Solar/Back-Up Power for Field Day

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NØUXR

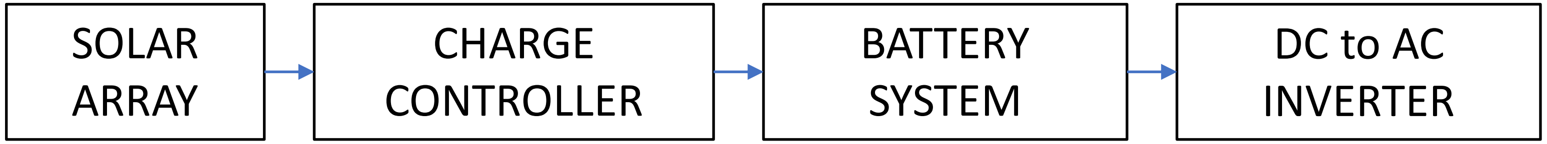
Goal: Reliable Power for Field Day – Day & Night

What are the Power Requirements for the Station

- **Radio Transceiver** – Typically radios are DC but depending on the radio transmit power this component can make up the largest part of the station's power requirements. Best to leave the linear amp at home and stay with the standard 100 watt transceiver. In our design a TS-570D was used as the station radio which requires 20.5 amperes at 13.8 volts in transmit mode. That's 283 watts of DC power. Hopefully the club won't have the "key" down 100% of the time. The radio receive mode only requires 13 watts.
- **Lights** – It would be nice to have some lighting if the club plans on operating a 24 hour shift. LED lights are the only way to go!
- **Laptop** – You can't have Field Day without a computer and a wireless card for internet access. A good thing about laptops is they have their own battery. Just need to keep them charged.
- **Fan** – Field Day is in June and unless you are in Alaska the crew's going to need some air movement in an outdoor environment. Inside an air conditioned building would be nice but we're going for a few extra points by running on emergency power and there's no room for refrigerated air in our 2 day power budget. A fan will have to do!

We'll go through the design process for each section of the emergency solar power system. There's a specific order we must follow. Step 1 will feed into Step 2 etc. First, let's look at a system diagram of a emergency solar power back-up system to understand the various parts. Secondly we will dive into each design step and finish with a completed system. Then the fun part comes: ordering equipment and building the system so you can operate it safely.

Solar Emergency Power Back Up System Block Diagram



SOLAR ARRAY	CHARGE CONTROLLER	BATTERY SYSTEM	DC to AC INVERTER
Converts sunlight into DC electrical power	Takes the DC power from the solar array and correctly applies to the battery system to charge but not damage	The battery system is a power source and a storage system	The inverter will transform DC power into AC power acceptable for most AC based devices

NEVER POWER A DC DEVICE, LIKE OUR RADIO, DIRECTLY FROM A SOLAR ARRAY!!!!

STEP 1: Determine the load requirements (both AC & DC) and device usage time. Pick your inverter based upon the AC power requirements.

Load Calculations					
	Voltage (V)	**Current (A)**	**Duty Cycle**	**Watts DC**	**Watts AC**
Radio Transceiver (Transmit)	13.8	20.5	35%	99.0	
Radio Transceiver (Receive)	13.8	0.95	65%	8.5	
Computer	19.5	4.62	15%		13.5
Fan	120	0.45	100%		54
Phone Charger	5	1	50%		2.5
3-LED Lights	120	0.27	75%		24.3
Total Wattage (Load)				107.5	94.3
Inverter Calculations					
Load Supported (AC Watts only)					94.3
Inverter Efficiency			89%		
Inverter Minimum Rating					106.0
Inverter Upsize Rule of Thumb - Provides margin			2	211.9	
Inverter DC Input Voltage & Current	13.8	15.4		**Choice 300 watt 12 V Pure Sine Wave Inverter**	
Inverter Maximum Load %			71%	Good inverter load. Never design to 100% load	

STEP 2: Perform battery system design to determine number of batteries needed to meet night-time power requirements.

Battery Calculations

Battery choice is 12V allowing radio to run directly from battery but design must never allow discharge of batteries lower than 80%

A battery voltage of 11.8 volts indicates the battery is 80% discharged

A battery rated at 12 volts will measure 13.0 volts when fully charged

The battery system MUST support both the DC and AC loads (seen at the batteries as the inverter) over a 24 hour period

Design assumes 8 hours of FULL sunlight & 16 hours of low or no light

Calculate battery requirements based upon 16 hours of low or no light

Constant Current Discharge Characteristics: A (25°C)

F.V/Time	5MIN	10MIN	15MIN	30MIN	1HR	2HR	3HR	4HR	5HR	8HR	10HR	20HR
9.60V	393.3	289.5	213.7	125.0	71.50	43.61	29.42	24.46	19.49	14.07	11.45	6.091
10.0V	381.9	275.5	209.3	122.9	70.07	43.29	29.19	24.35	19.37	13.95	11.33	5.978
10.2V	370.6	265.8	206.0	120.6	68.31	42.96	28.64	24.23	19.25	13.84	11.22	5.864
10.5V	332.8	245.2	196.1	119.7	66.88	42.63	27.97	24.01	19.01	13.72	11.11	5.750
10.8V	300.3	223.6	180.8	117.7	64.90	41.87	27.51	23.44	18.86	13.49	11.01	5.692
11.1V	256.5	199.9	162.2	110.2	62.59	40.01	27.04	22.31	18.39	12.92	10.88	5.461
11.8 V											10.00	5.00

7.0 A

Interpolate battery data specifications for the current one battery will deliver for 16 hours and be discharged no more than 80%.

Load requirement during 16 hours of low or no light conditions.

	Voltage (V)	Current (A)		Watts DC	Watts DC (from inverter)
	13.8	15.5		107.5	106.0
From the battery data spec sheet, one battery can supply		7			
Total number of batteries in parallel		**3**			
Battery set can deliver our current requirements for 16 hrs		21			

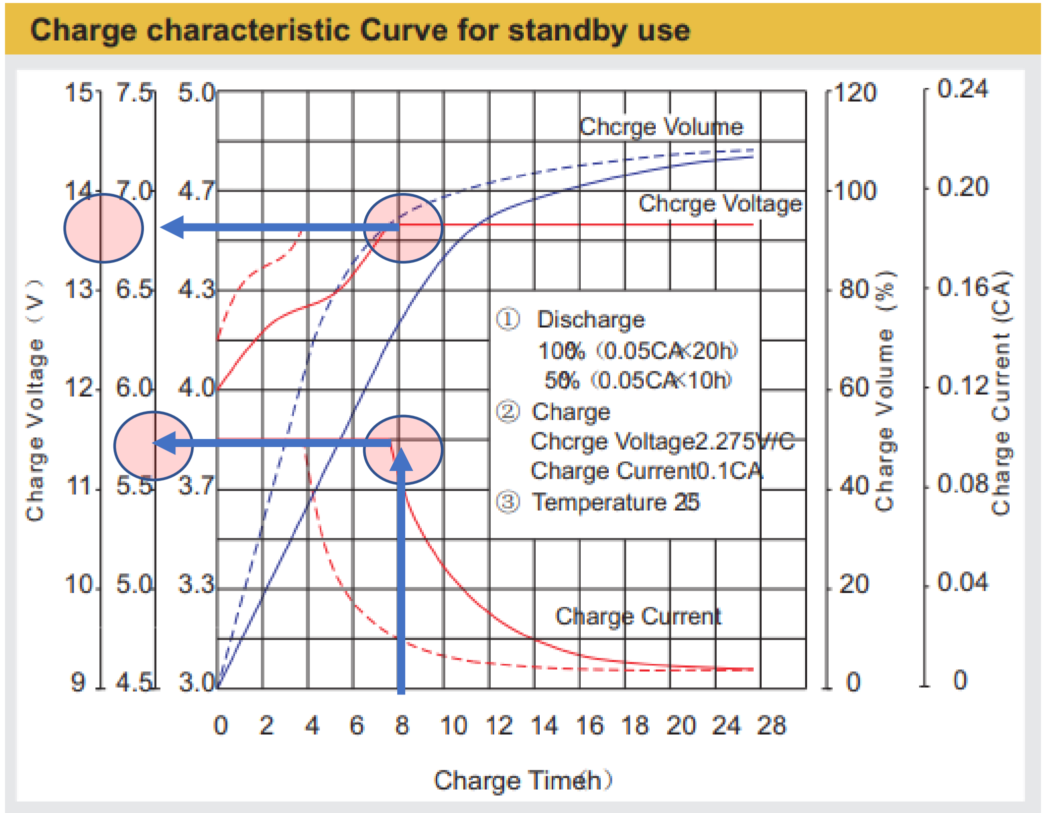
Solar Panel Calculations

The array of panels must support operations during the 8 hour of full sunlight for the equipment load AND enough power to recharge batteries.

We know what the load is that must be supported during daylight from the Load Calculations

	Voltage (V)	Current (A)	Watts DC	Watts DC (from inverter)
	13.8	15.5	107.5	106.0

From battery data sheet we must determine the charge current necessary to fully recharge batteries in 8 hours



	Current (A)
One battery can be fully charged in 8 hours at	5.8
Batteries required in this application	3
Requirement for 8 hour recharge of batteries set is	17.4

The solar array MUST simulataneously supply enough power, through a charge controller, to recharge batteries and power station equipment during the 8 daylight hours.

Panels must supply this much current	**32.9**

STEP 3a: Perform solar array calculation to determine the amperage required to run back-up system at night & day **PLUS** recharge the batteries during the day!

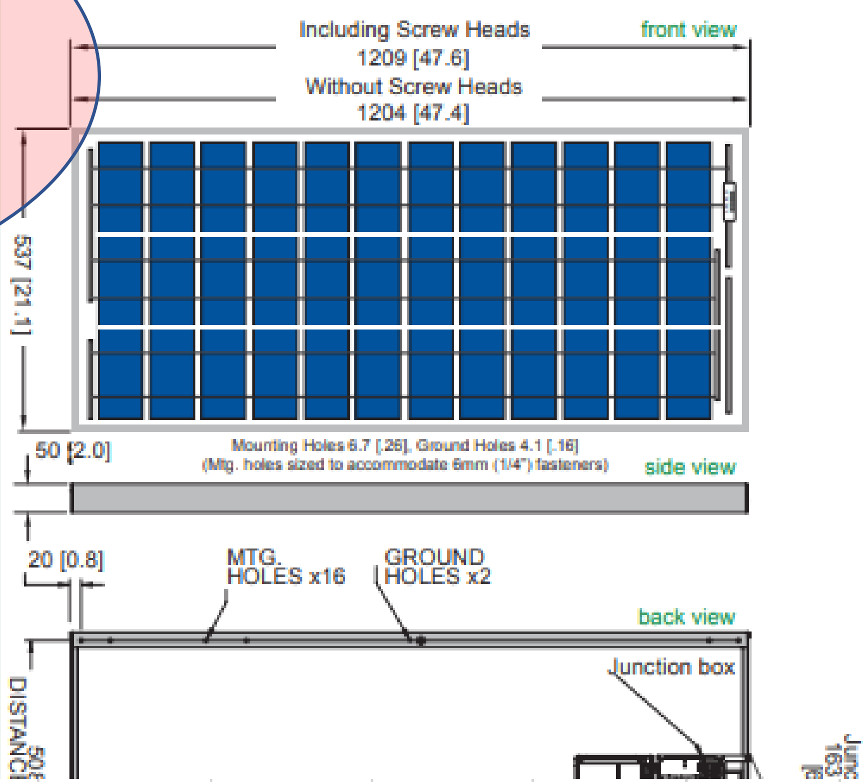
STEP 3b: Once the array amperage is determined, select the panel type that fits the system voltage and will supply the required amperage.

90W PHOTOVOLTAIC MODULES - 90J

Electrical characteristics

	(1) STC 1000W/m²	(2) NOCT 800W/m²
Maximum power (P_{max})	90W	65W
Voltage at P_{max} (V_{mpp})	17.9V	15.9V
Current at P_{max} (I_{mpp})	5.03A	4.0A
Short circuit current (I_{sc})	5.21A	4.2A
Open circuit voltage (V_{oc})	22.1V	20.1V
Module efficiency	13.1% / 13.9%	
Tolerance (P_{max})	+10% / -5%	
Nominal voltage	12V	
Efficiency reduction at 200W/m²	<5% reduction (efficiency 13.2%)	
Limiting reverse current	5.58A	
Temperature coefficient of I_{sc}	0.105%/°C	
Temperature coefficient of V_{oc}	-0.360%/°C	
Temperature coefficient of (P_{max})	-0.45%/°C	
(3) NOCT	47±2°C	
Maximum series fuse rating	20A	
Application class (according to IEC 61730:2007)	Class C	
Maximum system voltage	600V (U.S. NEC) / 1000V (IEC 61730:2007)	

1: Values at Standard Test Conditions (STC): 1000W/m² irradiance, AM1.5 solar spectrum and 25°C module temperature
2: Values at 800W/m² irradiance, Nominal Operation Cell Temperature (NOCT) and AM1.5 solar spectrum
3: Nominal Operation Cell Temperature: Module operation temperature at 800W/m² irradiance, 20°C air temperature, 1m/s wind speed



	Voltage (Vmpp)	Current (Impp)
A single panel in full sunlight will deliver	17.9	5.03
Number of panels required		**7**

Charge Controller Calculations		
	Voltage (V)	Current (A)
Charge Controlller Current Requirements		**35.2**
Choice is TriStar-45 Charge Controller		

STEP 4: Select your charge controller that will support the maximum solar array amperage expected.

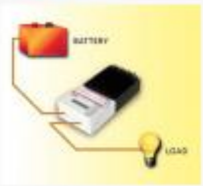
MORNINGSTAR
PROFESSIONAL SERIES
World's Leading Solar Controllers & Inverters

Technical Specifications

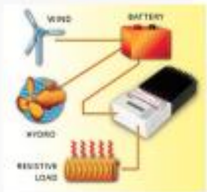
Versions	TrStar-45, TriStar-60 and TriStar-60M
Electrical	
Rated solar, load or diversion current	TriStar-45 45A TriStar-60 60A TriStar-60M 60A
System Voltage	12, 24, 48V
Accuracy	12/24V ≤0.1% ±50mV 48V ≤0.1% ±100mV
Minimum voltage to operate	9V
Maximum solar voltage (Voc)	125V
Self-consumption	
Controller	<20mA
Meter	7.5mA
Mechanical	
Dimensions	Height: 26.0cm/10.3 in Width: 12.7cm/5.0 in Depth: 7.1cm/2.8 in
Weight	1.6kg/3.5lb
Largest Wire	35mm²/2 AWG
Conduit knockouts	Eccentric 2.5/3.2 cm (1.0/1.25 in)
Enclosure	Type 1, indoor rated

Charge Control 1

Load Control 2



Diversion Control 3



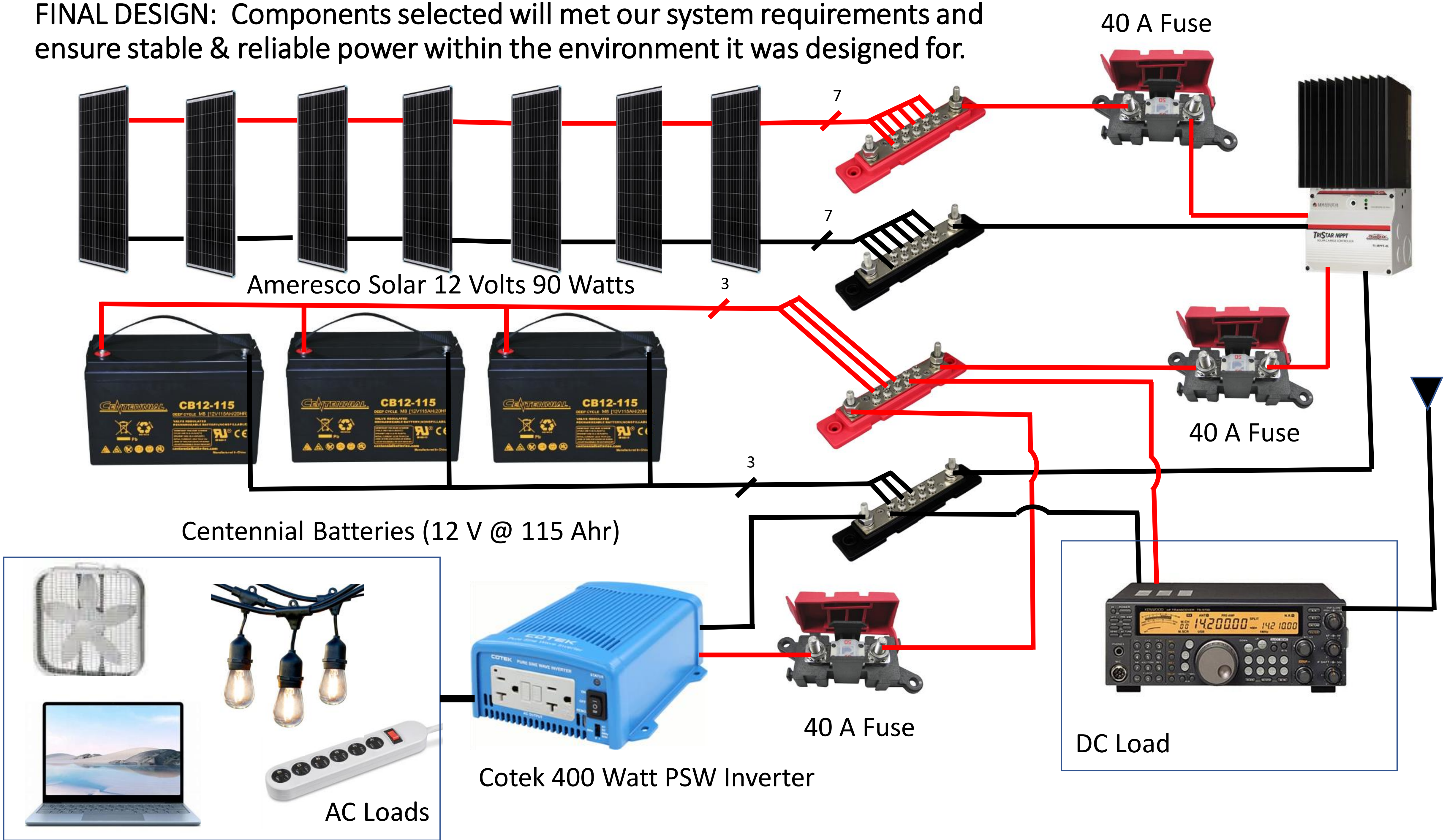
1
- Constant voltage series PWM design to provide highly efficient battery charging
- 4-stage charging to increase battery capacity and life: bulk charge, PWM regulation, float and equalize
- Parallel for larger solar arrays up to 300 amps or more

2
- Starts large loads including motors and pumps with no damage to controller
- Allows inrush current to 300 amps
- Electronic short-circuit and overload protection with automatic reconnect
- LVD is current compensated and has a delay to avoid false disconnects

3
- May be used for solar, wind or hydroelectric
- To protect against battery overcharge, excess energy is diverted from the battery to an alternate DC resistive load
- PWM reduces power into diversion load during overcurrent conditions

Options

FINAL DESIGN: Components selected will met our system requirements and ensure stable & reliable power within the environment it was designed for.



Questions?