



## **Inverter / Charger Installation**

### **General Operations and AC and DC Connections**

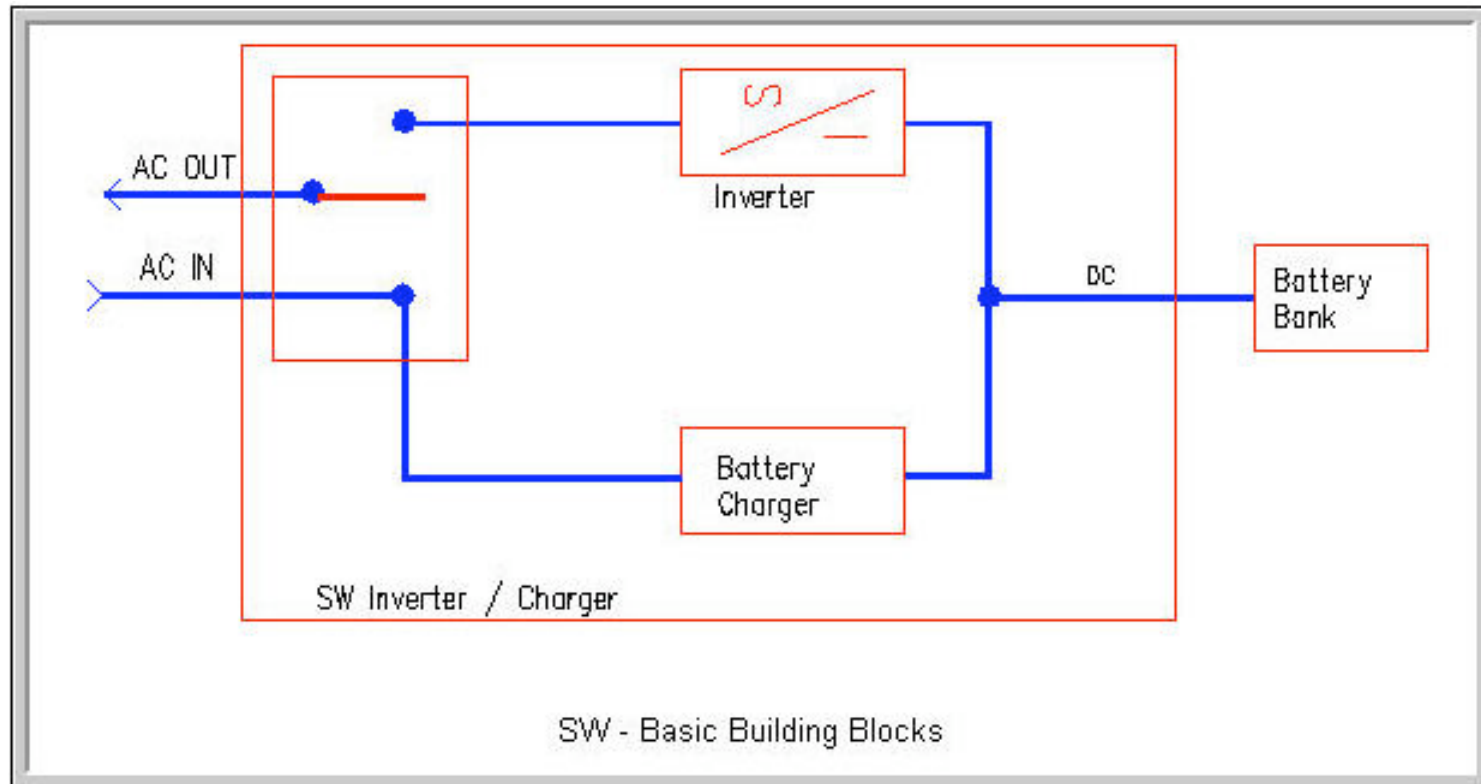


# The Inverter is just one piece.



- Sometimes, a tendency is to mount the inverter and batteries, and “make it work”
- It is better if we pay attention to the other practices that make a good, reliable installation.

# Elements of the Inverter / Charger



# Elements of the Inverter / Charger

- DC to AC Inverter;
- AC to DC Battery Charger;
- Transfer Switch between using AC Incoming Power or Battery Power;
- Transfer Switch to choose between two different AC Sources;
- Relays to perform a variety of user selected functions; and
- Computer with LCD screen and user input for customizing most of the variables.



# Applicability

This presentation is based on the Xantrex Model SW inverter, observed most frequently during field visits, and is applicable to models SW 4048 and SW 5548, which were most prevalent. With minor variations, this information can be applied to Outback Power equipment and other manufacturers' equipment.

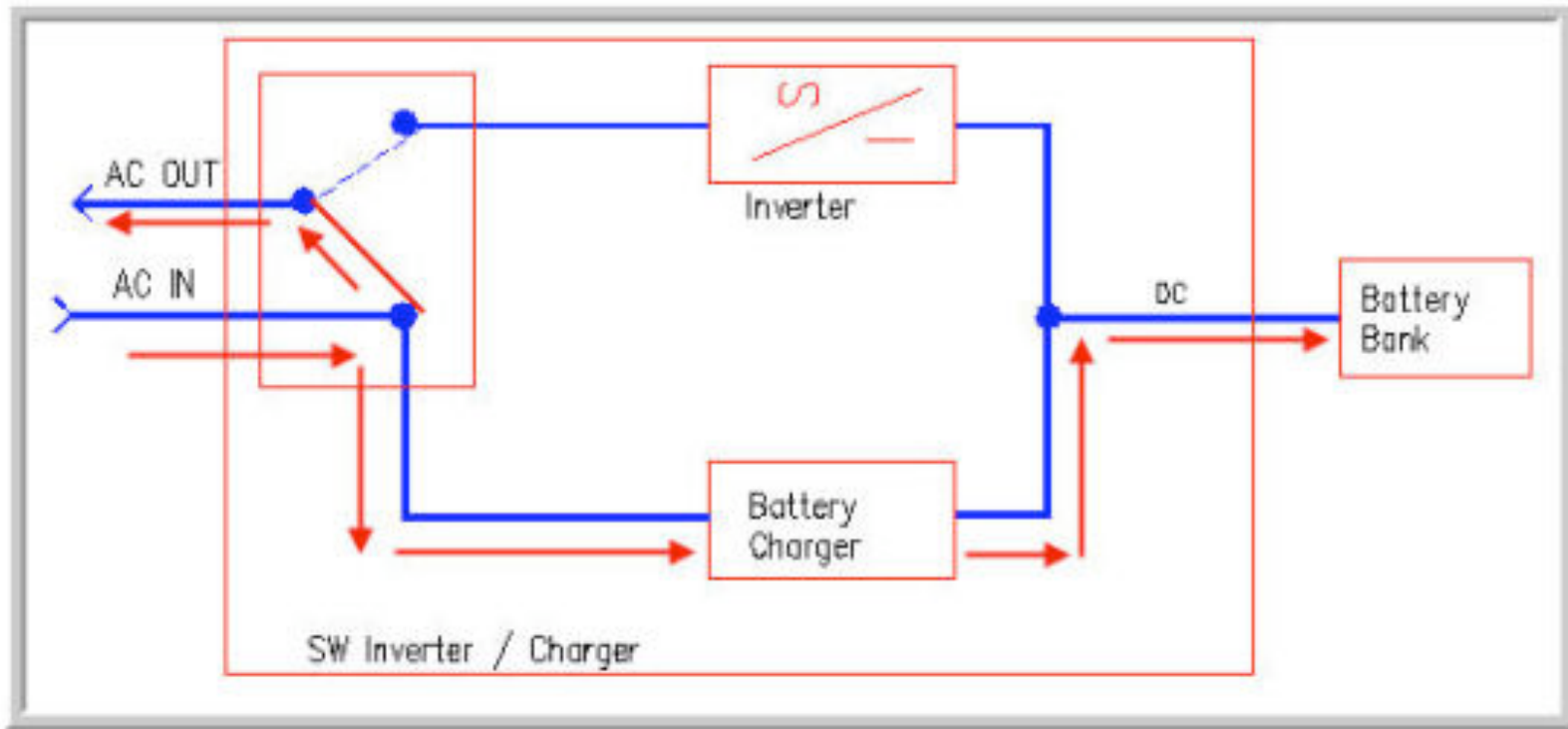


# Modes of Operation: AC IN Operational

- The SW can be connected into an electrical scheme in many different ways. However, some common elements remain unchanged from installation to installation.
- **The over-riding purpose of the SW is to provide continuous power to the loads (AC OUT).** If there is power (with the proper characteristics) at the AC IN terminals, then the equipment will utilize this power to:
  - **Power the Loads (AC OUT);** and
  - **Charge the Batteries** – through the built-in Battery Charger.
- The following diagram shows the operation and power flow when there is proper power supply at the AC IN terminals:



# Modes of Operation: AC IN Operational



SW-AC IN Energized

# Operation:

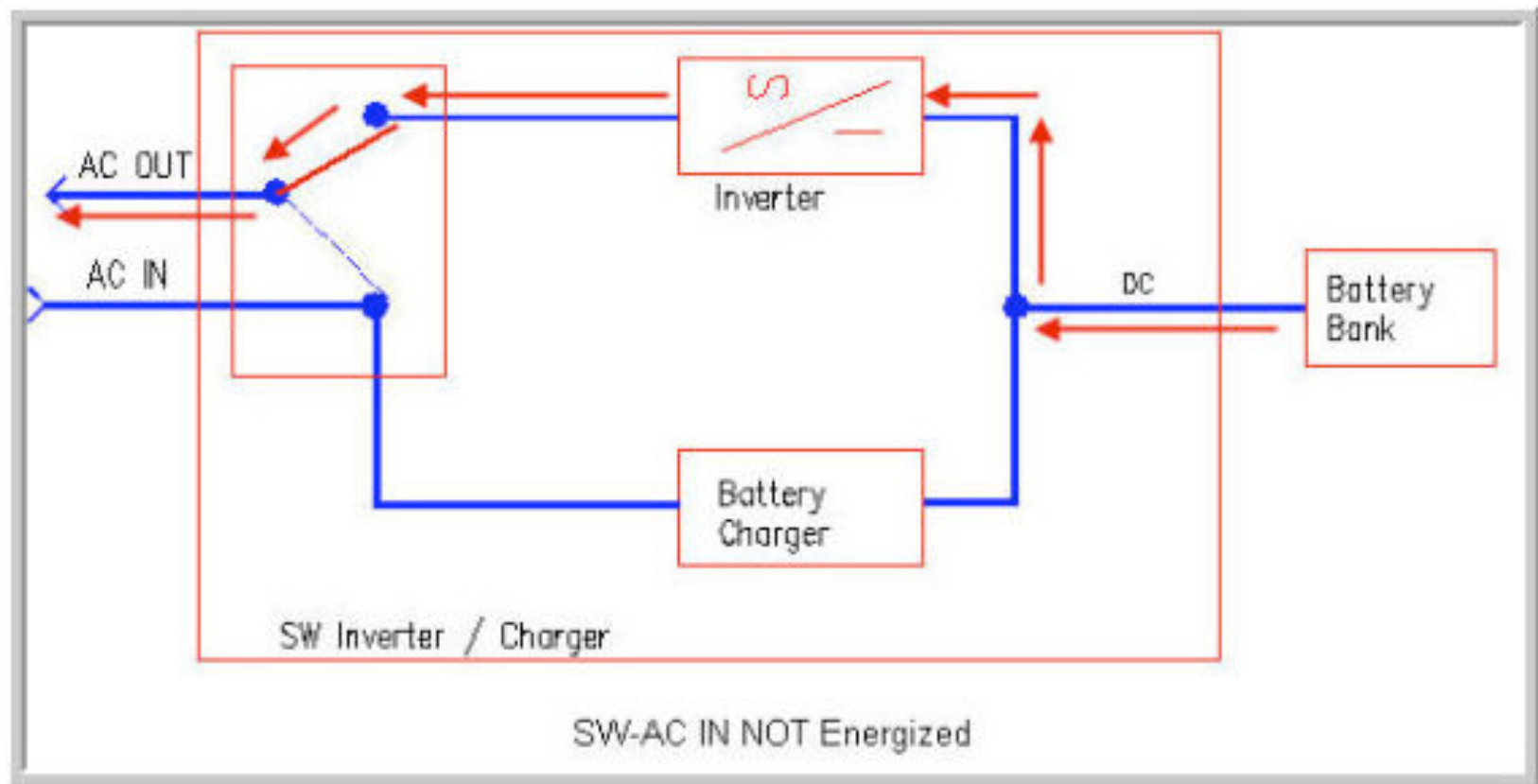
## When AC IN Power is lost

- When power is **lost** to AC IN, the on-board computer switches the transfer switch so that the AC OUT loads are fed from the battery through the DC to AC Inverter, and the inverter is turned on. This happens nearly instantaneously.
- When this situation occurs, the entire load is powered by the battery bank. **Of course, this can not go on forever**, and when the battery bank reaches a programmed low state of charge (depicted by low voltage) the system turns off. (Alarms can be installed to warn operators of impending cut-out, see section 10.2)





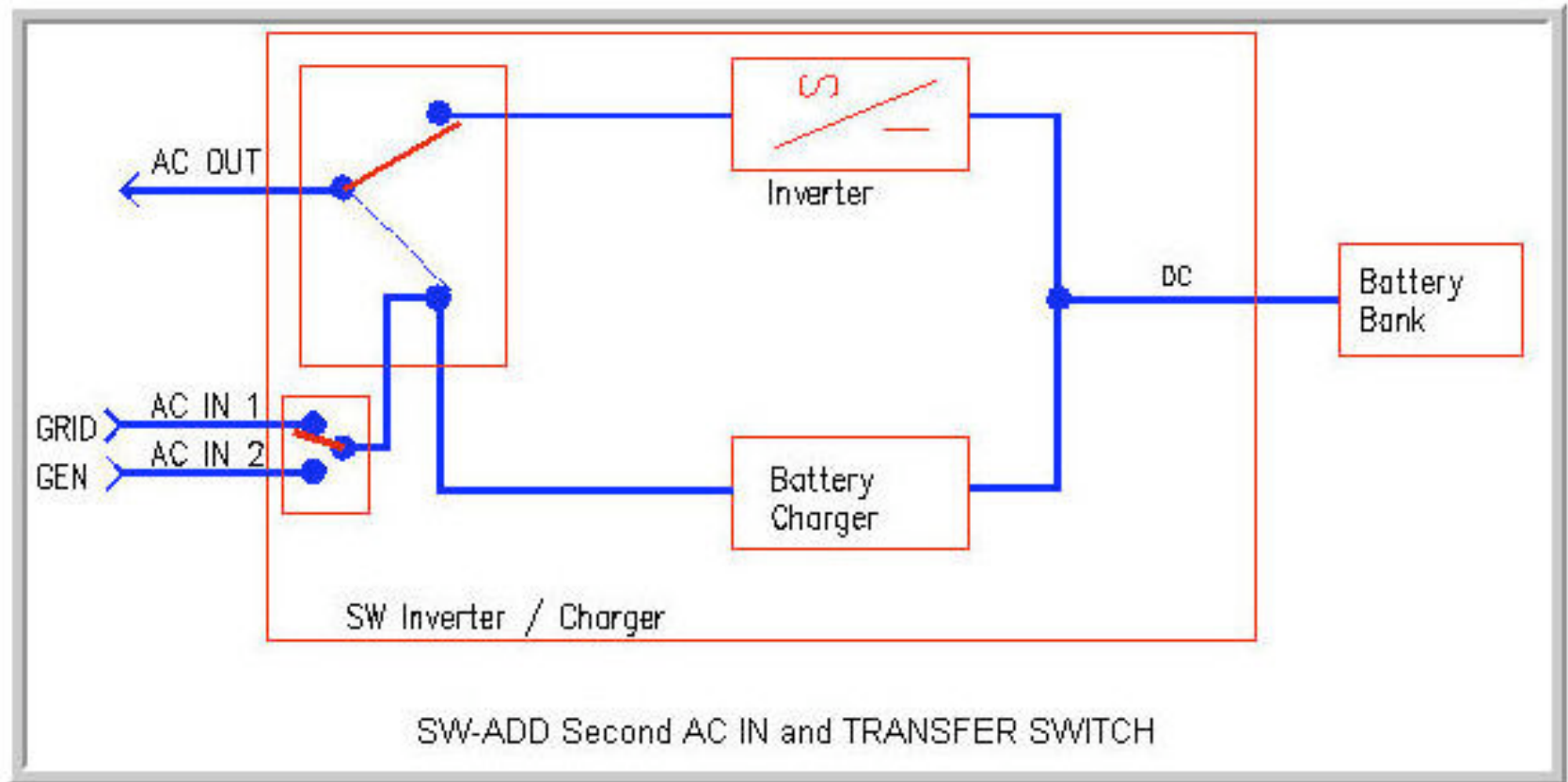
# Modes of Operation: AC IN Operational



# AC IN 1 and AC IN 2

- The SW model inverter/charger includes provisions for **two AC Inputs**. Field visits did not reveal any field application where both inputs were used. In many cases, both inputs will not be needed, but there are many applications where they would be useful. The basic system diagram changes only at the AC IN provisions:

# AC IN 1 and AC IN 2



# Connections to the Real World

- The SW equipment is strictly the core equipment necessary to monitor and switch power sources to feed the given load.
- In order to become part of the entire wiring system, it is essential to use proper wire sizes, and the proper fusing and disconnecting means to (a) protect the wiring, (b) protect the equipment, and (c) protect people.
- In many cases, when improper auxiliary equipment is used (or not used at all) not only is the result unsafe, but it also results in improper operation, battery failure and un-powered loads. These problems can be avoided by following some guidelines on connecting the SW equipment to the rest of the electrical system.
- In the next section, the manual will discuss AC OUT connections, AC IN connections, and finally DC and battery connections.



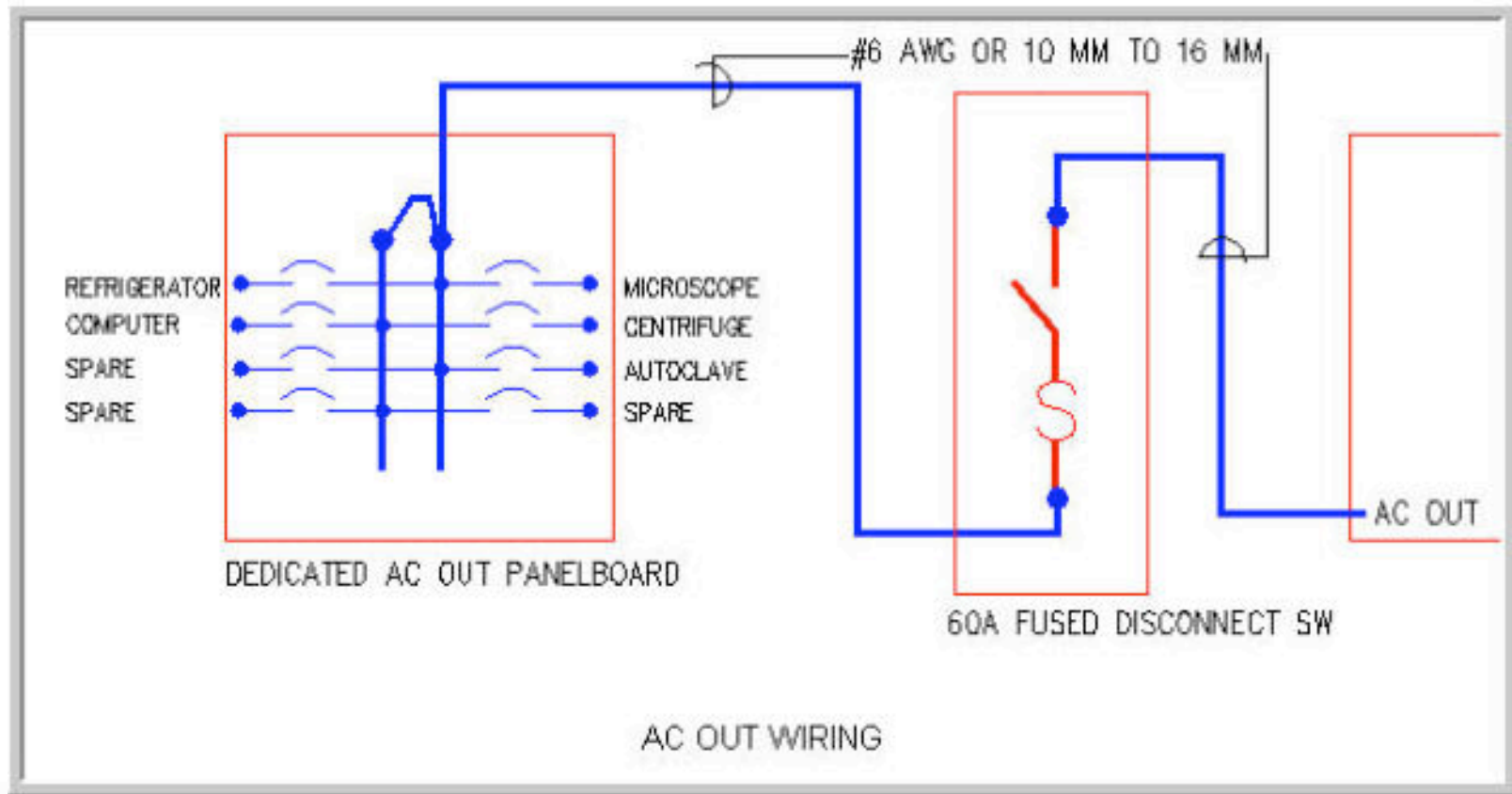


# AC OUT Connections

- All of the AC terminal blocks inside the SW AC box (on the left hand side of the unit) will accept up to **#6 AWG conductors (16mm<sup>2</sup>)**. It is advised that this **#6, 10mm<sup>2</sup>, or 16mm<sup>2</sup> wire** be used.
- The AC OUT terminals should be supplying only a **pre-determined set of loads**. These loads should have been the basis of the selection of the size of the battery bank and the size of the inverter. These loads should be fed from a separate, dedicated circuit breaker panelboard connected to the AC OUT terminals. The conductors carrying the load current from the SW to this panelboard should land first in either a fused disconnect switch, or a main circuit breaker on the panelboard.



# AC OUT Connections



# AC IN Connections

There are several options for AC IN connections:

- AC IN from a **grid supply only**
- AC IN from a **generator supply only**
- AC IN from **both a grid supply and a generator supply**
- AC IN from a **combined grid / generator supply.**

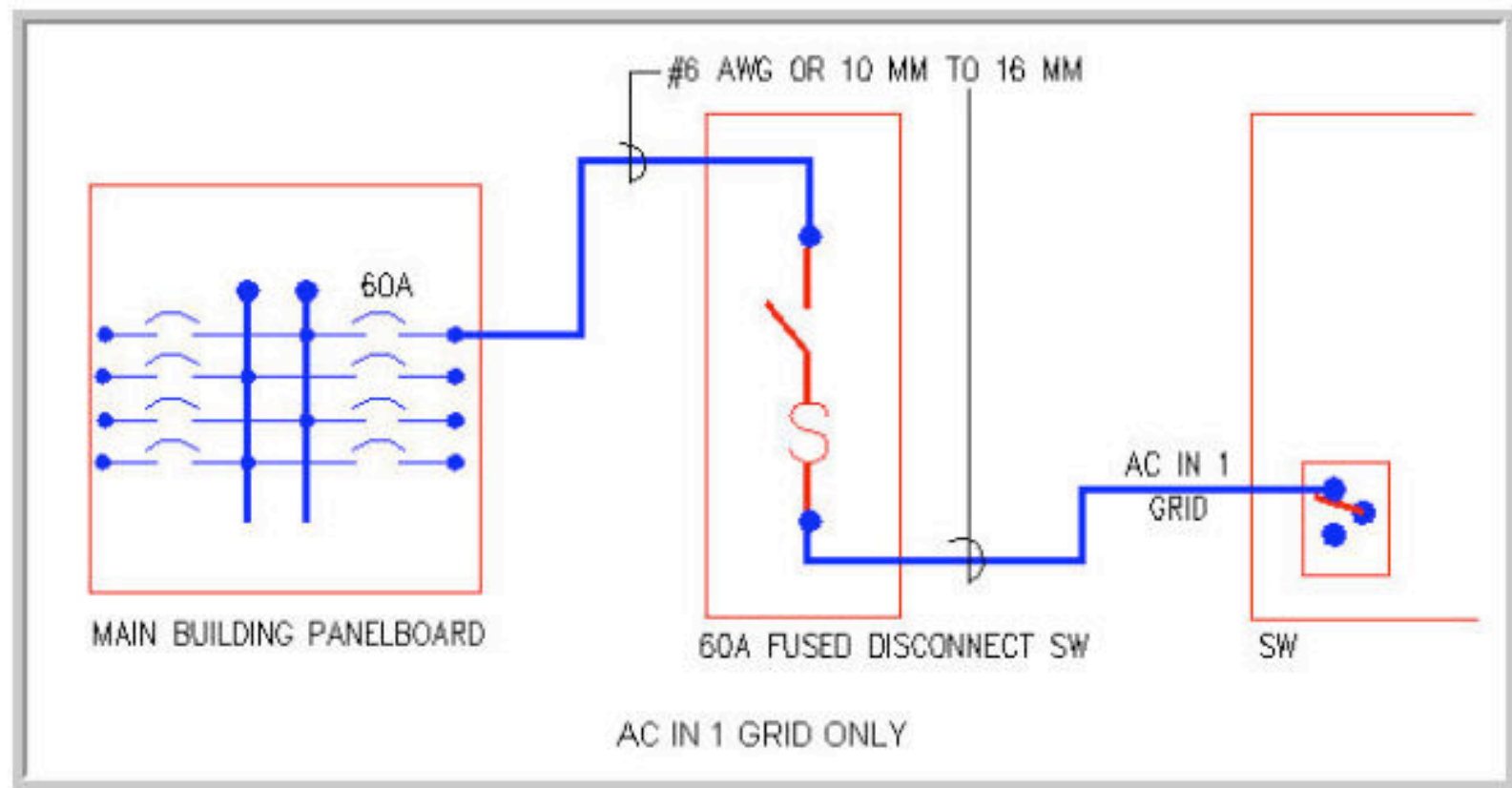
The following section discusses each option.





# AC IN 1 – Grid Supply

## 7.1 AC IN 1 FROM A GRID SUPPLY ONLY



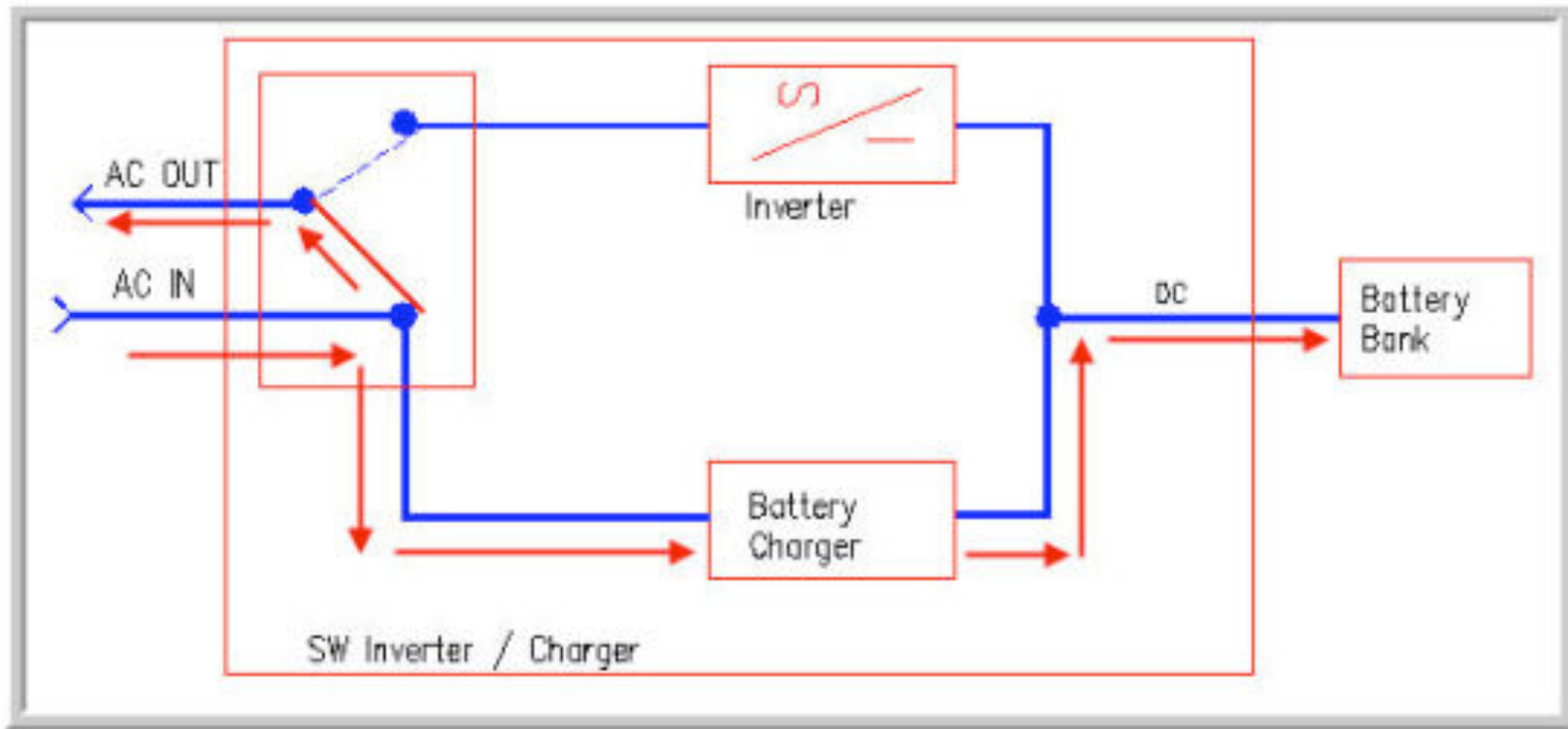
Here, the AC IN power is obtained from the main building panelboard, using a 60A circuit breaker and 60A wire.

# AC IN 1 – Grid Supply

- Even though the output of the inverter is limited to either 33 or 46 amps, it is important that the 60 amp circuit breaker is used and conductors feed the AC IN terminals. **This is because when the grid power is on, it is performing two functions: First it is feeding the loads, and secondly it is powering the battery charger.** The battery charger could draw up to as much as 30 amps depending on how the settings are programmed.
- If it is not possible to provide a 60 amp supply to the ACIN 1 terminals of the SW, **then certain settings MUST be changed** in the programming, and the design needs to be studied to be sure that the batteries will receive enough charging power. See the discussion under “Programming” for more information on this subject.



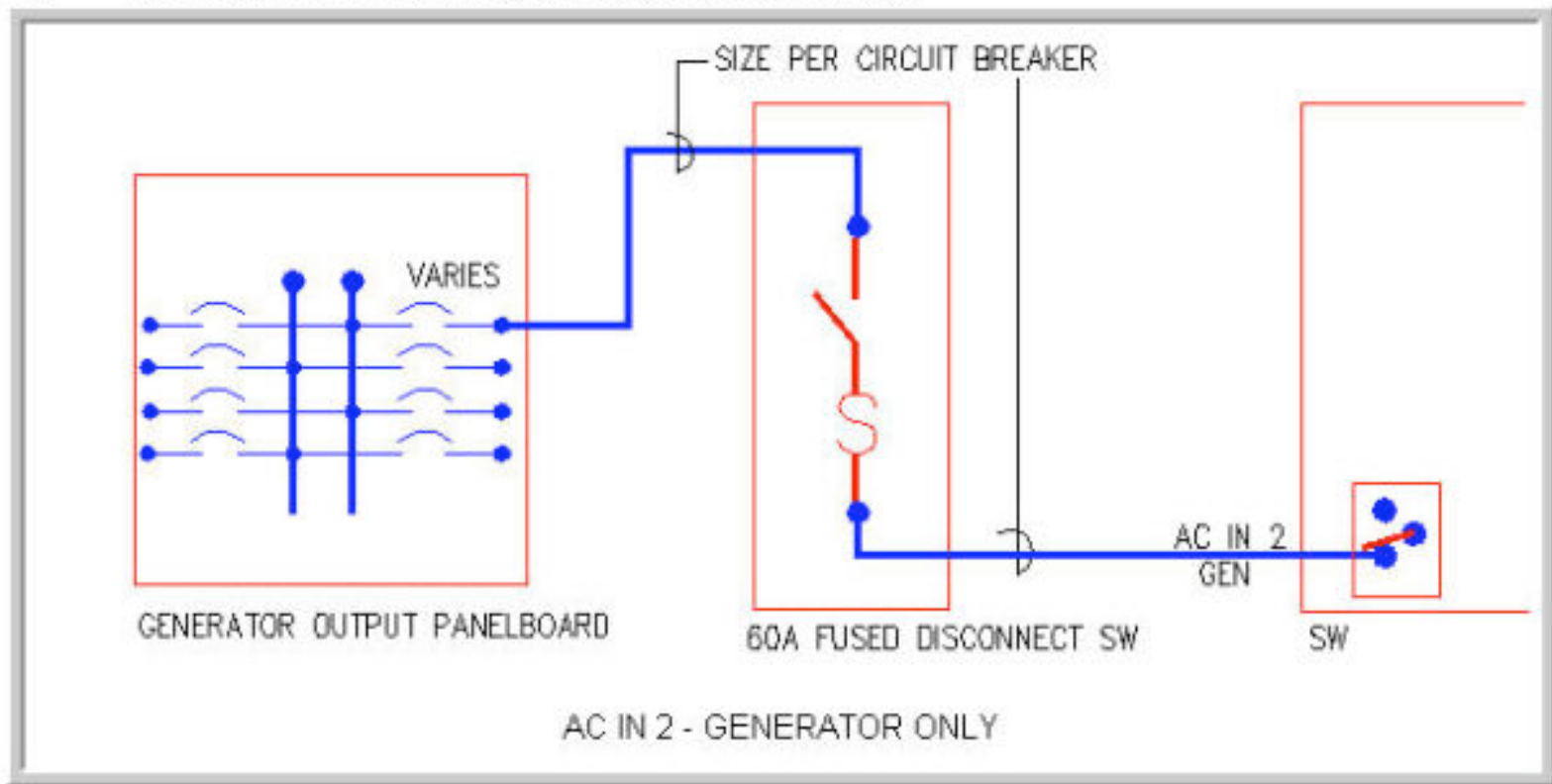
# AC IN 1 – Grid Supply



SW-AC IN Energized

# AC IN 2 - Generator

## 7.2 AC IN 2 FROM A GENERATOR SUPPLY ONLY



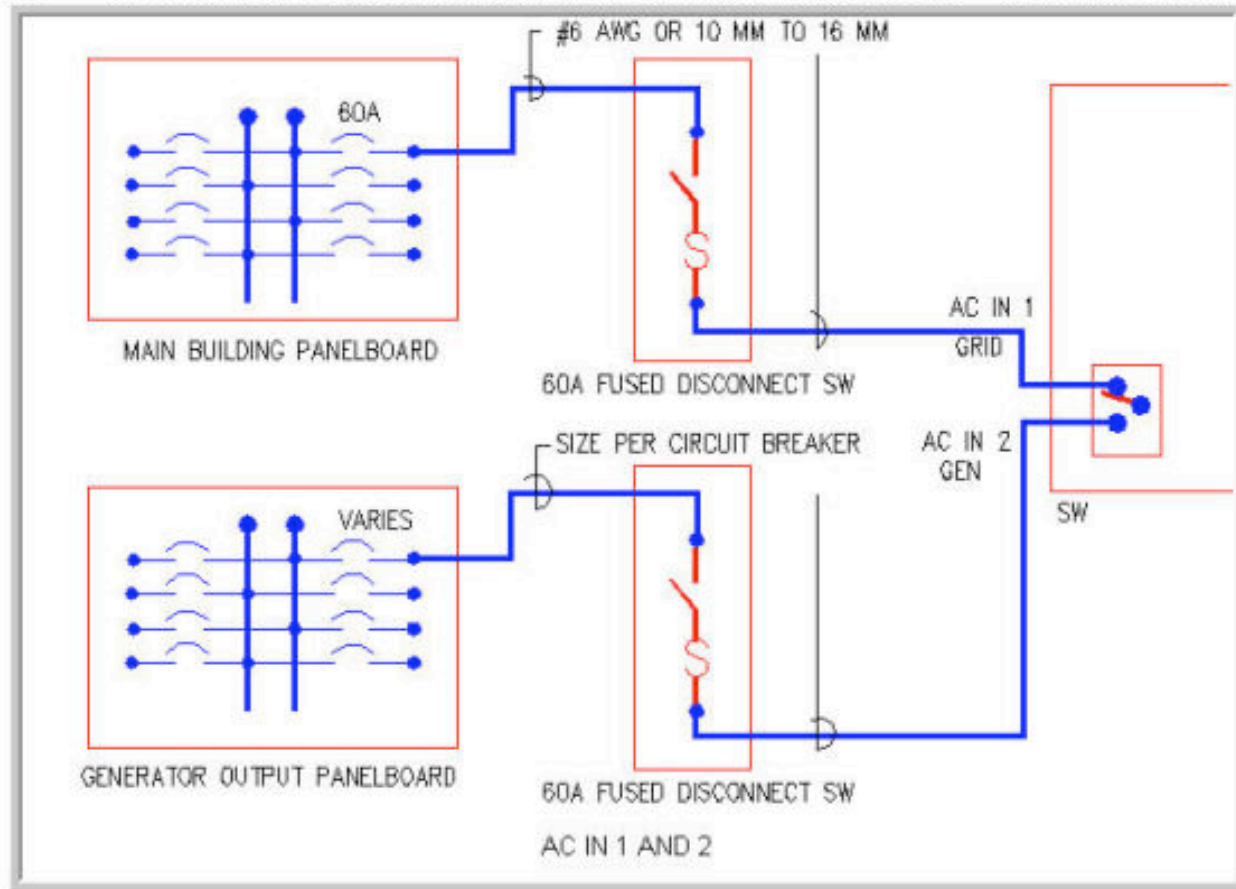
# AC IN 2 - Generator

- The amount of power that can be drawn from the generator needs to be calculated (based on the size of the generator and other loads the generator may have to supply). If, for example, a 6KW generator is dedicated to this inverter, then the maximum power that can be obtained from the 6KW generator (if it is single phase) is  $6000\text{w} / 120\text{V}$  or 50Amps. In this case, a 40 amp breaker to feed the SW and a therefore, 40A wire will be sufficient.
- If the generator is designed to support other loads as well, then how much of its power can be dedicated to the SW equipment needs to be determined and the breaker and conductors needs to be sized accordingly. The proper programming needs to be completed to match this value.
- The equipment needs to be programmed so that it does not try to pull any more power than the circuit breaker feeding it (or any more power than the generator feeding it.). This would trip the breaker and/or overload the generator. See the section on “Programming” for more information.



# AC IN from both Generator and Grid

## 7.3 AC IN FROM BOTH A GRID AND A GENERATOR SUPPLY – AC 1 AND AC 2

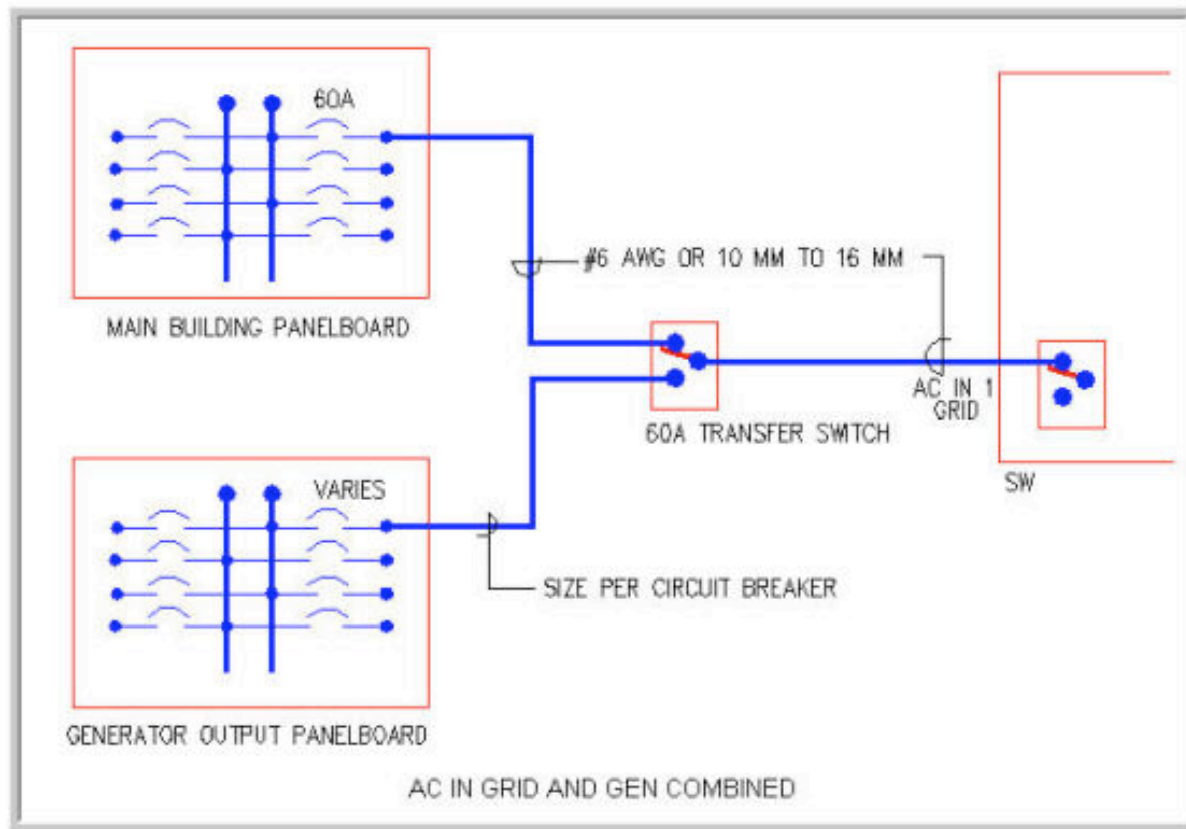


# AC IN from both Generator and Grid

- When both grid power supply and generator power supply are available, the above is the preferred method for connecting to the system, particularly when the generator size requires a smaller circuit breaker and feeder that would be allowed by the grid input power.
- However, in most cases with grid and generator available, the two sources are combined in a transfer switch, with one set of conductors going into the SW, as shown below.

# AC IN from both Generator and Grid

## 7.4 AC IN FROM A COMBINED GRID AND GENERATOR POWER SUPPLY





# AC IN from both Generator and Grid

Discuss pros and cons of the combined Generator / Grid AC IN wiring versus the separate Generator and Grid AC wiring.

# AC IN and OUT Connections

- **Summary of AC IN and AC OUT Connections**
- There are several different configurations possible for the AC IN and AC OUT connections. Key factors to consider in planning the installation are:
  - **Sizing of the conductors** for the greatest possible current that they may experience;
  - Using dedicated, **separate, AC OUT circuit breaker panelboards** for the loads decided to be powered by the SW;
  - Bringing **separate AC IN 1 Grid conductors and AC IN 2 Gen conductors** to the SW equipment panel; and
  - Providing **disconnecting means** for the ACIN 1, AC IN 2, and AC OUT conductors to be able to isolate the SW equipment from any power wires.
  - Additionally, the SW Cabinet should be installed in a **readily accessible location** (not in a storeroom), where ventilation from left to right is unobstructed, to provide adequate cooling.



# AC IN and OUT Connections

All of things cost money and take added effort, but compare the cost of the electrical work to the cost of the medical equipment we are trying to protect.



# DC Connections



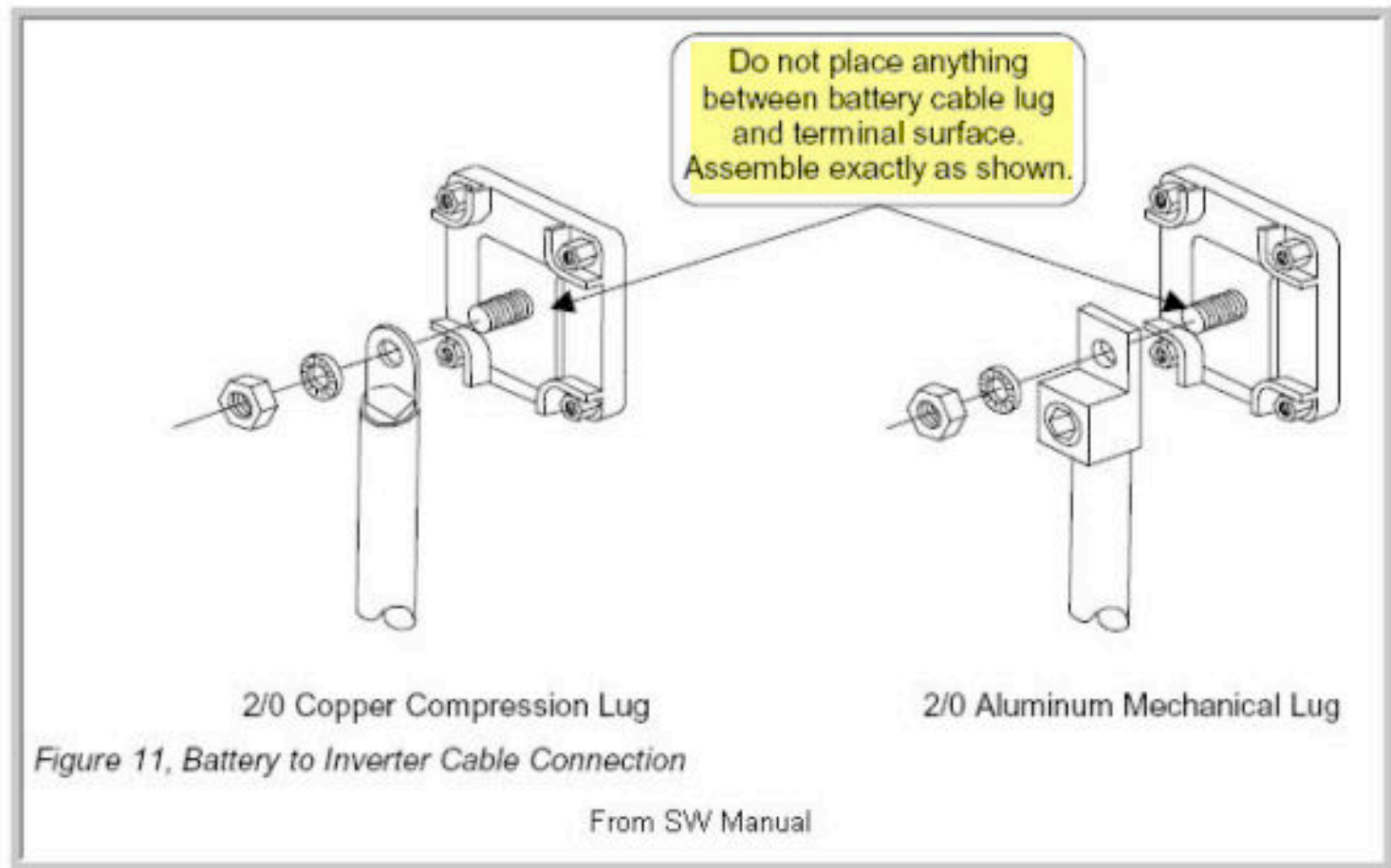
# DC Connections

Discussion topics here will include:

- Proper DC Cable connections to the SW Cabinet;
- Overcurrent / Disconnecting means in the DC Input cables;
- Connecting **Strings** of Batteries; and
- **Paralleling the Strings** of Batteries.



# Connecting the DC Cables to the Inverter



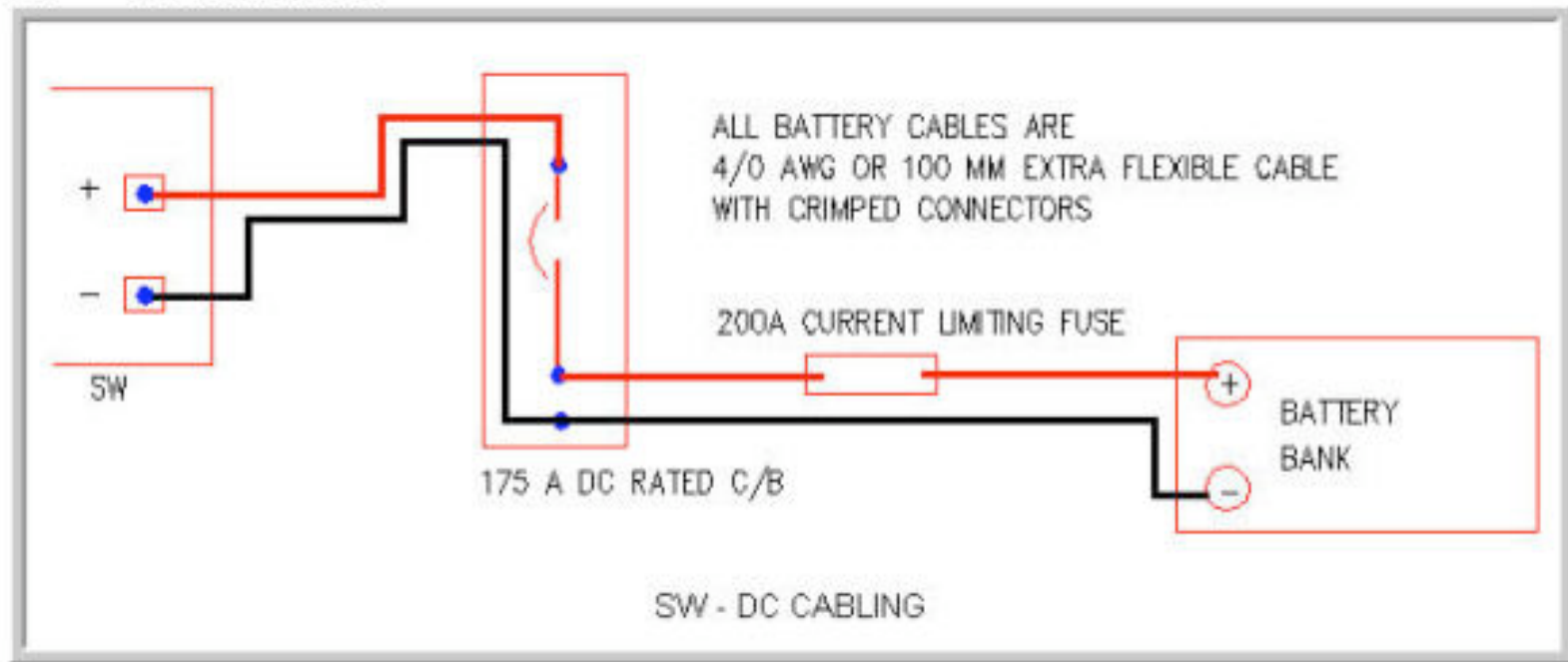
# Polarity

IT IS EXTREMELY IMPORTANT THAT **POLARITY IS NOT REVERSED** AT THESE TERMINALS. THIS IS ONE OF THE FEW CONDITIONS THAT IS NOT PROTECTED WITH INTERNAL PROTECTION ON THE SW EQUIPMENT. IF BATTERY POWER IS APPLIED AT THESE TERMINALS WITH REVERSE POLARITY, BESIDES PHYSICAL DAMAGE, MOST OF THE INTERNAL POWER TRANSISTORS WILL BE DESTROYED RESULTING IN **NON-WARRANTY DAMAGE** AND THE UNIT WILL HAVE TO RETURNED FOR EXPENSIVE REPAIRS.



# DC Cable – from Battery to Inverter

## 7.9 DC CABLING





# Battery Cable Sizing (use 4/0)

Table 2, Minimum Recommended Battery Cable Size vs. Cable Length

INVERTER MODEL	TYPICAL DC AMPS <sup>1</sup>	NEC AMPS <sup>2</sup>	1 TO 3 FEET ONE WAY	3 TO 5 FT ONE WAY	5 TO 10 FT ONE WAY
SW2512	267 Amps	334 Amps	#4/0 AWG/107 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>	Not Recommended
SW2612E	278 Amps	348 Amps	#4/0 AWG/107 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>	Not Recommended
SW3024E or J	160 Amps	201 Amps	#4/0 AWG/107 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>
SW4024 or W, K	214 Amps	267 Amps	#4/0 AWG/107 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>
SW3048E or J	80 Amps	100 Amps	#2/0 AWG/67.4 mm <sup>2</sup>	#2/0 AWG/67.4 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>
SW4048 or K	107 Amps	134 Amps	#2/0 AWG/67.4 mm <sup>2</sup>	#2/0 AWG/67.4 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>
SW4548E or A	120 Amps	150 Amps	#2/0 AWG/67.4 mm <sup>2</sup>	#2/0 AWG/67.4 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>
SW5548	147 Amps	184 Amps	#4/0 AWG/107 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>	#4/0 AWG/107 mm <sup>2</sup>

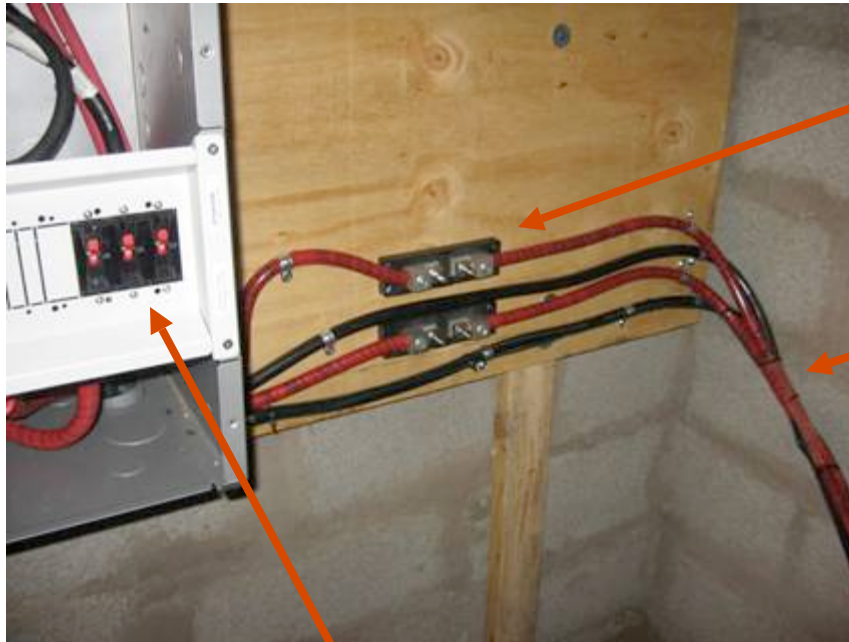
<sup>1</sup> TYPICAL DC AMPS is based on Low Battery Voltage with an efficiency of 85%.

<sup>2</sup> NEC AMPS is based on Low Battery Voltage, an efficiency of 85%, and a 125% NEC de-rating.



**WARNING!** Battery cables that are too small will melt and burn the first time the inverter is operated at high power levels.

# DC Cable – from Battery to Inverter



Current Limiting Fuses in Positive Cables (4/0)

Positive and Negative Cables kept together.

DC Circuit Breakers in positive feed to individual inverters.

System shown is Outback

# Series Connections



Sometimes the series connections are made with copper bus bars.

These are 2V batteries, in sets of 24 in series

# Series Connections

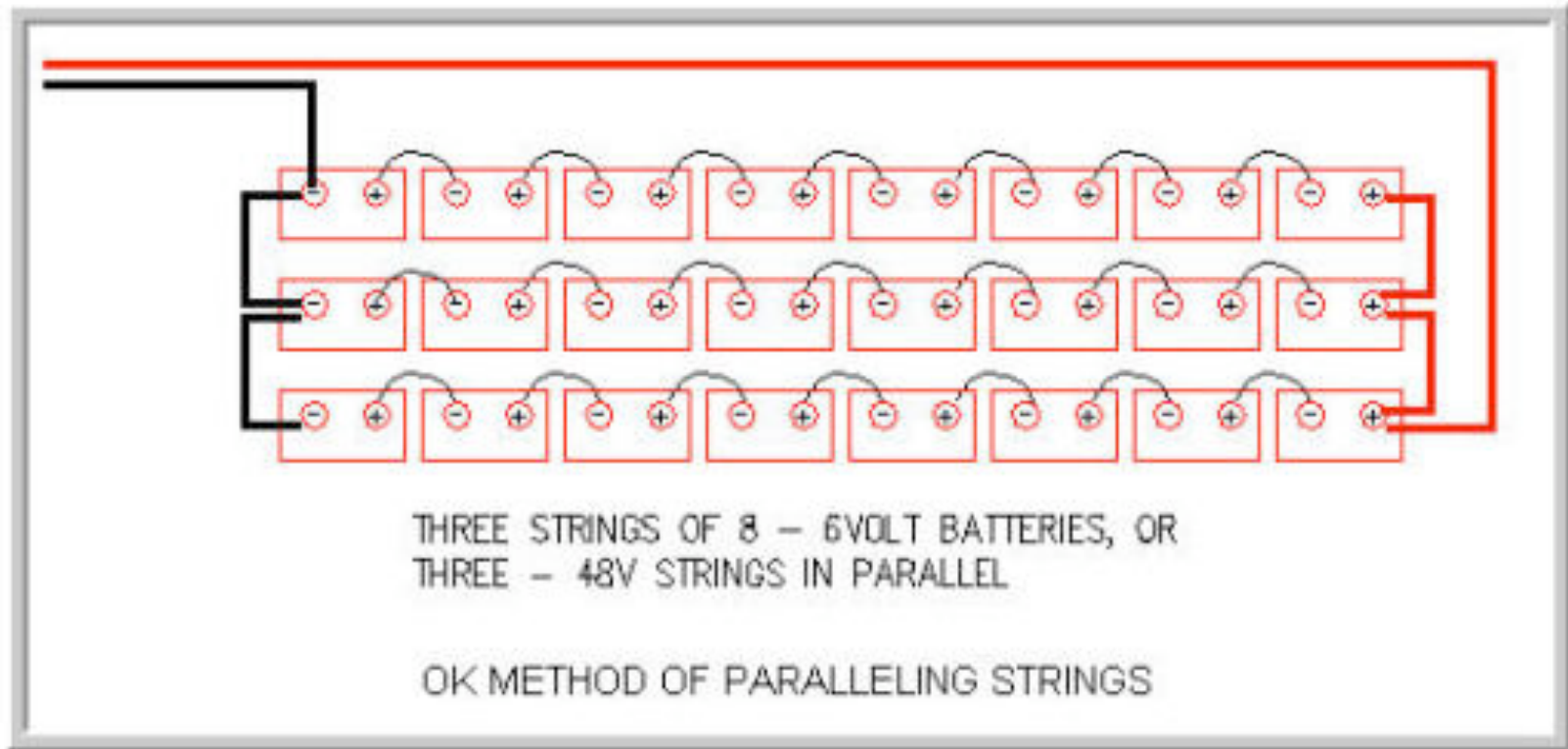


More often, series connections are made with cables.

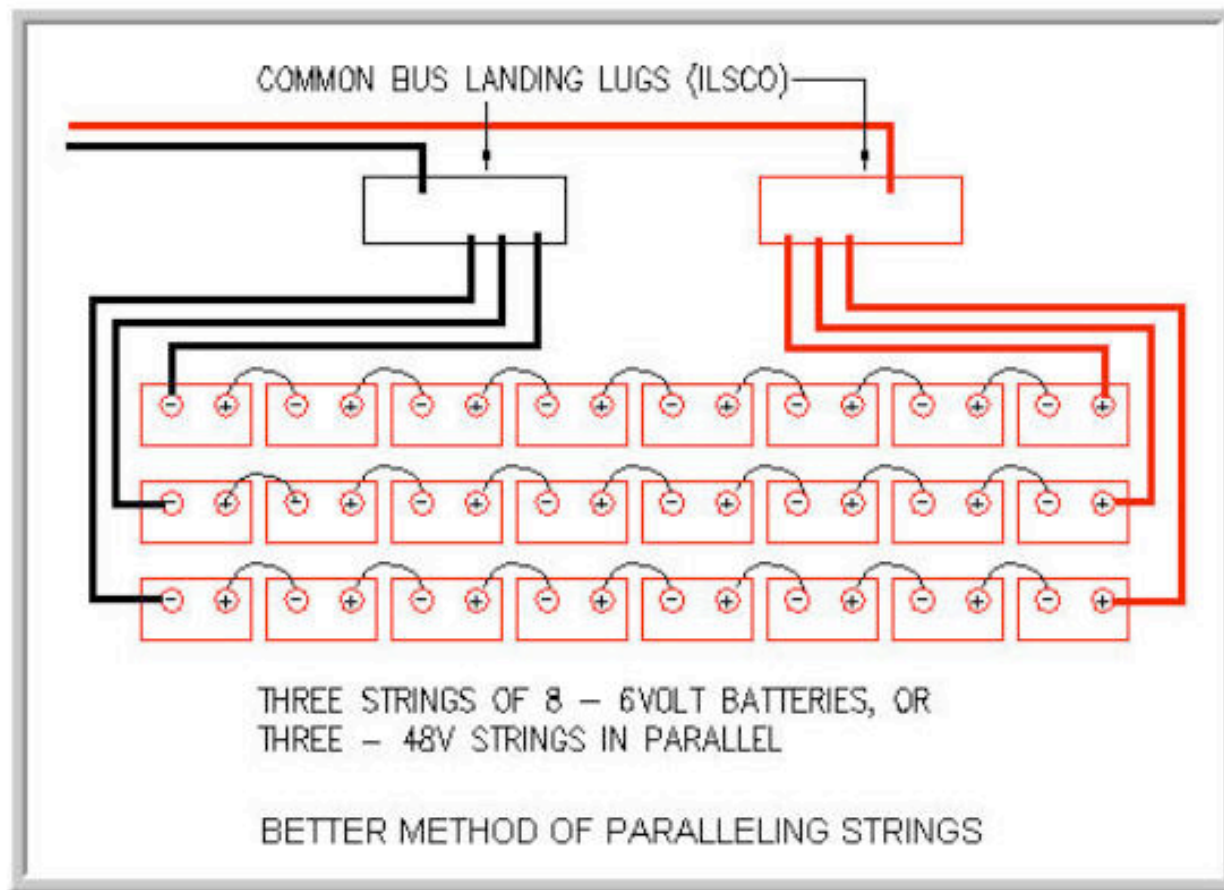
These are 12V Batteries – in sets of 4 in series



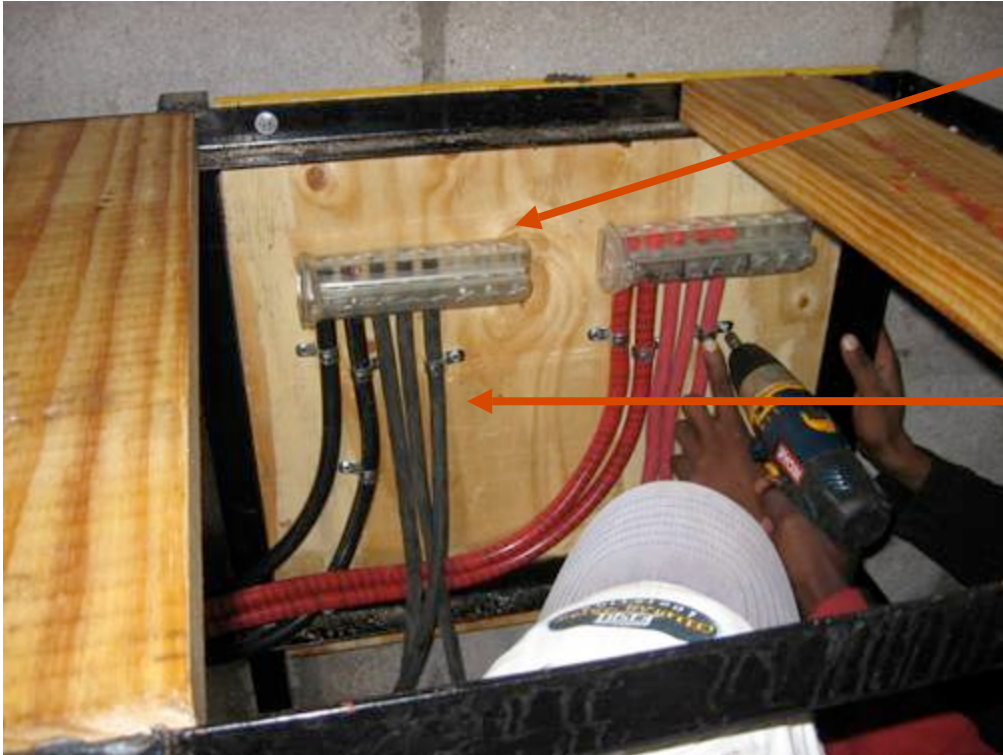
# Connecting Batteries



# Connecting Batteries



# Paralleling Batteries



“ILSCO” common bus terminal blocks for 4/0 cables

4 Strings of 48VDC batteries connected in parallel, and 2 home run cables back to cabinet.

# Keep the Battery Cables Together

- We need to always keep the positive and negative battery cables together, as long as possible. As battery cables are separated by a distance, they have much more **inductance** than if they are close together. This induction creates an induced current which opposes the applied current. This leads directly to loss of inverter performance and greatly reduced efficiency. With cables separated by 48", the inductance can be **3 times greater** than the inductance recognized if the cables are together.
- The result can be as dramatic as the inverter **failing to allow certain loads to start**, because it can not get the required current to flow in the batteries. This has been seen in cases where installers have done a very neat job in the installation but have grouped all positive cables on one side of a wall, and the negative cables on the other side.





# Sum-UP

- We have Covered
- Elements of the Inverter / Battery System
- Connections to the Real World
  - AC OUT Connections
  - AC IN Connections
  - DC Connections
- Still to come:
  - Programming
  - Operations and Maintenance
  - Troubleshooting

