



SOLAR 2025

Design and Implementation

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PURPOSE

- Purpose – Design a hybrid electric system that allows for self sufficiency and continues operation of household, office, and workshop.
 - Must leverage Utility Power, Solar Power, and Generator to make the best of all 3.
 - Reduce monthly electric bill to “manageable sum”.
 - Make it easy to service and have as easy to install as possible.
 - Make sure uptime is as high as possible.
 - Lack of power can equal severe problems for life and work
-

MOTIVATIONS

- Power Reliability
 - Power failure in sub-freezing for a week, almost took me out
 - To work I need power and electricity
 - Almost monthly failures in algood.
 - 6 Hours this month and counting.
 - Power Cost - \$250-300 a month is not a great price, and its going higher
 - Generator is noisy, and Natural Gas/Propane are not cheap.
-

SIZE. - VERY DIFFERENT NEEDS

- Systems can be as small as 100Watts to 100's of kilowatts
 - Target for our discussion is “whole-house”, with a modern house
 - Min is 16KW, with the system being 32KW, and ease of expansion to 48KW
 - Assumes a 200Amp utility service
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MODULES

- Module
 - Module 1 – Issues, Theories, and Problems
 - Module 2 – Physical Plant/Design Implementation
 - Module 3 – Electrical, Settings

MODULE 1 – ISSUES, THEORIES, AND PROBLEMS

- Issues
 - Theories
 - Problems
-

MODULE 1 - ISSUES

- Knowledge in the local community
 - Electricians just refusing to accept project – Not Done That
 - Contractors having no clue
 - Cheating/Scalping
 - Companies that are “selling” solar with no battery
 - No definition of what you’re getting
 - And not getting much
 - Cross Trades Issues
 - Roof Guys don’t want it, “Invalidate warranty”, when there is no penetrations.
-

MODULE 1 - ISSUES

- Cross Trades Issues
 - Roof Guys don't want it, "Invalidate warranty", when there is no penetrations.
 - Complexity Issues
 - Number of additional Boxes
 - Torque Issues
 - System Compatibilities
 - AC Coupled – DC Coupled
 - Compliance
 - Building code differences
 - HOA
-

THEORIES

- System Types
 - AC Coupled / DC Coupled
 - Grid Connected / Off-Grid / Hybrid
 - Solar Panels – Types – Connections – Standards
 - Mounts
 - Safety
 - Inverters – Types and Kinds
 - Batteries – Types and Kinds
 - Meter to Inverter "Accessories"
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SYSTEM TYPES

- AC Coupled
 - DC Coupled
 - GRID Connected
 - OFF-GRID
 - HYBRID
-

SYSTEM TYPES – AC COUPLED

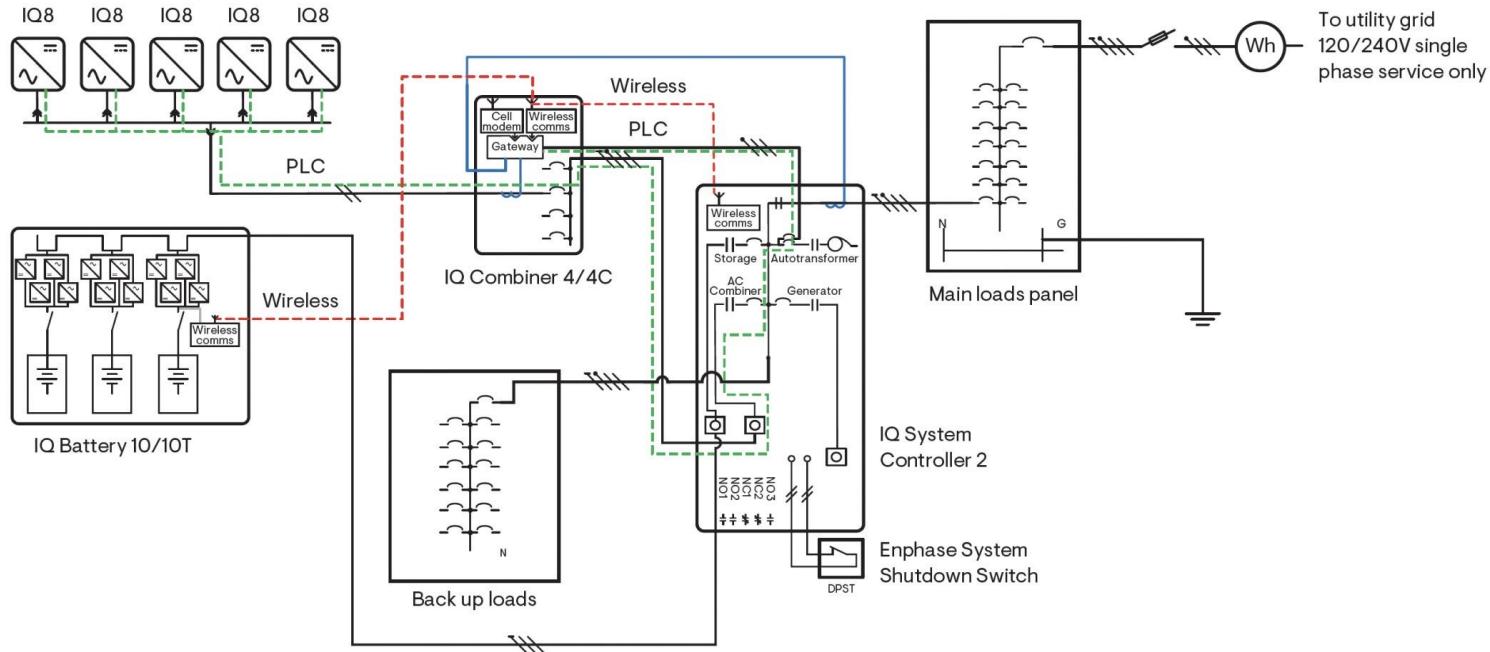
- What Is IT:
 - What if everything is AC – 110-120V AC
 - OOPS: Solar panels are DC
 - So How:
 - Microinverters
 - MOST FAMOUS Brands
 - TESLA Power Wall
 - ENPHASE
-

AC COUPLED – WHAT IS A MICRO-INVERTER

- A microinverter is a small device that changes direct current (DC) electricity from solar panels into alternating current (AC) electricity
- Microinverters are installed on individual solar panels
- They operate independently of other inverters in the system
- Each panel produces independently
- They can track performance of each panel in real-time
- AC is connected in “Parallel” in a micro-inverter system

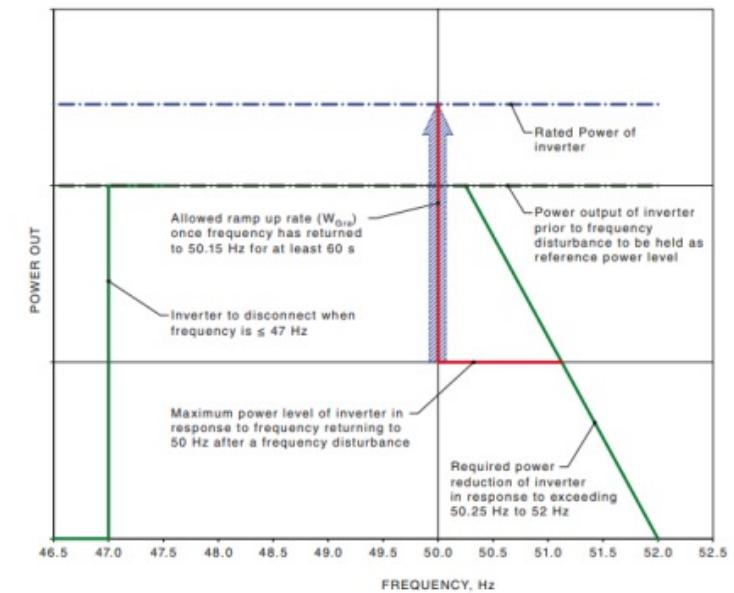


SYSTEM DIAGRAM

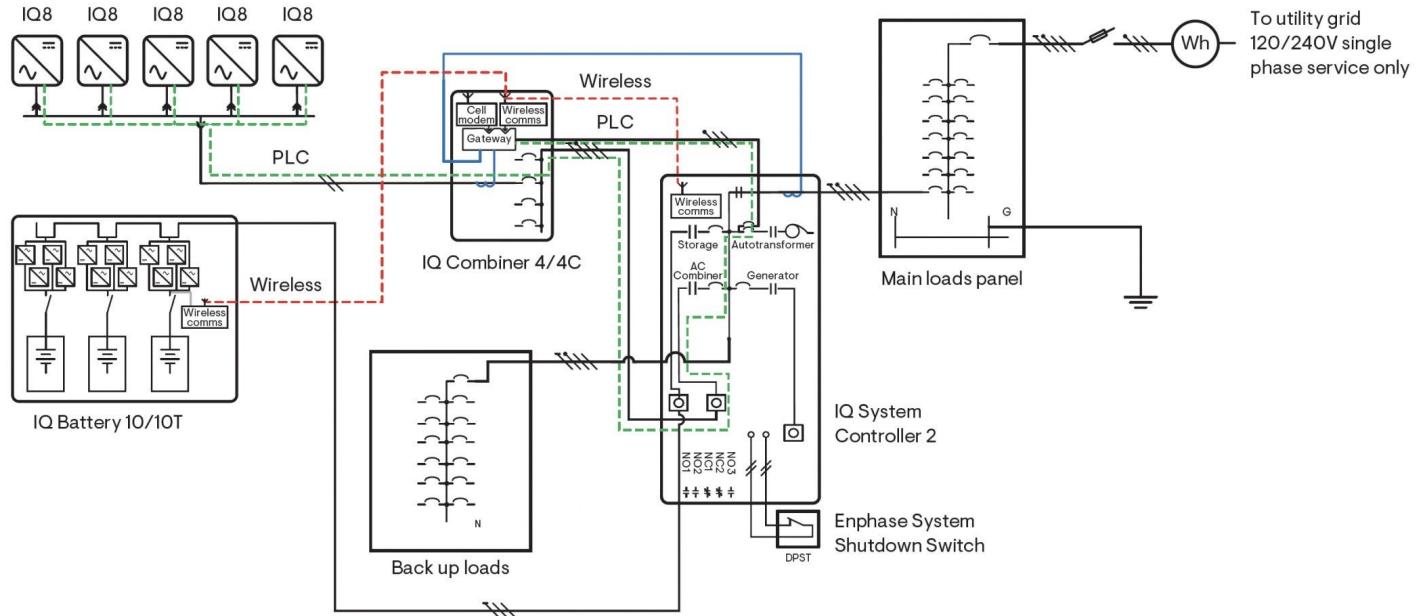


AC COUPLED

- Cross Vendor Compatibility
 - While there is standards – details become “analog” wave form issues,
 - AS4777.2
 - Mixing and Matching gets to be difficult
- Batteries are DC!
 - Need inverters on top
- Need specific vendor training
- Need multiple vendor training to hope to mix and match



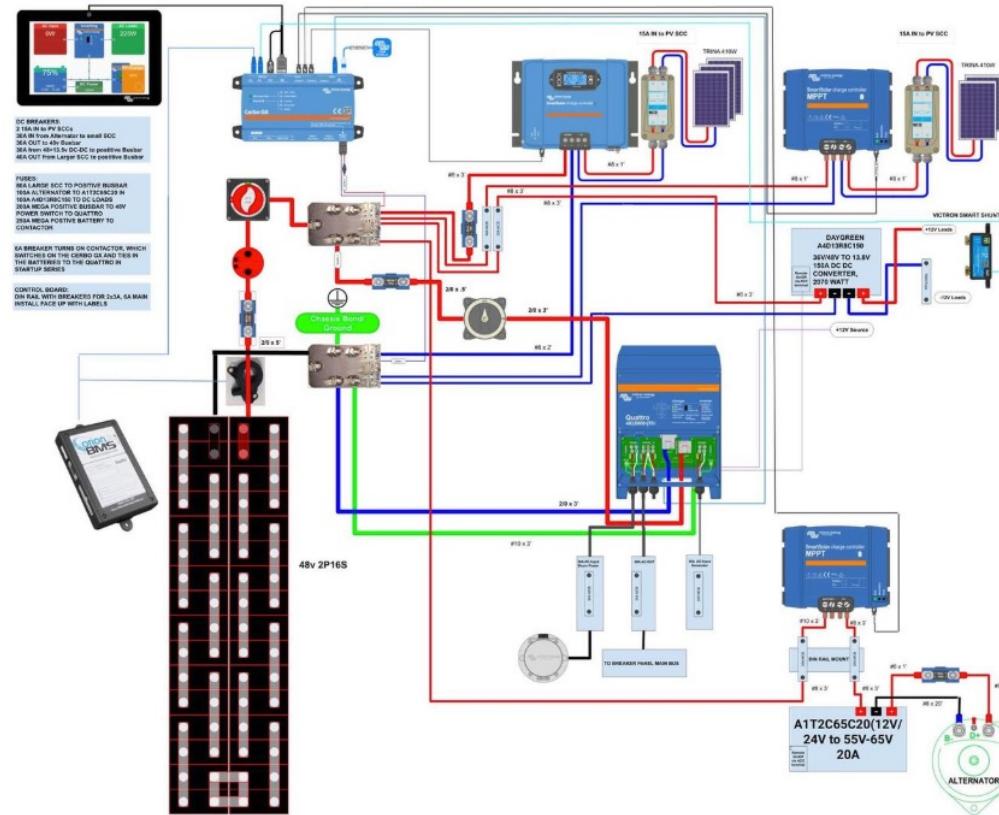
SYSTEM DIAGRAM – AC COUPLED



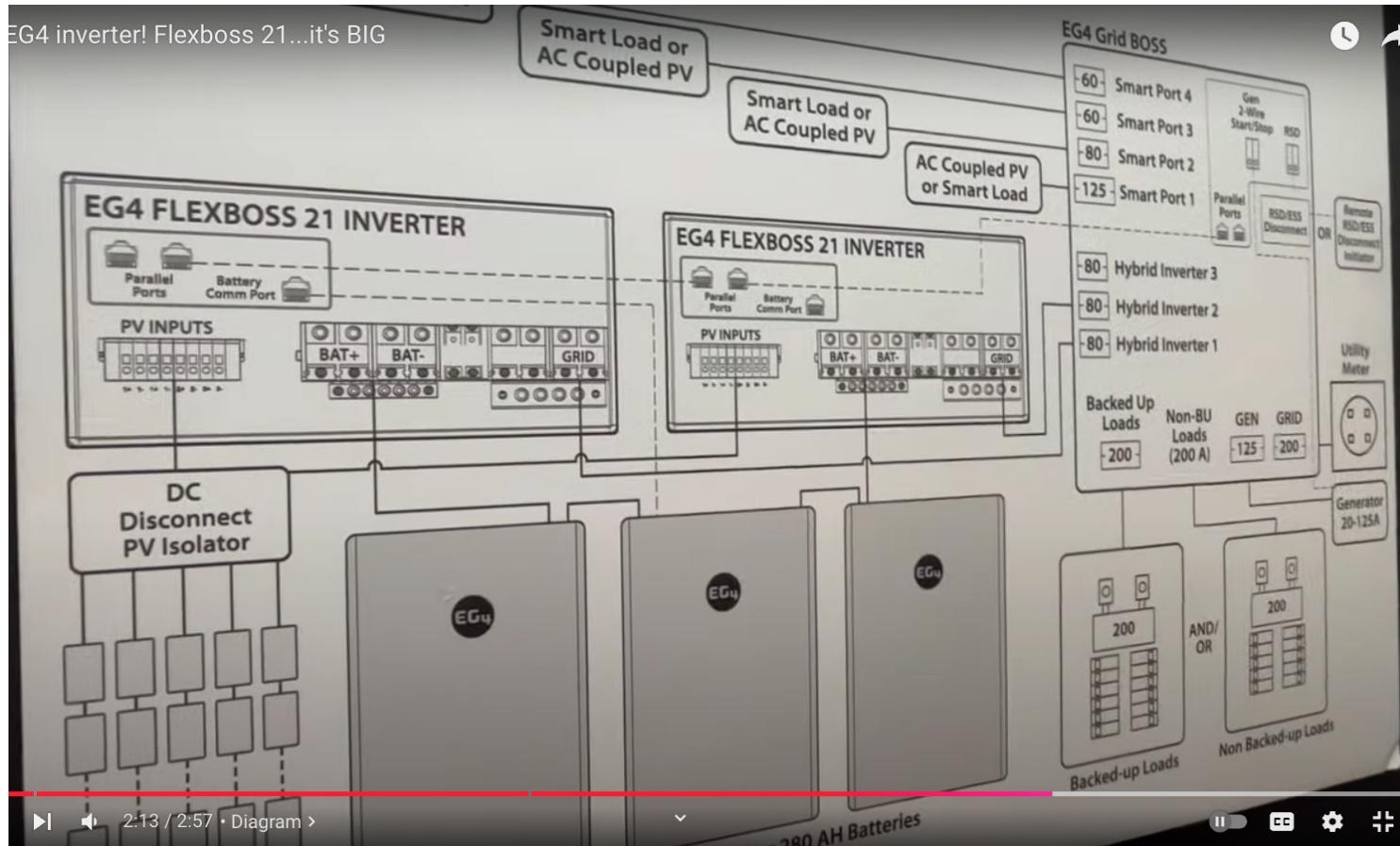
SYSTEM TYPES – DC COUPLED

- Traditional Solar Solution
 - Solar Panels are DC devices
 - Batteries are DC Devices
 - Components
 - Panels
 - Inverters
 - Batteries
 - Accessories and safety devices
 - Mix and Match
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EXAMPLE – OLD SCHOOL – BOX CENTRIC



EXAMPLE – NEW SCHOOL – ALL-IN-ONE

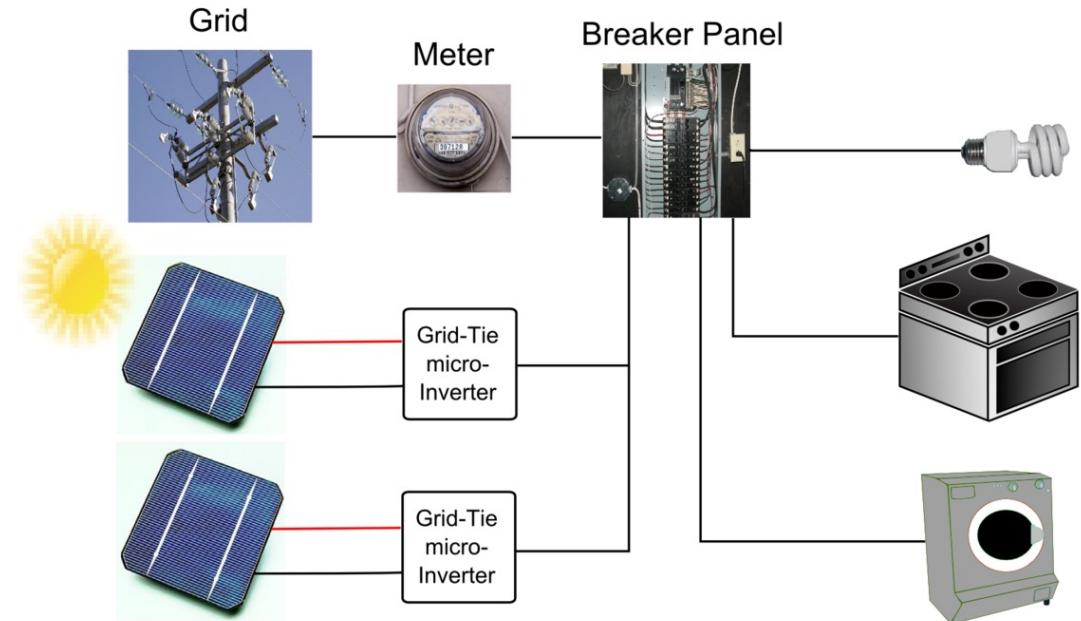


SYSTEM TYPES – GRID CONNECTED

- Definition: A grid-connected system allows you to power your home or small business with renewable energy during those periods (daily as well as seasonally) when the sun is shining, the water is running, or the wind is blowing. Any excess electricity you produce is fed back into the grid. When renewable resources are unavailable, electricity from the grid supplies your needs, eliminating the expense of electricity storage devices like batteries.
 - Power failure from Grid/Utility results in power failure to house
 - Most common grid connected are AC Coupled – Difficult to add batteries
 - Intense framework/regulation on grid connected – Power flow is bidirectional – Don't electrocute linemen
-

GRID CONNECTED COMPONENTS

- AC Coupled:
 - Panels
 - Micro-Inverters
 - Accessories and safety devices
 - Power on wrong side of breaker ☺
 - Utility Meter
- DC Coupled
 - Panels
 - Inverter
 - Accessories and Safety devices
 - Utility Meter

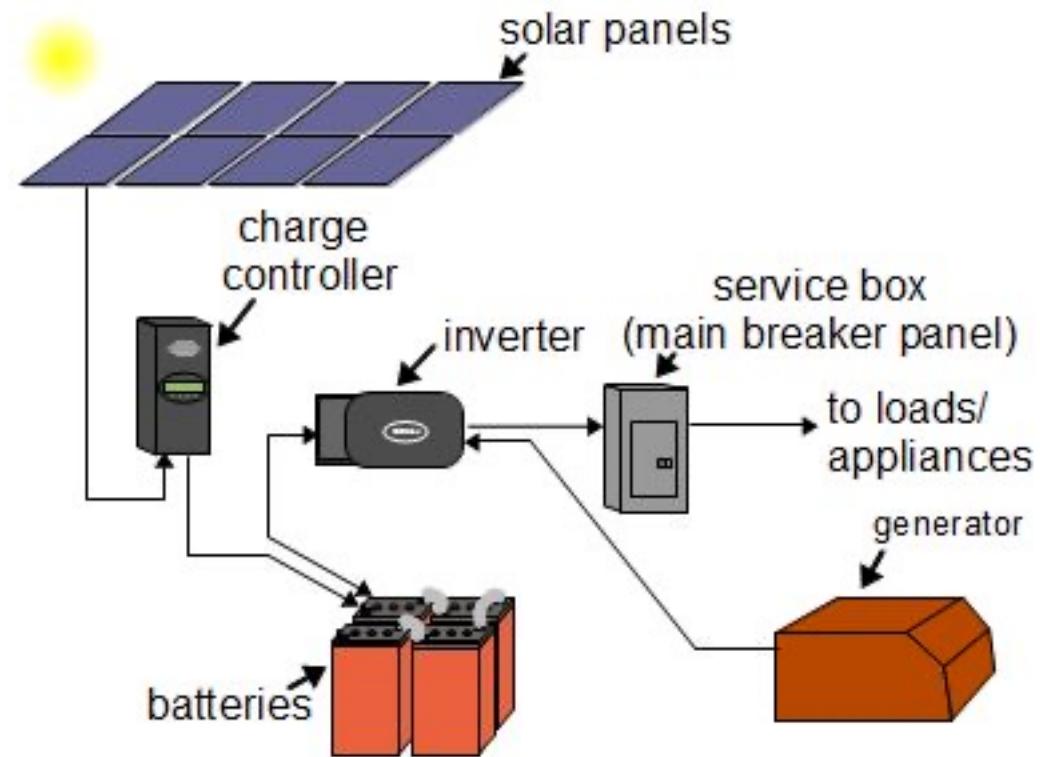


OFF-GRID SYSTEM

- Definition: Off-grid solar means a solar panel system is not connected to the utility grid. Instead, it generates electricity directly from the sun and stores it in batteries.
 - No grid is needed or included. No utility meter.
 - Batteries are required
 - Electricity anywhere there is sun – Alaska may get interesting in “winter”
 - Compared to grid connected:
 - Delete the meter
 - Add one or more batteries
-

SYSTEM TYPES – OFF-GRID COMPONENTS

- AC Coupled
 - Panels
 - Micro Inverters
 - Battery with inverters inside
 - Accessories and safety devices
- DC Coupled
 - Panels
 - Inverter
 - Battery
 - Accessories and safety devices



SYSTEM TYPES – HYBRID

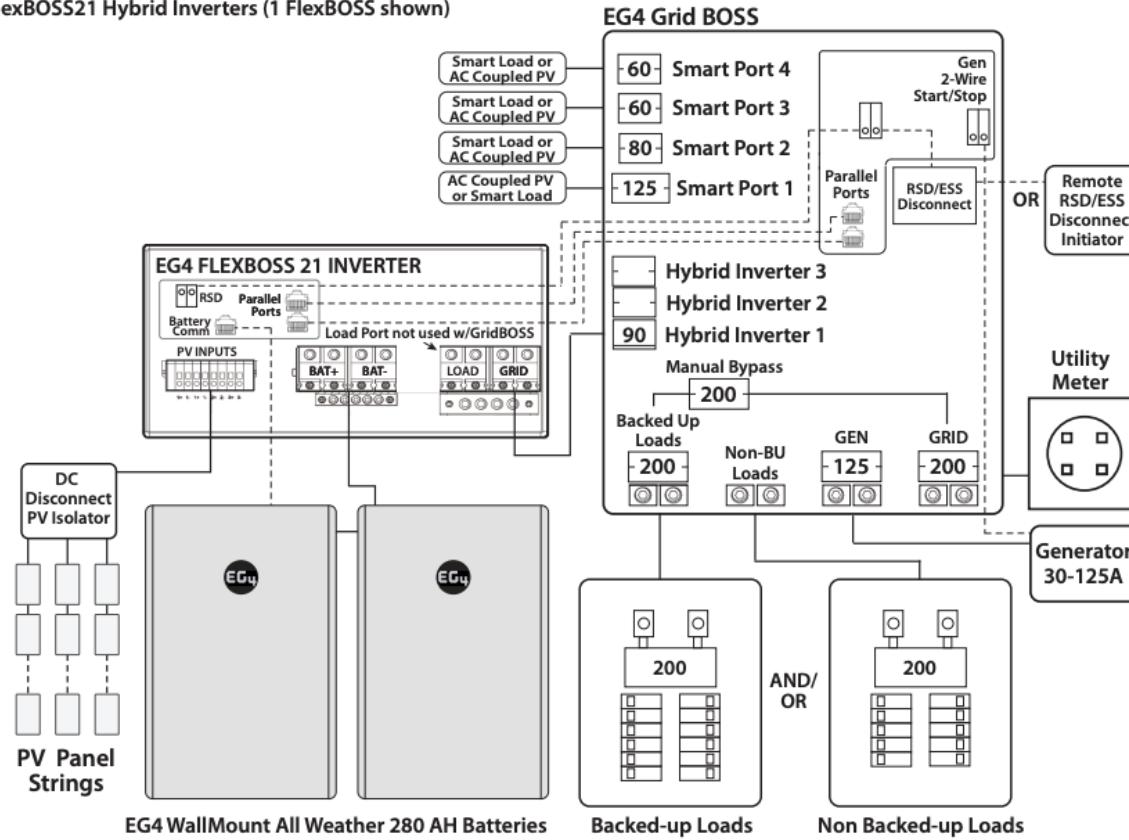
- Definition: A solar hybrid system is a renewable energy system that uses solar photovoltaic (PV) panels to generate clean energy to power your home. A hybrid solar system intelligently switches between using solar power, battery storage and grid power. It allows you to avoid using grid power at peak prices leading to bill savings.
 - Combines both on-grid and off-grid into one
 - Choices become software/settings driven
 - Export of power / grid connected is optional
 - Usage of grid can be selected with a variety of parameters
 - Select between solar, grid, and solar
 - UPS – Interruptible power
-

HYBRID SYSTEM COMPONENTS

- AC Coupled:
 - Panels
 - Micro-Inverters
 - Accessories and safety devices
 - Power on wrong side of breaker ☺
 - Utility Meter
 - Batteries
 - DC Coupled
 - Panels
 - Inverter
 - Accessories and Safety devices
 - Utility Meter
 - Batteries
-

HYBRID SYSTEM DIAGRAM

GridBOSS supports 1, 2, or 3 EG4 18kPV, 12kPV or FlexBOSS21 Hybrid Inverters (1 FlexBOSS shown)



SOLAR PANELS

- Solar panels have a array of solar cells
- Solar panels are measured in “watts”. - Volt x Amps here
- They go from 50 watts(Toy) to 700 watt plus
- History:
 - 2020 – First 600 Watt Introduced
 - 2020 20 Manufacturers are showing 600 watts
 - 2024 many manufacturers are offering 700 watts
 - Plans over two years is 800 Watts



SOLAR PANEL COST

- .0252/watt to 0.409/watt
- Pallet 12.30KW x 30 Panels = \$3,104.00
- Panels need a place to “live” – Mounting is a important part of cost
- Panels come in a variety of sizes
 - Above is 7ft x 3 1/3 ft x 1.3 in per panel

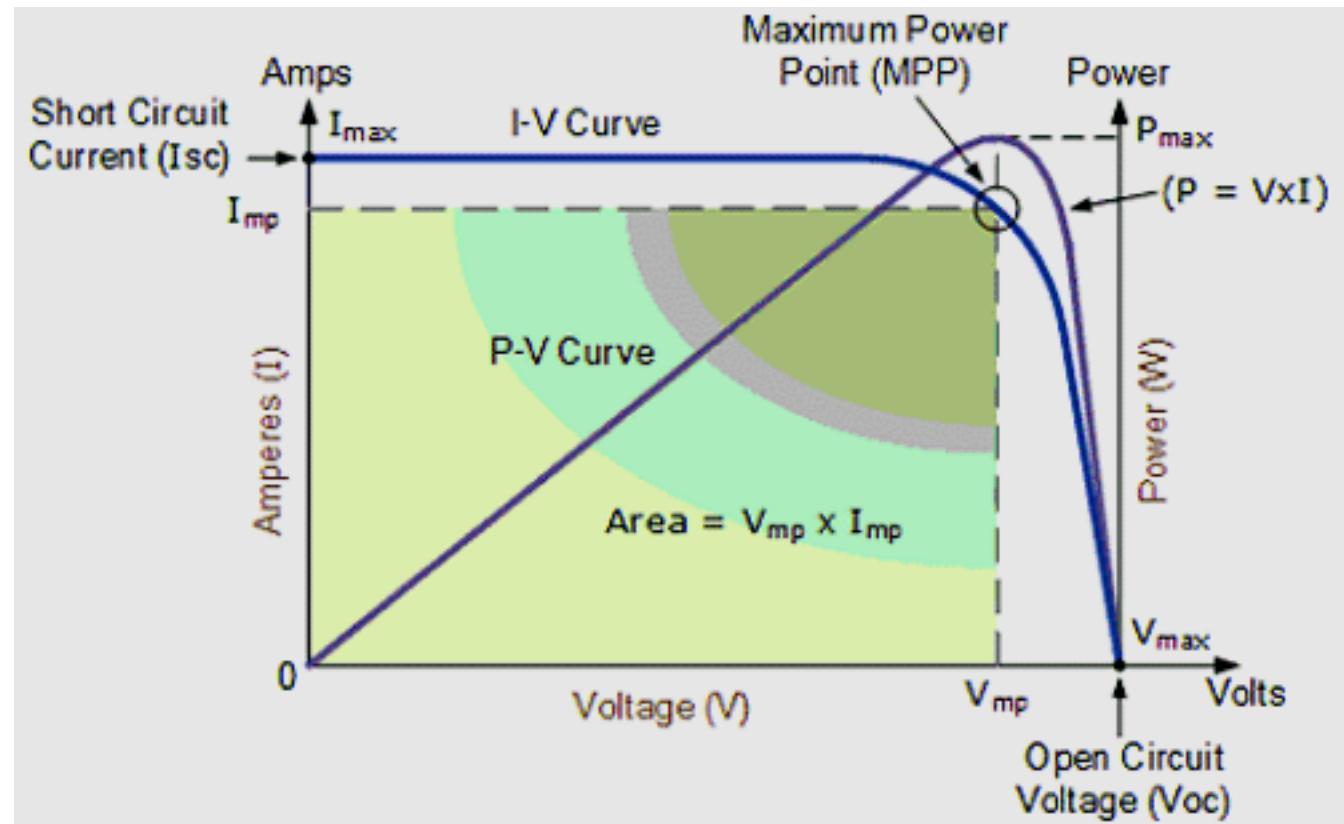


SOLAR PANELS – TYPES

- Bifacial – Take sun from both sides including reflections
 - Monocrystalline – Efficiency
 - Perc – Improved Monocrystalline.
 - Polycrystalline – Cheap and has problem with heat tolerance
 - Thin Film – Lightweight, flexibility on size, less efficient
 - Choice for our app:
 - Bifacial Perc
-

SOLAR PANEL – IMPORTANT VALUES

- Open-circuit voltage (V_{oc}) is the maximum voltage a solar panel can produce when there is no load connected to it. It's an important specification for solar panels.
- VOC is used while determining the number of solar panels

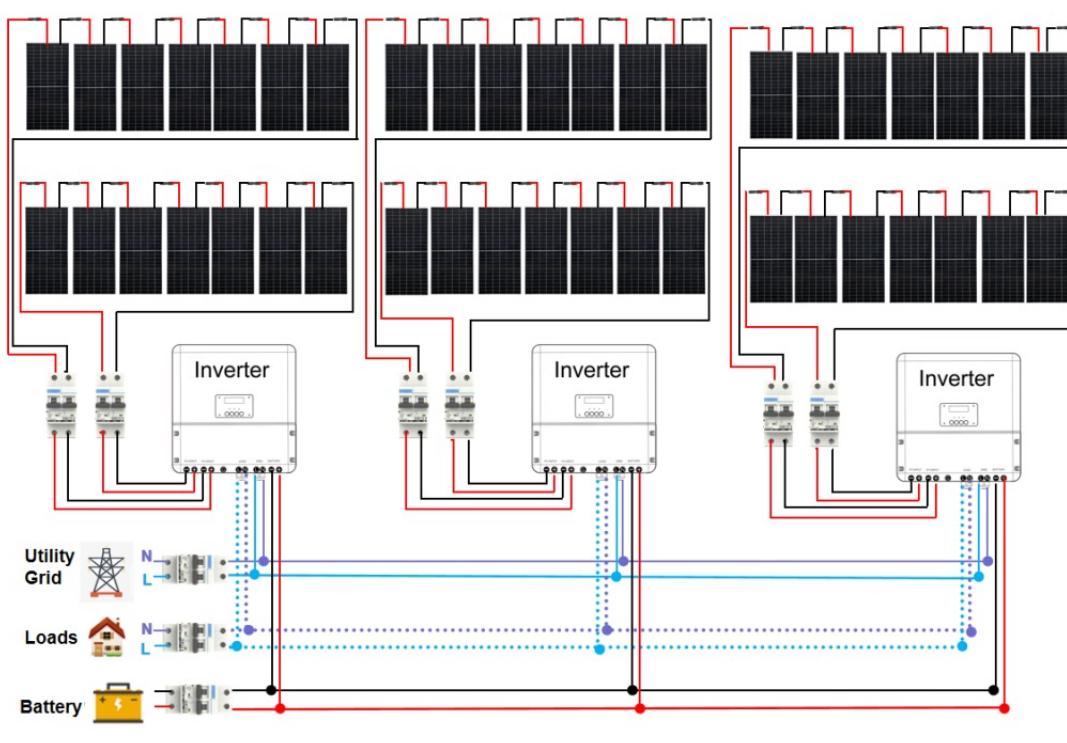


TEMPERATURE COEFFICIENTS

Temperature	
Temperature Coefficients P_{mp}	-0.39%/ $^{\circ}\text{C}$
Temperature Coefficients I_{sc}	+0.06%/ $^{\circ}\text{C}$
Temperature Coefficients V_{oc}	-0.30%/ $^{\circ}\text{C}$
Normal Operating Cell Temperature (NOCT)	$45^{\circ}\text{C} \pm 2^{\circ}\text{C}$

- Hot – Use loose efficiency
- Cold – You gain it – Voltage goes up
- Max String Voltage should never exceed max MPPT Max input voltage

SOLAR PANEL – DC COUPLED - DESIGN



- How many MPPT/Solar Panel Inputs do we have? 1? 5? 10?
 - Not all strings are equal!
- Each one represents a “string”
- Strings can only contain 1 type of panel
- A string can only contain one “facing”
- String implies a series connection
- String VOC = Panel VOC * number of panels

STRING VOC CALCULATION

- Example Panel:
 - Aptos 410 W with Bifacial Gain
 - VOC: 48.8
 - String Length: 10 Panels
 - String Voltage: 405.6(Cold) / 484 (Normal) Volts
 - String Amps: 13.69A
- Example Inverter:
 - MPPT Input Voltage: 100-600VDC
 - Usable Input Current: 15A Single – 26 Amp Double
 - Total 5 – Chains – 50 Panels –
 - 20.5Kw per inverter – Solar Input
 - Double Strings – 29.31 A – Max is 31
 - Single String – 14.63 A – Max is 19



LIES – DAMM LIES – STATISTICS

IDEAL CONDITIONS = STATISTICS

- Panel output is 22KW (Cold Day)
- Normal Temp output is 19.2kw (80f)
- Horizontal Mounting = 2.5% better Annually
- Cloudy Days give only 25% of typical power
 - Cloudy day – we get 5.5kw
- Output changes with Temp
- Blockage and obstructions
- Cleanliness



SOLAR PANELS – MOUNTS

- Roof Mount
- Ground Mounts
- Vertical Mount
 - Solar Fence



SOLAR PANELS - ROOF MOUNTS

- Depends on Roof Type
 - Roof Penetrations are always a problem
- Racks
- Best solution
 - Metal Roof with Standing Seam PV-KIT 2.0

Tile



Shingle



Metal



SOLAR PANEL – STANDING SEAM METAL ROOF - PV-KIT

- Strongest Roof
- Solar Panels connect using a simple adapter.
 - S-5! PV Kit 2.0
- Screws to the standing seam
- No roof Penetration
- The PVKIT 2.0 continues to be the easiest, most cost-effective way to install solar panels directly to standing seam and exposed fastener metal roofs



SOLAR PANEL – ROOF RACKS

- Ironridge@ – Flush Mount System
- Penetrates roof
 - Water Leakage becomes problem
 - Need more careful install
 - Removal needs sealing
 - Roof Waranty issues
- Needs Rails
 - Cost
- Proven in florida weather
- 25 Year warranty



SOLAR PANEL - GROUND MOUNTS

- Ground Mount is bit more expensive than roof mounts
- Issues:
 - Consumes space
 - Handles wind Speeds?
- Cost – Variable
- Dual Use Possible



SOLAR PANEL - PERGOLA

- Made out of wood/metal
- Dual Use Space
- Source from Lowes
- Scalability issue with large panel counts
- Solar Panel Greenhouse ☺



<https://www.youtube.com/watch?v=vLGzAscPr5k&t=190s>

SOLAR FENCE

- Vertical Mount – 2.5% better
- Dual Usage
- Can use a variety of mounting –
 - Concrete I-Beam Fence Posts
 - Aluminium I-Beam for Solar
 - Life Time Steel Post - \$39.99 ea

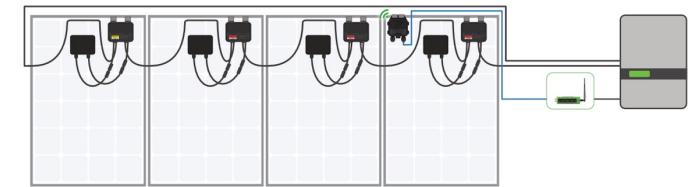


SOLAR PANELS – SAFETY

- Electrical Safety – DC
 - Single Panel = 50V with 10 Amps – ARC Welding is 50-60V DC
 - Multiple Panel – 400V to 600V – 10 amps = 8000 Watts Instantly Available
 - ARC Flash and ARC Blast are possible and likely
 - Use a Rapid Shutdown Device – Required in some states, should be required in all
 - Electrical Safety – AC
 - 110 – 120 V AC – 60 Amps – Same String above
 - Wet Environment
 - Micro Inverter does do sensing
 - Primary protection is Breaker
-

SOLAR PANEL SAFETY – DC – RAPID SHUTDOWN

- National Electrical Code (NEC) 690.12 section covers rapid shutdown devices (RSDs) for solar photovoltaic (PV) systems on buildings. The purpose of RSDs is to reduce the risk of shock for emergency personnel.
- Panel Output is reduced to zero
- Optimizes for shading
- Allows monitoring per panel



INVERTERS – TYPES AND KINDS

- Micro Inverters – Mounted behind panel – Give AC output at the roof for each panel
 - Grid Tied Inverter – Typically no battery, centralized
 - String Inverter – Converts a “string” of multiple panels high voltage dc into ac.
 - Off Grid Inverters – Designed to power house/shed without a utility connection
 - Hybrid inverter – Combines Off-Grid, Grid Tied, and String Inverter into one device
-

INVERTERS – THE “COMPONENTS”

- MPPT – Solar Charge Controller - MPPT stands for Maximum Power Point Tracking. It's a technique that maximizes the amount of energy that can be extracted from a variable power source. MPPT is most commonly used in solar panels.
 - This may be a separate box or component or integrated into a all-in-one.
 - Battery Charger – This is the part that can take either the output of the MPPT or AC from utility, convert to battery voltage (48V For example) and monitor and charge battery.
 - Inverter – The component that can take “power” from solar and convert it to AC.
 - Bypass – This part allows the 200A mains ac to go thru the inverter when battery is low.
-

BATTERIES – TYPES AND KINDS

- Li-ion – High Density but prone to fire. (That cannot be put out)
- LiFePO4 - Stable, less likely to catch fire. 4-5 times the life of lithium ion, easy to recycle
- Deep Cycle Lead Acid – Old School, still around but not recommended. Density is low, Mostly being taken over by LiFePO4, that “look” like Deep cycle.
- Sodium Ion (Future) – New Sodium battery, that offers the benefits at LiFePO4 at lower cost. TBD as it emerges.
- Solid State Batteries (Future) – Coming soon – highest density lowest cost per watt. Video attached.

METER TO INVERTER (MID) “ACCESSORIES”

- Traditional solution needs:
 - Breaker Panel with connection to meter
 - A breaker for each inverter
 - A Bypass Switch (200 Amp) to bypass the inverter
 - A Breaker panel to inverters input
 - A breaker panel for inverters output
 - Generator input distribution panel
 - To connect each inverter
 - Messy yet? (Have the design with part numbers if someone really wants to do this)
-

MODULE 2 – PHYSICAL PLANT/DESIGN IMPLEMENTATION

- Inverter Choice
- Battery Choice

HYBRID INVERTER – ALL IN ONE

- FlexBoss 21 –
 - 16kw Power Output per inverter
 - 21kw Solar Input
- To make this simple to install – We will use a “Hybrid” all-in-one inverter.
- This has all the components, except the bypass.
- Software/settings control its operating mode.
- Complete solution for offgrid for 16kw and up to 50 +/- panels



BATTERY – OUR CHOICE

- EG4-WallMount Indoor Battery
 - 48V 280Ah
 - 14.3kWh
 - Indoor
 - Heated
 - UL1973, UL9540A
 - 10-Year Warranty
- Wall Mount 280Ah LiFePO4 with a BMS
 - BMS Handles monitoring battery, and balances it.
 - Heating System to control temp
 - Built In Fire Arrestors
 - 48 Volt (54V Actual) – Why?
 - 200 Amp continuous, recommended 60A to 120A
 - Recommended watts out = 8.3 Kw
- For two inverters – 4 batteries is recommended – Giving 33.2kw



MID – BETTER SOLUTION

- EG4 Gridboss
 - Service Entrance
 - Breakers for up to 3 inverters
 - Grid Bypass
 - Generator input and control
- Wires / Breakers:
 - Meter to Gridboss (200 Amp)
 - Gridboss to Main Panel (200 Amp)
 - Up to 3 wires to inverter (90-125 Amps)
 - Generator Input (Up to 125 Amps)
 - Typical is 5 or 6 wires complete for AC
- Real Time Monitoring
- Smart Ports allow system to be used to shed/electric car etc without further breakers, and ability to software control



SOLUTION OVERVIEW - CONNECTIONS

- Gridboss
 - Connection to Meter
 - Connection To Generator
 - Connection To Main Panel – Main House
 - Connection To Barn (Via SmartPort)
 - Connection To PowerPod (Via SmartPod)
 - Connection to HvacPod (Via SmartPort)
 - Connection To
 - Connection to (2) Inverters
- Inverter(s)
 - Connection to Gridboss
 - Connection to 50 Solar Panels (DC)
 - Connection to Battery(s) (x4) (DC)
 - Connection to BMS on Battery (Data)

WHERE OH WHERE TO PUT ALL OF THIS?

- 4 Batteries
 - 1600 Amps at 48V of capacity
 - 3 Devices handling 100's of amps
 - Meter
 - Need to connect to multiple places/buildings
 - Early Operations
- Possible Solutions:
 - Garage of main houses
 - On outside wall of main house
 - Barn? Inside / Out
 - Or something else

POWER-POD

- Power-Pod is a 20 foot shipping container.
- Its finished:
 - Internal Steel Framing
 - Spray Foam Insulation
 - For Temp Control
 - For Strength
 - ¾ Inch CDX Fire-Retardant Pressure-Treated Plywood
 - 5/8-in Fire Resistant Type-X Drywall
- Pod Contains:
 - Utility Meter – Mounted on exterior – Designed for above or below ground
 - GridBoss – Our Power HUB
 - Up to 3 inverters
 - Up to 6 batteries
 - One Air-To-Water Fan Coil
 - Cooling of equipment
 - Radiant Floor Heating
 - Environment Monitoring
 - Smoke Alarm
 - Rapid Shutdown Equipment for Solar

POWER POD - CONTAINER

- 20 Foot High Cube 1-Trip Container
- 20ft long x 8ft wide x 9ft 6in tall



POWERPOD FRAMING

- Container Modification World® - Steel Stud Framing Kit for Shipping Containers/Sea Cans (Composite) - 2 Corner Casting Covers Steel Stud Brackets Hardware (20)
- 1"5/8 Steel Studs for sides
- 2.5 Inch Studs on Roof
- Door Flashing Kit

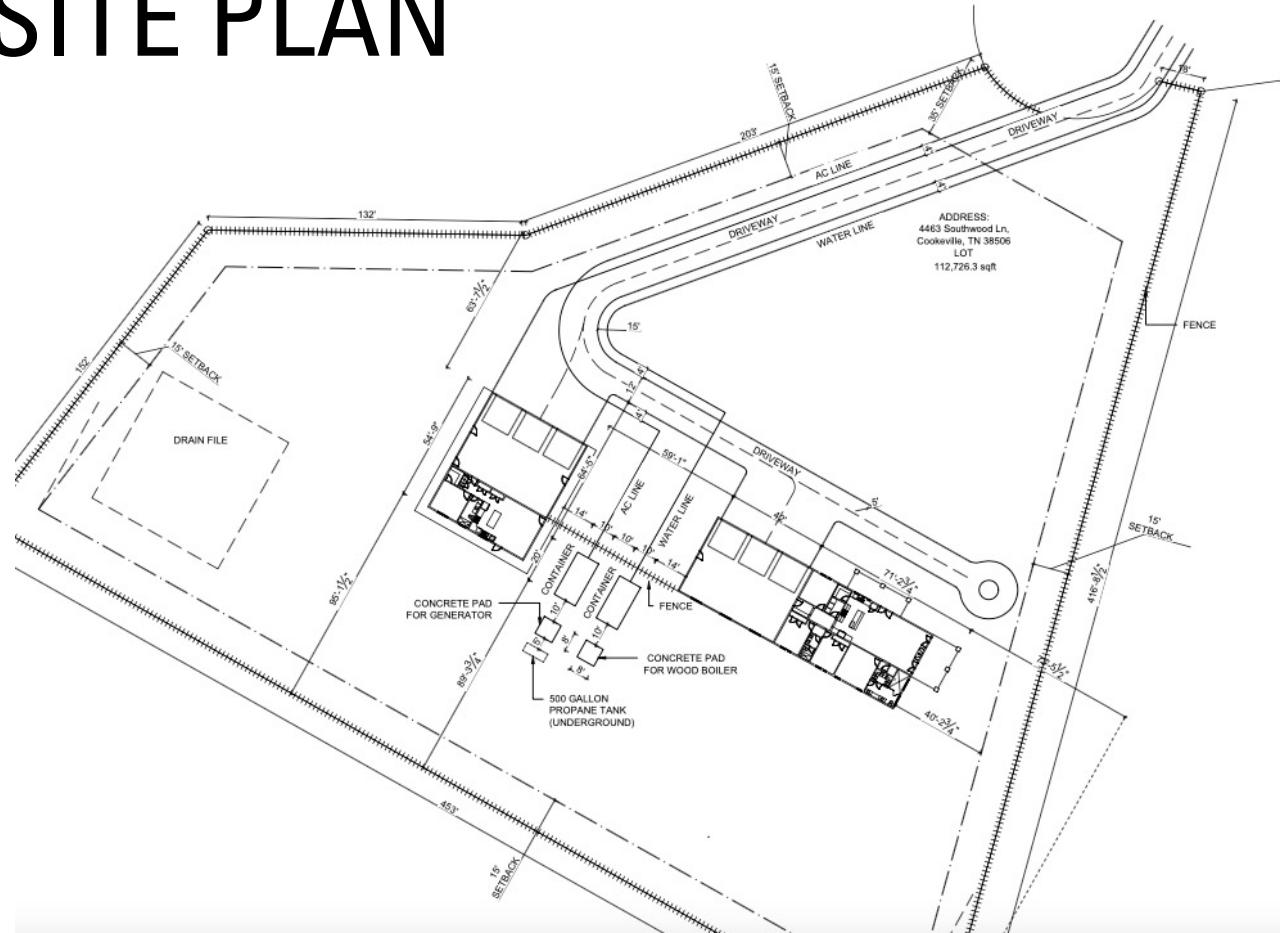


POWERPOD INSULATION

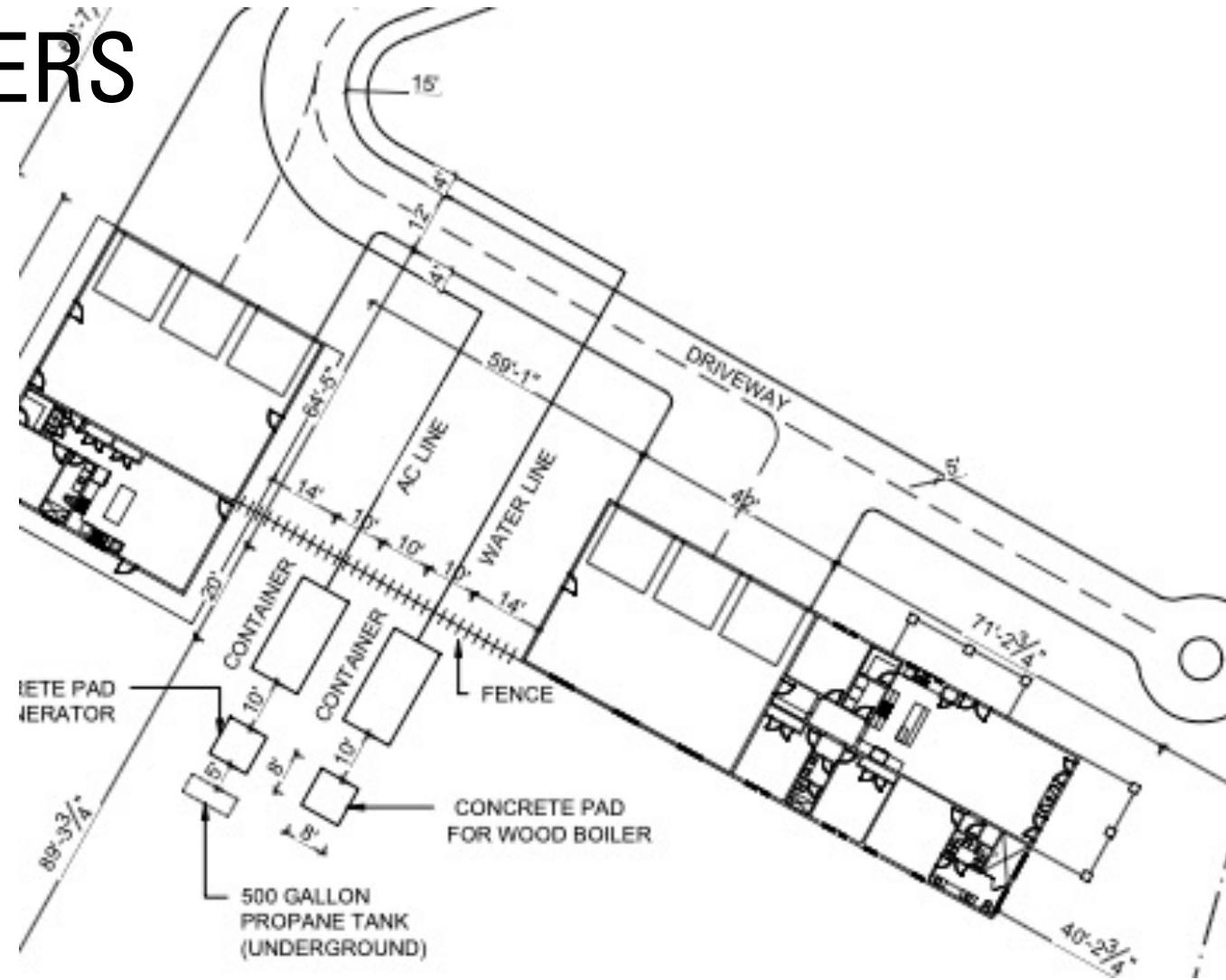
- Spray Foam
 - Provides vapor barrier
 - Thermal Break
 - Increases Strength of Walls/Ceiling



OVERALL SITE PLAN

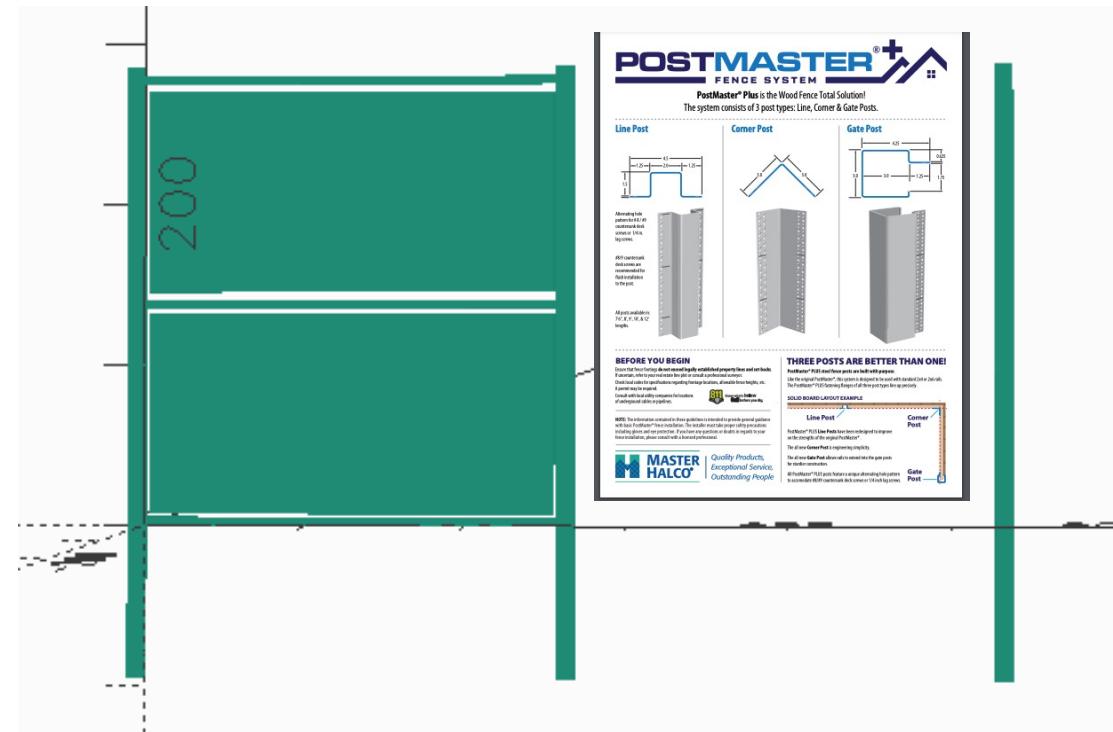


CONTAINERS



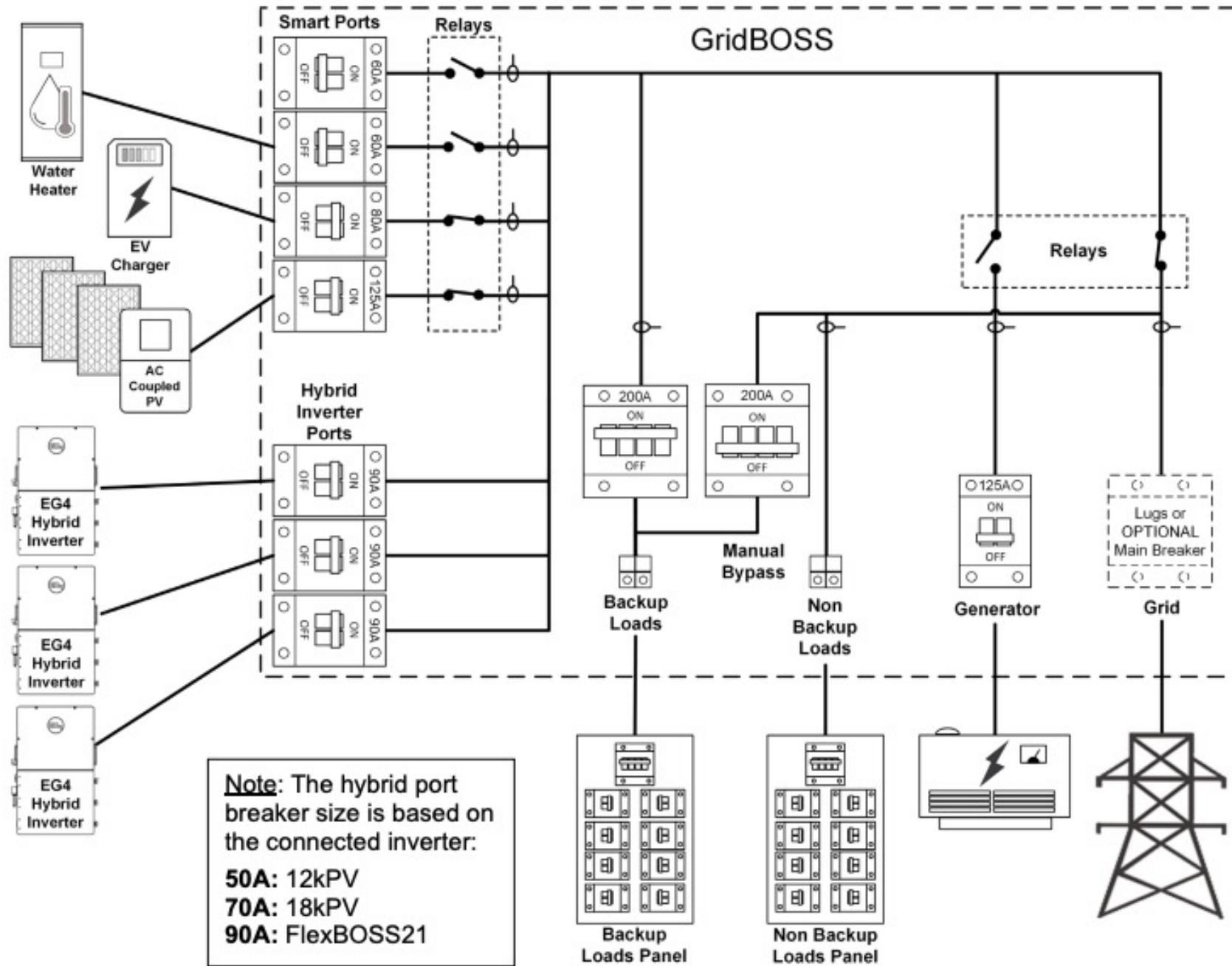
SOLAR FENCE

- PostMaster Fence Post
 - 10 Foot – Steel Post
 - 3.5 inch – 1.5 inch with 1 inch either side
- Qty 3 - OpenBuilds 4040mm Aluminium Rails
 - Custom Cut to 2160mm (Estimate)
- Bottom/ Top mounting plate – powder coated steel (Oshcut) – drilled for panel holes and matching holes for rails
- Middle Plate – powder coated steel (oshcut) – drilled for panel holes and matched holes for rails



MODULE 3 – ELECTRICAL AND SETTINGS

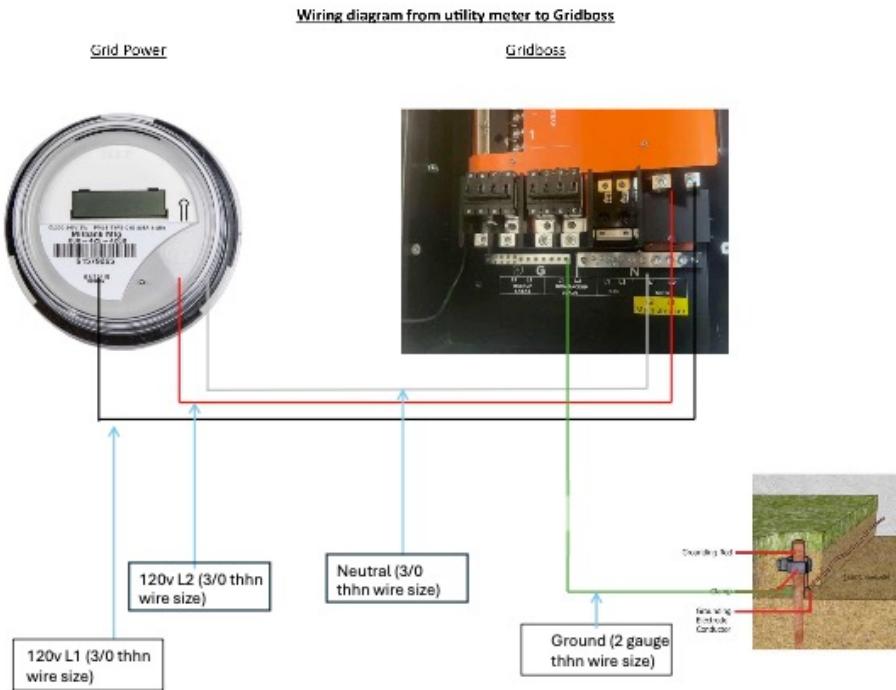
- Wiring The Inverter
 - Inverter Settings
-



EQUIPPING BREAKERS

- Main Breaker – 200 Amp
 - Inverter 1 Breaker – 90 Amp
 - Inverter 2 Breaker – 90 Amp
 - Generator Port – 80 Amp
 - Smart Port 1 – 125 Amp – For Barn Connection
 - Smart Port 2 – 80 Amp - For HVAC Container
 - Smart Port 3 – 60 Amp - For Electric Car Charger
 - Smart port 4 – 60 Amp - Power for Power Pod (Internal)
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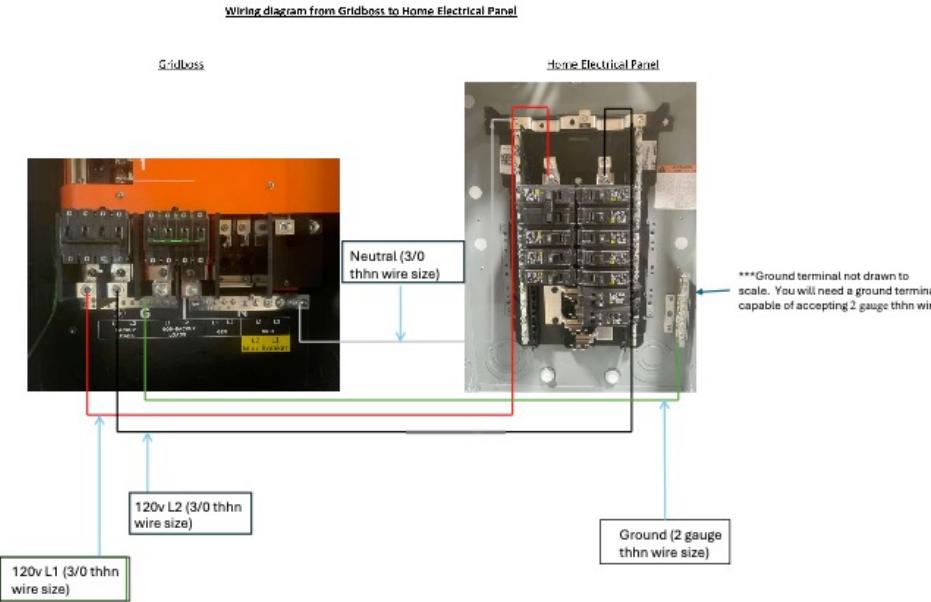
WIRING FROM UTILITY METER TO GRID BOSS “WIRE 1 AND GROUND”



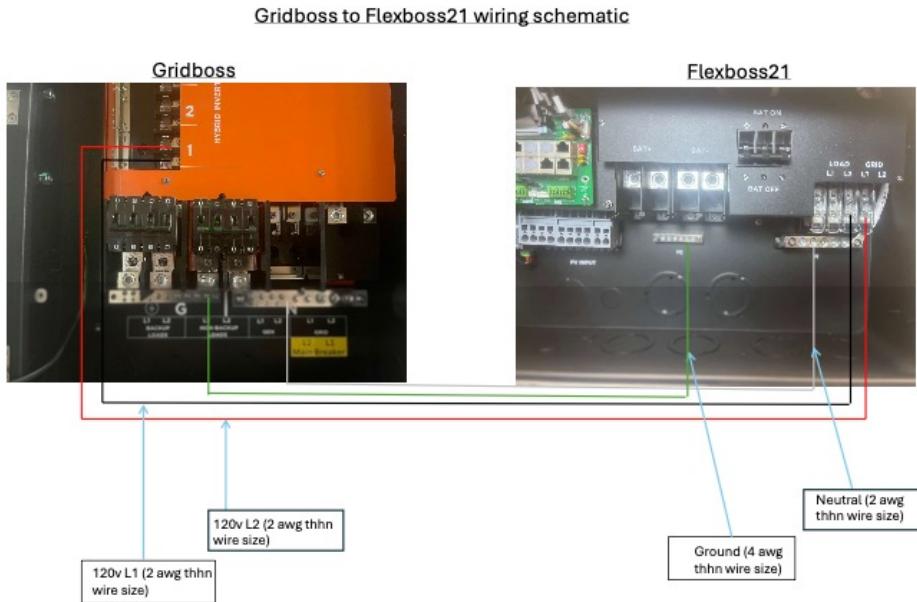
- 120v L1 – 3/0 thhn wiresize
- 120v L2 – 3/0 thhn wiresize
- Neutral - 3/0 thhn wiresize
- Ground - 2 gauge thhn wire size

WIRING FROM GRIDBOSS TO HOME ELECTRICAL PANEL – “WIRE 2”

- 120V L1 – 3/0 thhn wire size
- 120V. L2 - 3/0 thhn wire size
- Neutral – 3/0 thhn wire size
- Ground. - 2 gauge wire size

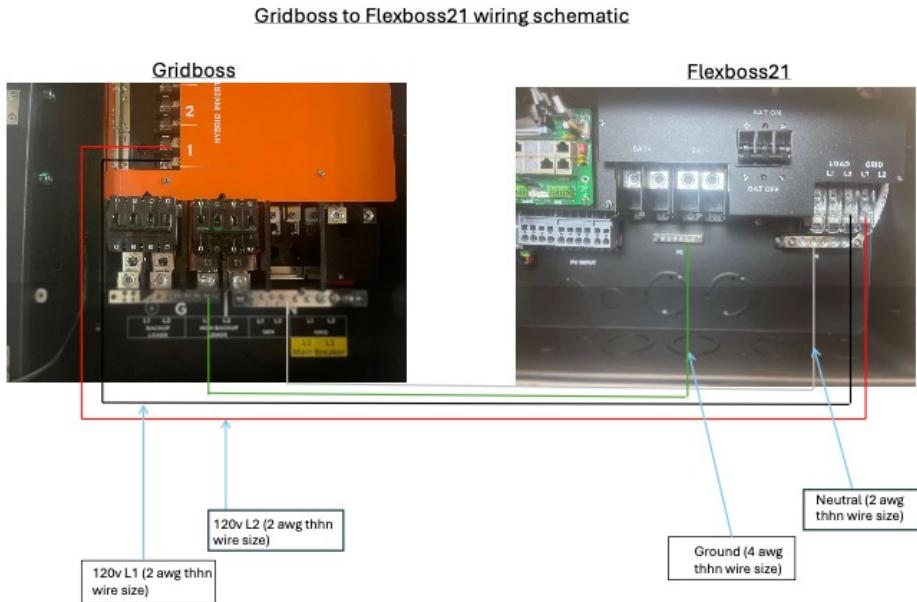


WIRING FROM GRIDBOSS TO INVERTER 1 (FLEXBOSS 21) – WIRE 3



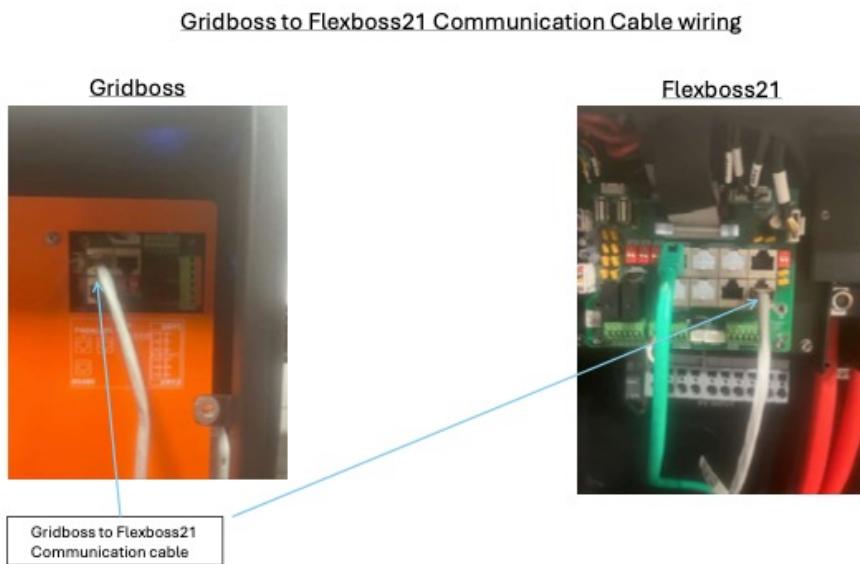
- 120V L1 – 2 awg thhn wire size
- 120V L2 – 2 awg thhn wire size
- Ground – 4 awg thhn wire size
- Neutral – 2 awg thhn wire size

WIRING FROM GRIDBOSS TO INVERTER 2 (FLEXBOSS 21) – WIRE 4



- 120V L1 – 2 awg thhn wire size
- 120V L2 – 2 awg thhn wire size
- Ground – 4 awg thhn wire size
- Neutral – 2 awg thhn wire size

GRIDBOSS TO FLEXBOSS 21 COMMUNICATION WIRING

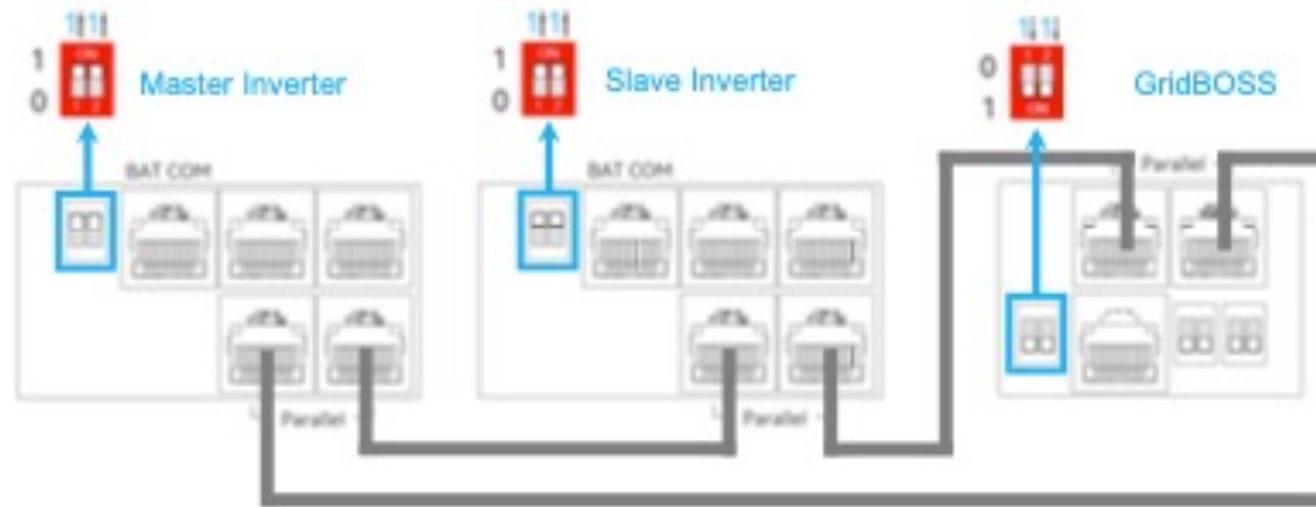


- Using standard “ethernet” cable
 - RJ45 Both Ends
 - 4 Pair – 8 conductor cable
 - Low Voltage
- Connect to left parallel port on Gridboss
- Connect to right parallel port on Flexboss

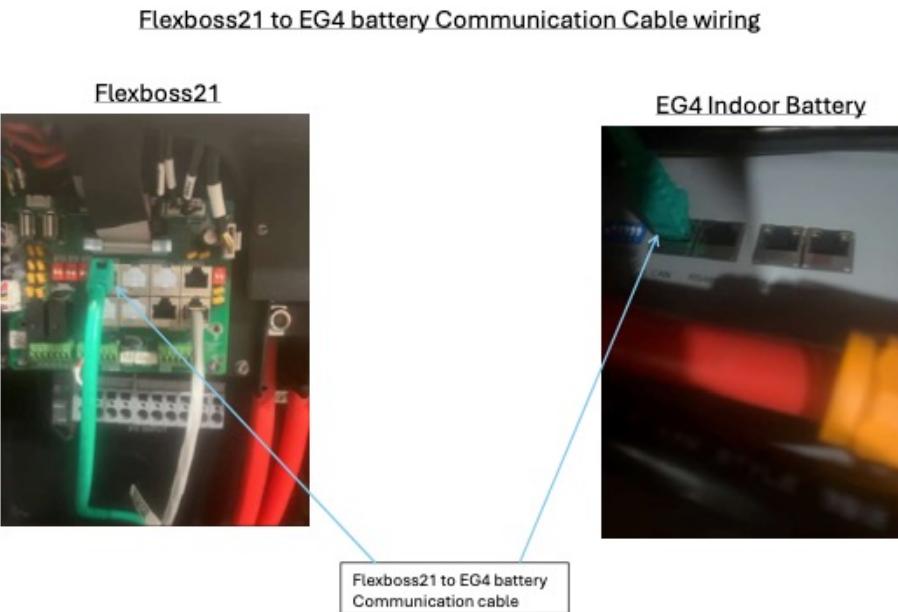
IMPORTANT You'll notice that the communication cable is on the left parallel port on the Gridboss, and the right Parallel port on the Flexboss21. It must be wired like this for it to work. If both cables are in the right parallel port it will NOT work. It will also not work if both communication cables are in the Left parallel port. Use the configuration in the pics above and it will work perfectly.

CONNECTING OUR 2 INVERTERS - DATA

GridBOSS with Two Hybrid Inverters



FLEXBOSS 21 TO BATTERY

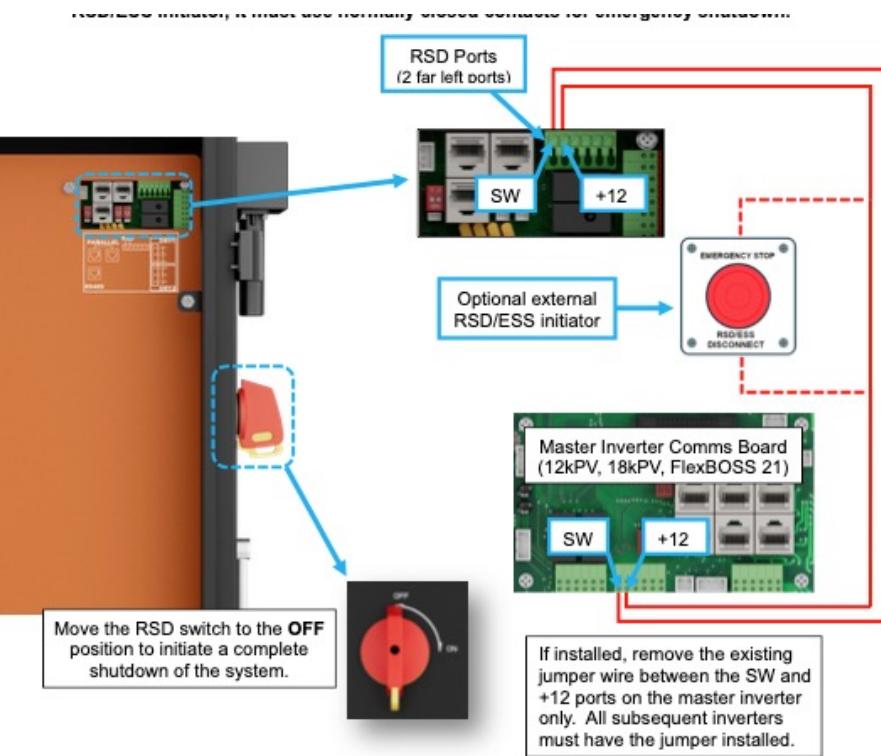


IMPORTANT you must connect the green battery communication cable to the "battery" port on the Flexboss21 and to the CAN port on the EG4 indoor wallmount battery.

- Using standard “ethernet” cable
 - RJ45 Both Ends
 - 4 Pair – 8 conductor cable
 - Low Voltage
 - Green Color
- Connect “battery port” on Flexboss and to the CAN port on the EG4 indoor battery
- Daisy Chain this from battery to battery

RAPID SHUTDOWN

- Gridboss supports rapid shutdown system that complies with 2017 and 2020 NEC 690.12 and ESS Disconnect that complies with NEC 706.15
- Switch on the right side of gridboss, when used will initiate total system shutdown, including the inverters, supported batteries, and PV (If using Tigo rapid shutdown devices)



SETTINGS - INTENT

- Use as much Solar for loads as possible
 - 50% should be able to charge batteries as well
- Use battery before grid on a cloudy day
- At 8pm – Charge battery to full – if below 50%
- Bad weather Expected – Charge to full from grid as soon as possible
- Never send power to grid
- At start of day, if battery below 30% charge to 60%
- If battery's are at 30% and no grid, charge from generator, turn off generator at 90%

SETTINGS

- Power Backup: Enable
 - We are Now a “UPS” for house
- No Grid Sell Back
 - No electricity will be sent to the public grid
- Fast Zero Export – Adjust power so there is no power export instead of every 5 seconds
- Off-Grid Mode – Allows absolute zero-export when there is a AC Connection, only will charge if AC Charge is enabled
- RSD: Enable Rapid Shutdown
- Share Battery: Yes
- AC Charge:
 - AC Charge Enable
 - AC Charge Based On: Time
 - Set AC Charge Power:

SETTINGS

- PV Charge Priority: Prioritise Solar
 - PV Charge Power: 12kw (Per Inverter)
 - Offgrid Discharge Cutoff : 20%
 - Weather Optimization:
 - Intelligent Charging Control
 - Working Mode: Self Consumption
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