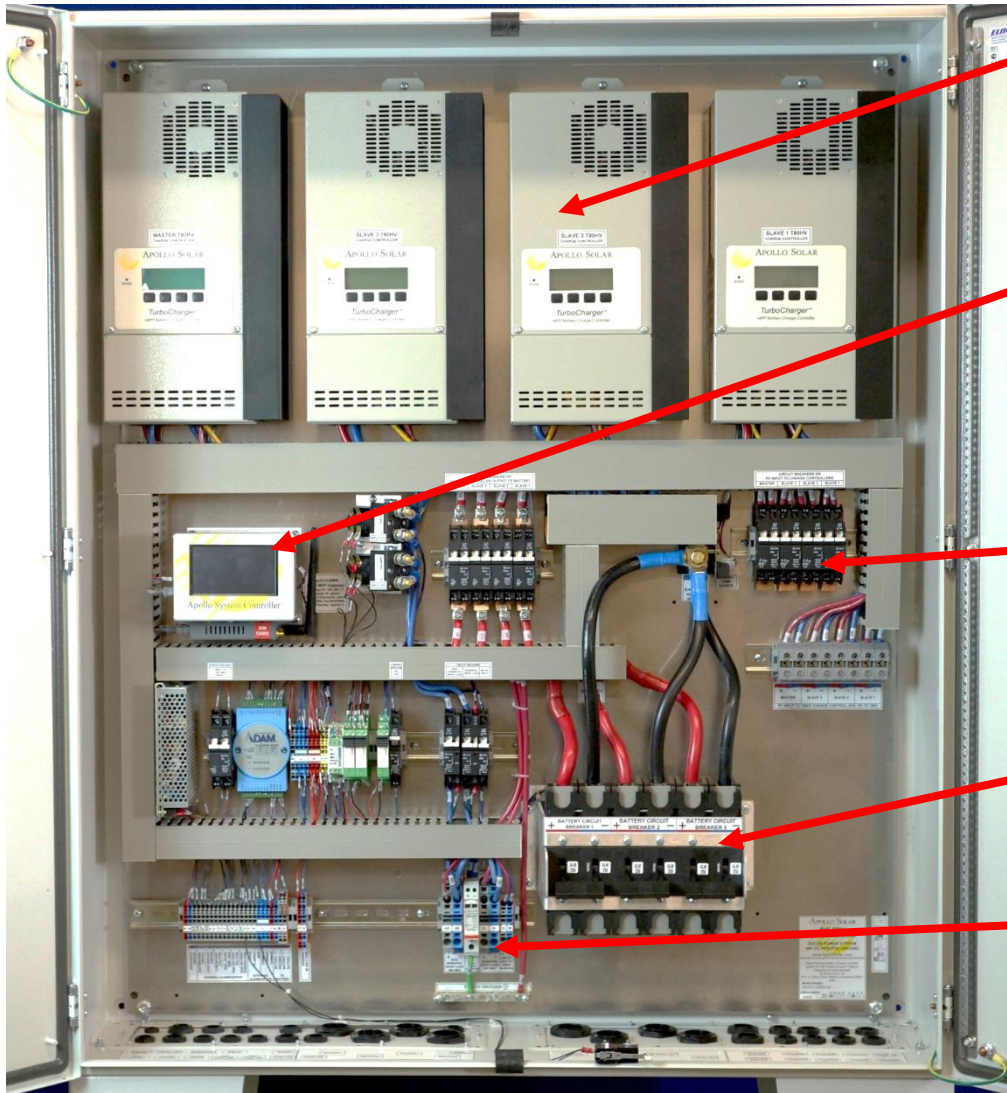
The PV Input Breakers must be turned OFF until battery voltage is applied to the T80HV Charge Controllers.

PV Input Voltage from Combiner Boxes

Battery Voltage at Panel

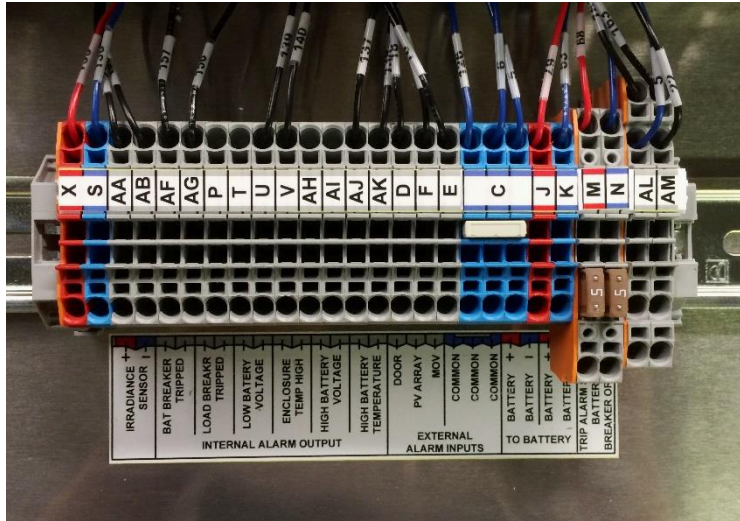


Inside the Apollo Solar Cabinet



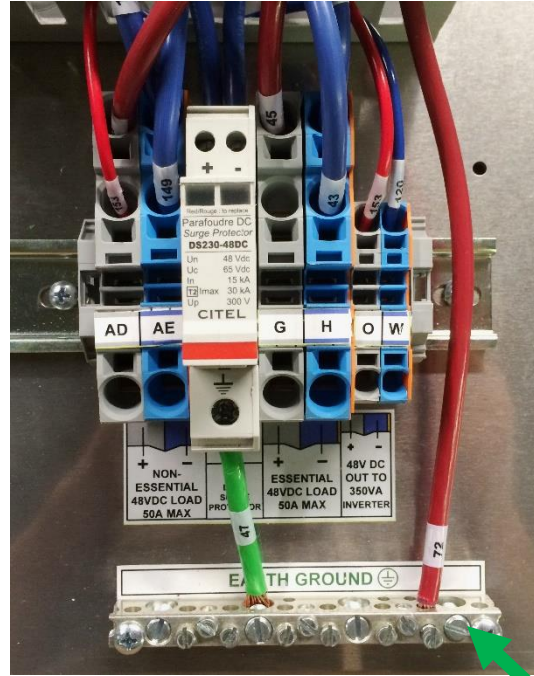
- **SOLAR CHARGE CONTROLLERS**
The cabinet will support up to 4 T80HVs at 4kW of PV each.
- **APOLLO SYSTEM CONTROLLER –**
The ASC provides smart control of all power sources and distribution along with the Remote Monitoring.
- **CIRCUIT BREAKERS –** Hydraulic-Magnetic Circuit Breakers are immune to ambient temperature.
- **BATTERY BREAKERS –** Multiple poles are provided for parallel battery stacks.
- **EXTERNAL WIRES AND GLANDS –** Easy field wiring to well labeled terminals.

Apollo Solar Gen 4 Wiring Details

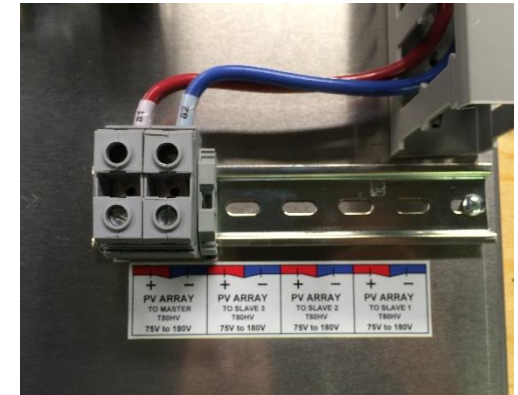


The smaller terminals are used for connecting the Irradiance Sensor, the Alarm signals and the battery voltage sense wires.

Terminals M and N from the battery are fitted with 5 Amp automotive type fuses.



The DC Outputs to the Essential Load and the Non-Essential Load should be measured at terminals G/H and AD/AE.



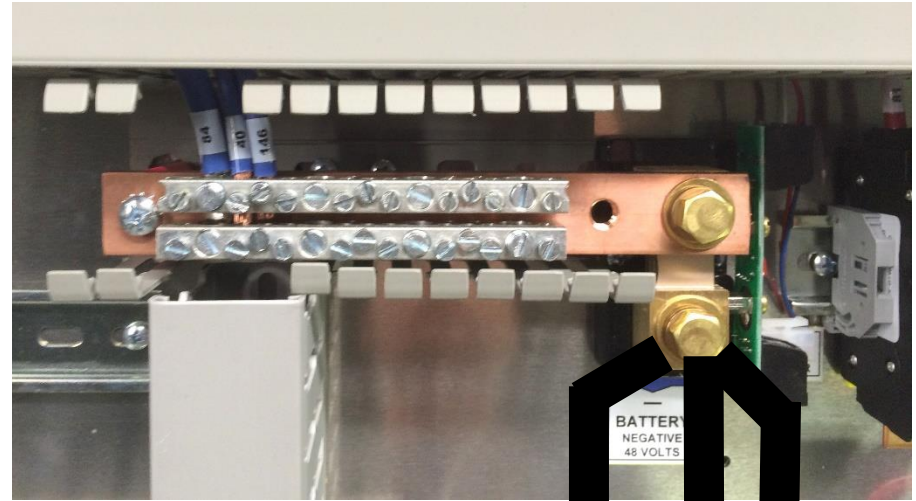
The PV inputs have screw type connectors which will accept up to AWG 2 wires from the Combiner Boxes. Torque the screws to 4.6 N-m (40 in-lbs).

The Earth Ground is a single point with a terminal strip to connect to the external Ground Rod. Torque the screws to 4.6 N-m (40 in-lbs).

Apollo Solar Gen 4 Installation Details



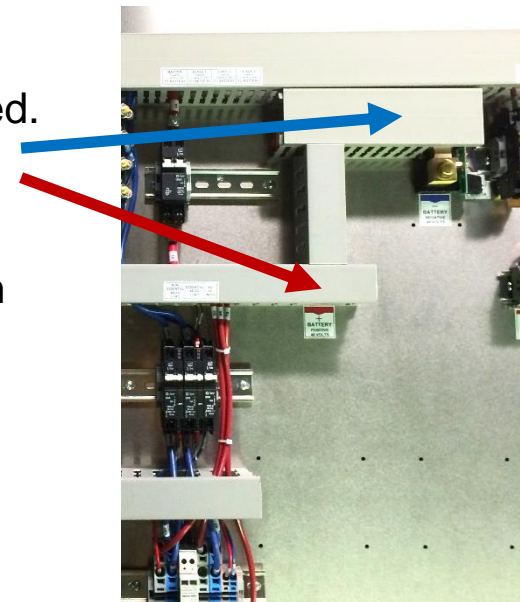
The POSITIVE battery cables are to the POSITIVE BUS BAR.



The NEGATIVE battery cables are to the LOWER TERMINAL ON THE SHUNT.

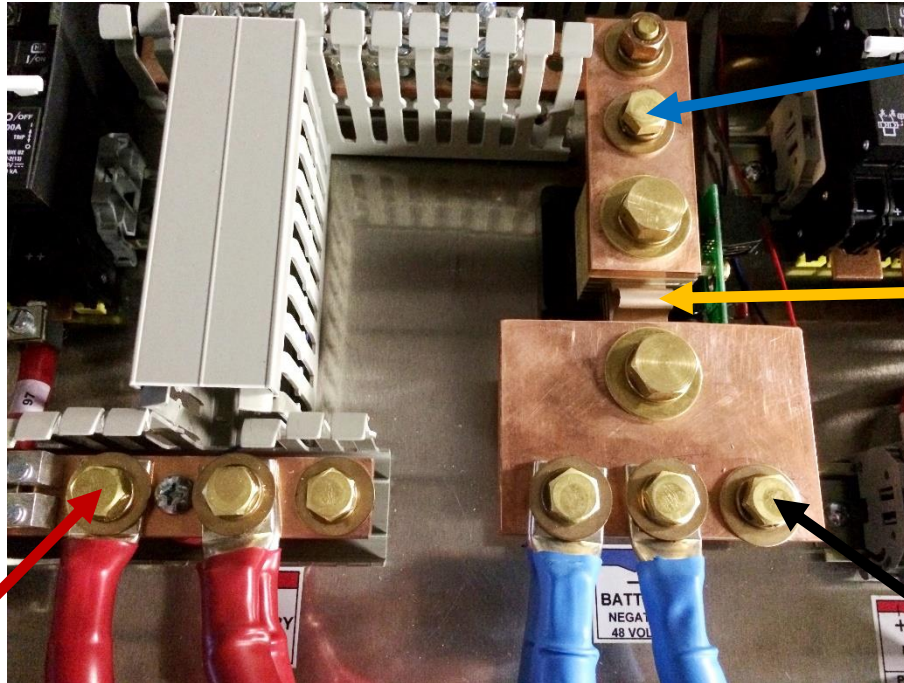
The Bus Bars are shown above with their covers removed. The arrows point to their locations on the Gen 4 Panel.

The battery cables must be AWG 4/0 or 95mm² for minimum voltage drop. The terminals **MUST** be tightened with a calibrated torque wrench 20.2 N-m (180 in-lbs.).



Installation Details – Multi Cabinet Systems

Multiple Cabinet Systems are used when more than 4 T80HVs are required. The 1000 Amp Shunt in the Master Cabinet provides high current terminals to connect to the Bus Bars in the additional cabinets.



The NEGATIVE BUS BAR with terminals to connect to additional cabinets

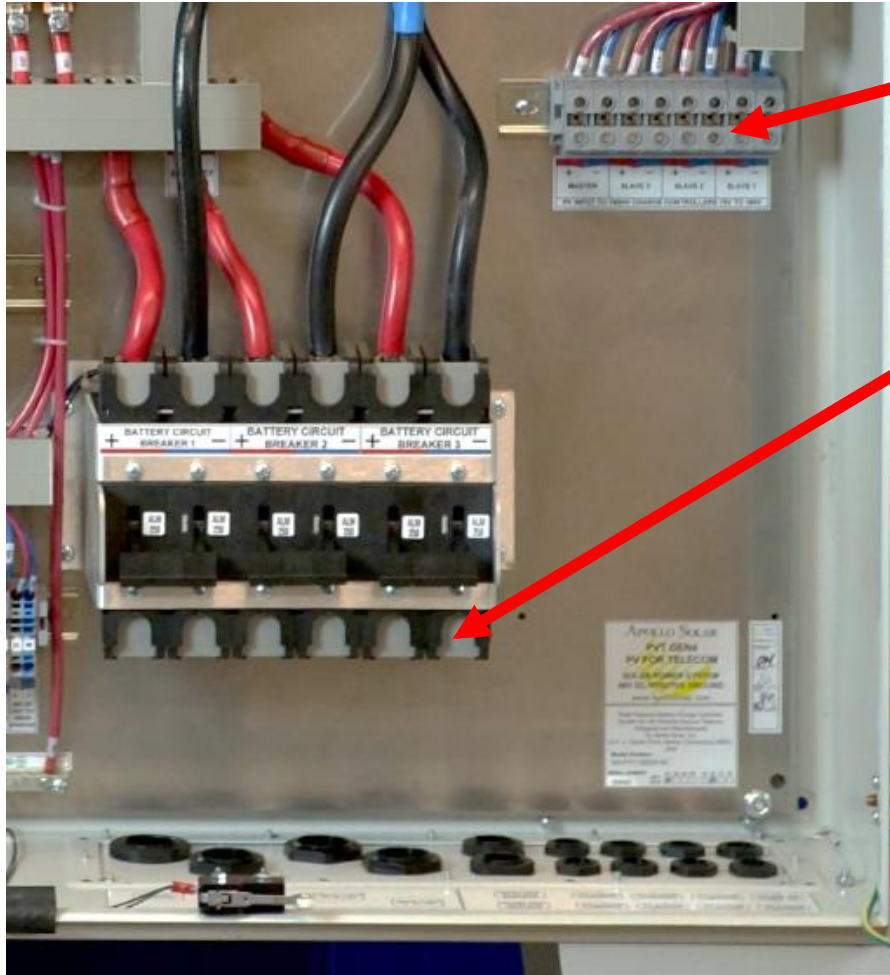
The 1000 Amp Shunt

The POSITIVE battery cables terminate at the POSITIVE BUS BAR.

The NEGATIVE battery cables terminate at the lower terminals on the Shunt Bus Bar.

The battery cables must be AWG 4/0 or 95mm² for minimum voltage drop. The terminals MUST be tightened with a calibrated torque wrench 20.2 N-m (180 in-lbs.).

Gen 4 Wiring – 4X T80HV, 3 Battery Breakers



- The 4 PV Combiner Boxes are connected through the glands at the lower right to the screw terminals marked for PV Inputs. Torque the screws to **4.6 N-m (40 in-lbs)**.
- Cables from the Batteries are connected into the bottom of the Battery Circuit Breakers.
- Double check the Positive + and the Negative – are correct.
- **Torque the Allen head screws to 20.2 N-m (180 in-lbs.)**



FOR SAFETY, IT IS RECOMMENDED THAT THE BATTERY SHOULD BE THE VERY LAST CONNECTION MADE.

AFTER THE CABLES ARE CONNECTED TO THE BREAKER, THEN THE CABLES CAN BE CONNECTED TO THE BATTERIES THEMSELVES.

Inside the Mini Cabinet

The Mini Cabinet provides the same features and quality as the Standard Cabinet but with room for only 2 Charge Controllers. It is designed for systems with less than 10kW of PV array.



- **One T80HV is shown with room for 2.**
- **APOLLO SYSTEM CONTROLER** – The ASC provides smart control of all power sources and distribution along with the Remote Monitoring.
- **BATTERY BREAKERS** – A single pair of 250A breakers supports a single string of batteries.
- **EXTERNAL WIRES AND GLANDS** – Easy field wiring to well labeled terminals.
- **GEN START RELAY** – This is a HYBRID system with a relay to start an external Diesel Generator.