P.V. Enthusiast
Sunshine Lane
Sunrise, FL

2800 Watt Photovoltaic Standby Power System
Supporting information for Installation Permit Application

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This PV System, when installed in accordance with the instructions herein, will be fully compliant with NEC 690 and FBC Chapter 16

This Photovoltaic System design package prepared by
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Kimandy Lawrence
April 16, 2008

2800 Watt Battery Backup Utility Interactive Photovoltaic System

System Description

This system is a grid-tied, PV system with battery back-up, with PV generation consisting of 14 Sanyo HIP200-BA3 PV modules with a combined STC rated dc output power of 2800 watts. The modules are mounted on a custom-designed mounting structure, engineered to withstand winds exceeding 150 mph, and are connected into seven, 2-module, source circuits. The source circuits feed an Outback Power Systems Maximum Power Point Tracking Charge Controller to maximize energy captured by the PV modules. The charge controller feeds the system batteries and the inverter, which is connected to supply 120 volt ac standby loads and also to the electric utility grid. The system is provided with all disconnects and labels required by the *National Electrical Code*. Optional system performance metering and optional bi-directional utility kWh meters are also available. The system batteries are sized for either 216, 224, 258 or 516 amp hours at 48 V for providing approximately 8, 8.6, 10 or 20 kWh of standby power from the inverter to standby (uninterruptible) loads.

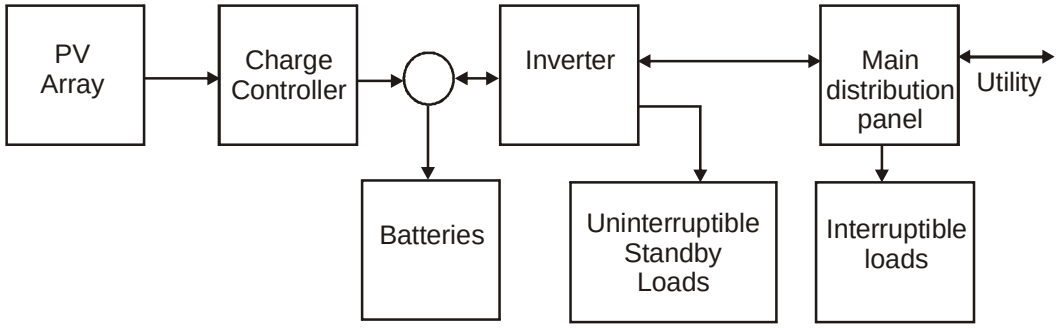
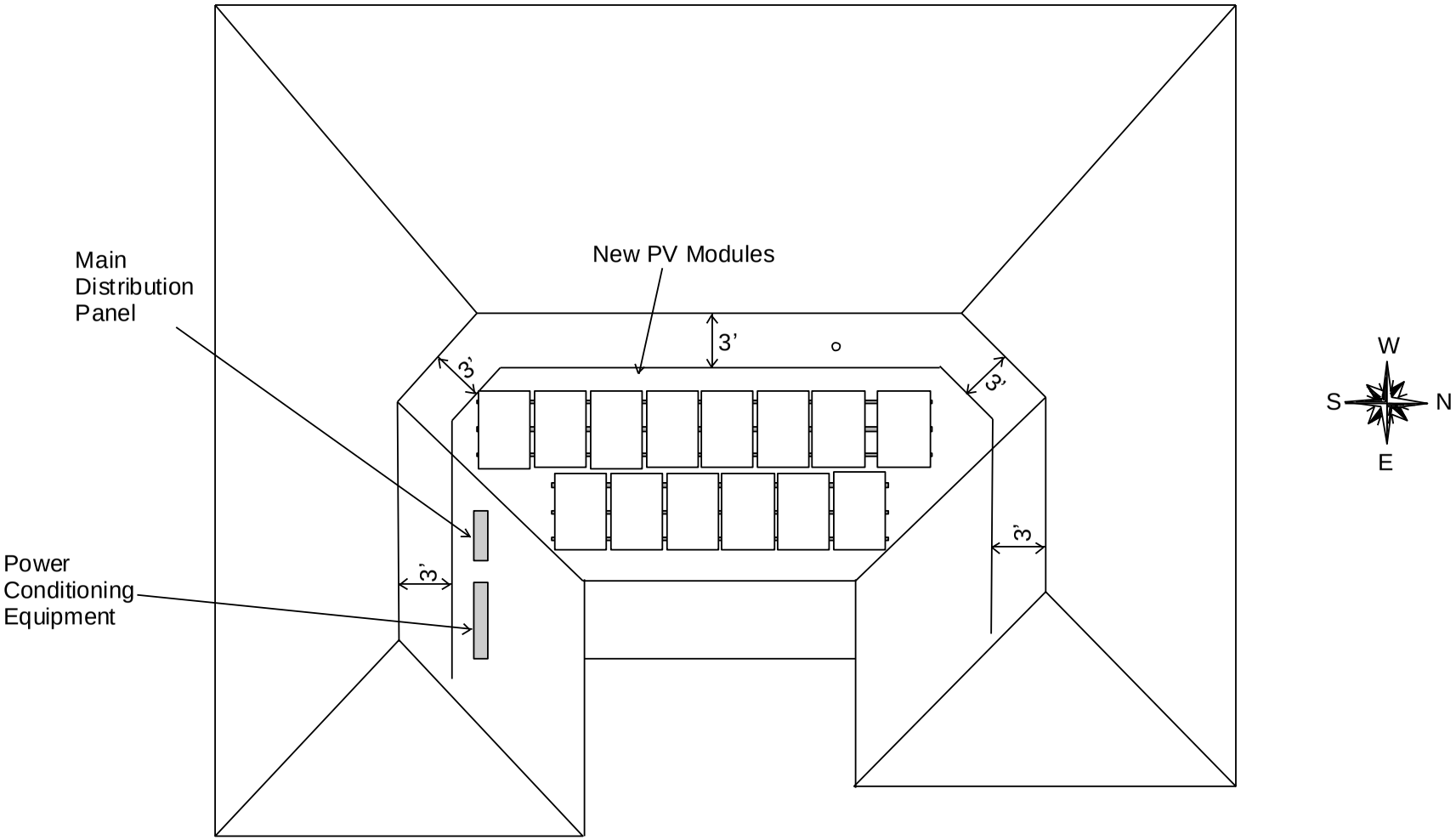


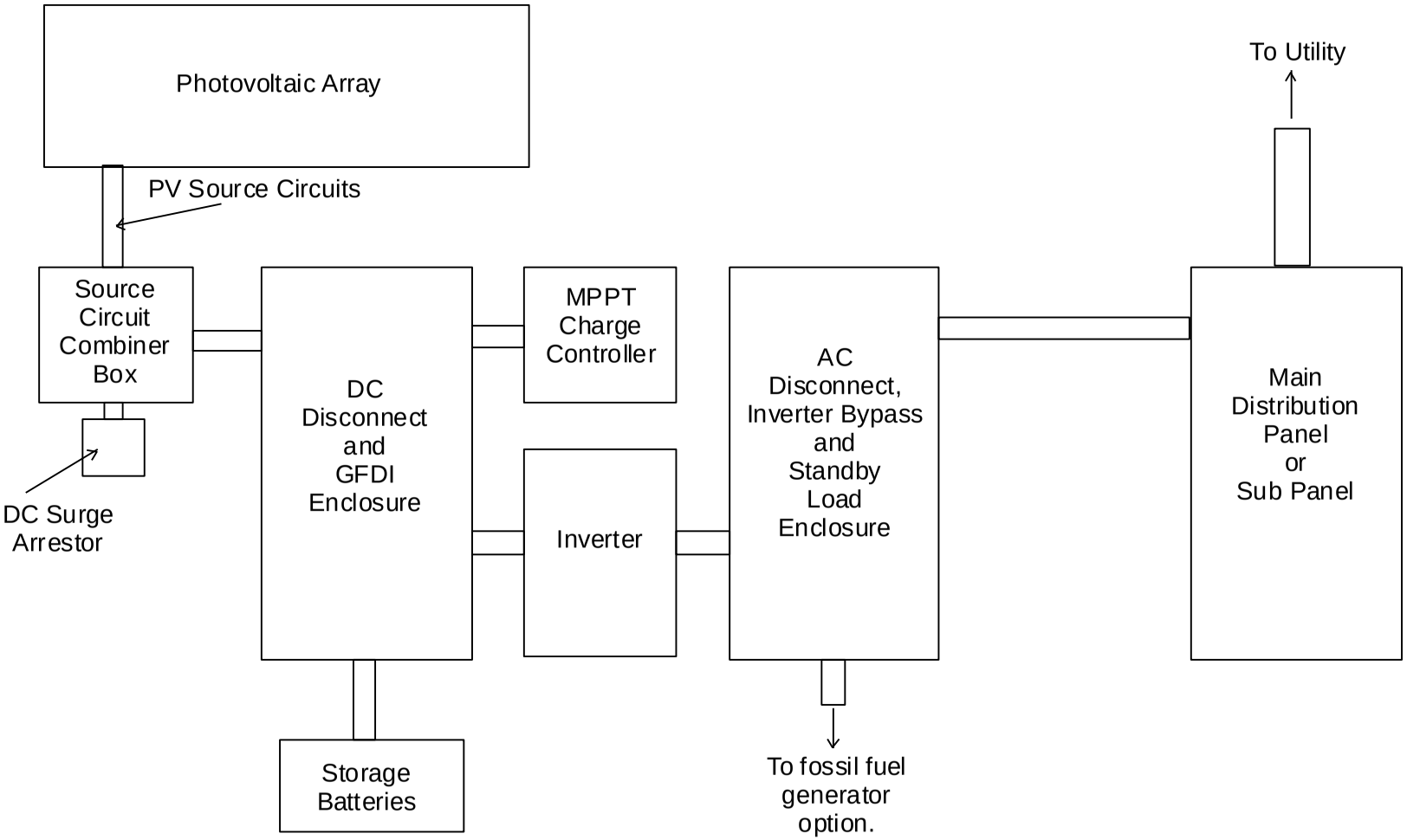
Figure 1: PV System block diagram showing main system components.

When the sun is shining, power from the PV array is used to keep the batteries fully charged. After charging the batteries, the PV power is made available to the standby loads. If PV power meets the requirements of the standby loads, any remaining PV power is then directed to the interruptible loads of the occupancy. If any PV power remains after the interruptible loads have been powered, it is delivered to the utility. When utility power is available, but if PV power is not available, standby loads are supplied by the utility. If neither utility nor PV power is available, standby loads are supplied by the batteries. Thus, the batteries are only cycled if utility power is lost. The batteries used are specially designed, deep cycle, maintenance free batteries that are capable of undergoing approximately 3,000-4,000 charge-discharge cycles. Designing the system to minimize battery cycling extends the life of the batteries.

The inverter meets the requirements of IEEE 1547 and UL 1741. This means that if it detects a loss of utility power, it will automatically disconnect from the utility. When this happens, only the uninterruptible loads are powered by the inverter. When utility voltage is restored, the inverter automatically reconnects to the utility grid after verifying utility voltage and frequency stability.



2800 W Utility Interactive PV System With Battery Backup
Site Plan



See schematic diagrams for wiring details.

I certify that this PV system fully complies with the requirements of NEC 690.

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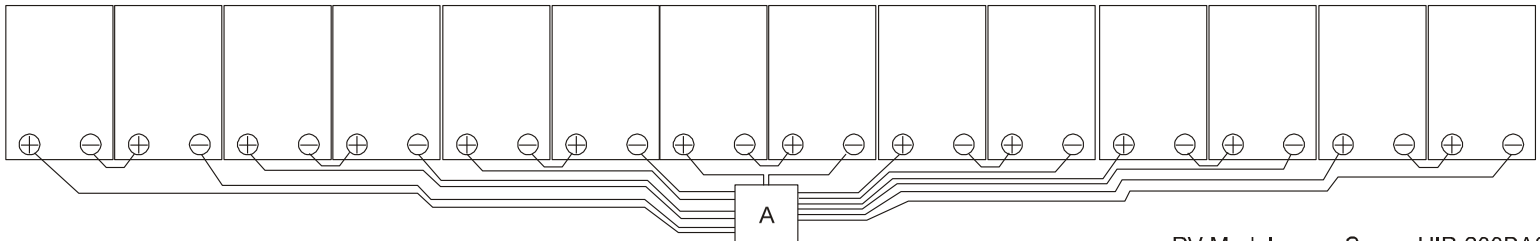
2800 Watt Utility Interactive PV System
System Riser Diagram

SHEET
E-1



Source circuits 1-7 to Source Circuit Combiner Box 14 #12 THWN-2 and 1 #10 in 1" conduit (See p. E-3)

Use only UL listed terminal blocks in junction box. Do not use twist connectors.

PV Modules are Sanyo HIP-200BA3
Module P_{MAX} = 200 W
Module V_{OC} = 68.7 V
Module V_{MP} = 55.8 V
Module I_{SC} = 3.83 A
Module I_{MP} = 3.59 A
Quantities measured at 25°C.

PV Modules are wired with #12 USE-2 open wiring, using UL-listed locking type MC connectors..

Junction Box A is 8"x8"x4" with 15 terminal blocks.

Loop #10 solid bare copper groundiing conductor from junction box to lay-in ground lugs on each module. Ground lugs to be tinned copper approved for direct burial, such as Ilsco, GBL-4DBT. Use UL-listed grounding clips between module frames and array mounting frame to ground each section of array mounting frame.

Depending upon the roof configuration, the need for roof penetrations for conduit and any other site-specific considerations, contractor should decide upon the best way to run source circuits back to source circuit combiner box. Source circuit combiner boxes will normally be near inverter to provide easier system test and maintenance.

I certify that this PV system fully complies with the requirements of NEC 690.

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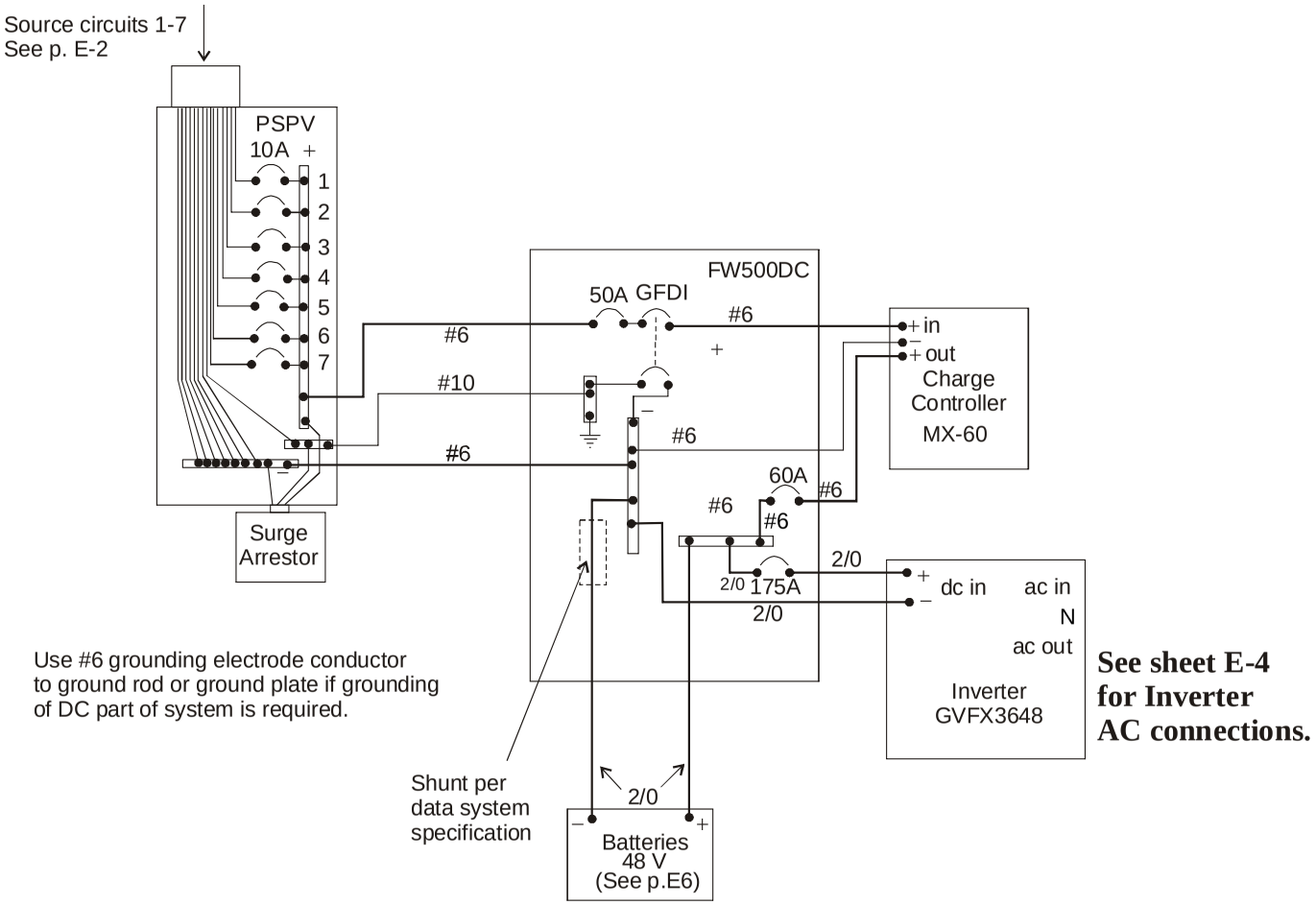
PV Array Wiring

2800 W 120V UPS Utility Interactive PV System

SHEET
E-2



See sheet E-4 for Inverter AC connections.

Note: All wiring is THWN-2 except for battery cables and module exposed wiring.

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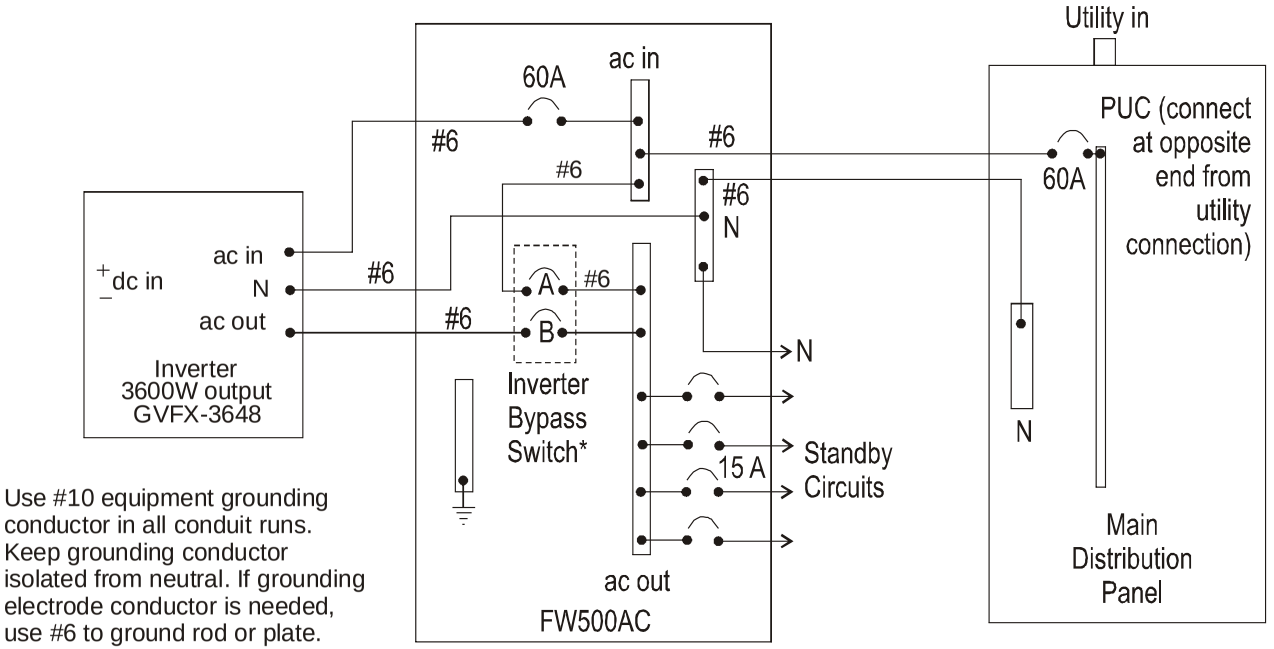
System DC Wiring

2800 W 120V UPS Utility Interactive PV System

SHEET
E-3



Use #10 equipment grounding conductor in all conduit runs. Keep grounding conductor isolated from neutral. If grounding electrode conductor is needed, use #6 to ground rod or plate.

*When A open and B closed, Inverter is connected to emergency loads. When B open and A closed, Inverter is bypassed to utility feed.

Except for module wiring and battery cables all wiring is THWN-2.

I certify that this PV system fully complies with the requirements of NEC 690.

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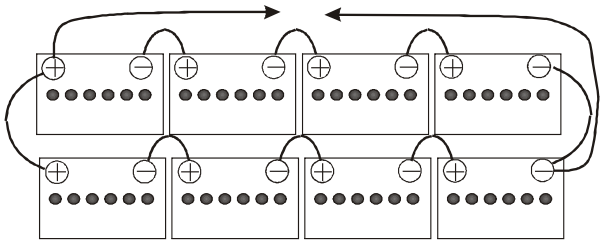
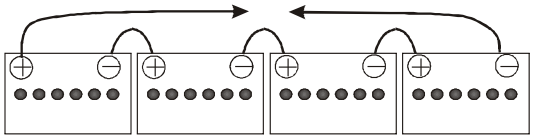
System AC Wiring

2800 W 120V UPS Utility Interactive PV System

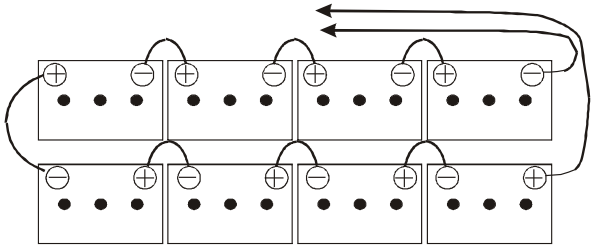
SHEET
E-4



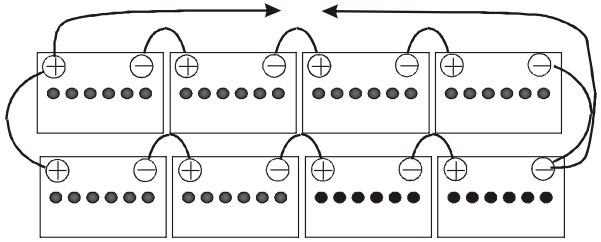
Option 1
8 Concorde PVX1080T AGM Sealed Lead Acid
216 Ah@48V 8 kWh nominal



Option 3
4 Concorde PVX2580L AGM Sealed Lead Acid
258 Ah@48V 10 kWh nominal



Option 2
8 Concorde PVX2240T AGM Sealed Lead Acid
224 Ah@48V 8.6 kWh nominal



Option 4
8 Concorde PVX2580L AGM Sealed Lead Acid
516 Ah@48V 20 kWh nominal

Install all battery systems according to NEC.
Sealed, Maintenance Free batteries may be
installed in accordance with IEEE 1187.

I certify that this PV system
fully complies with the
requirements of NEC 690.

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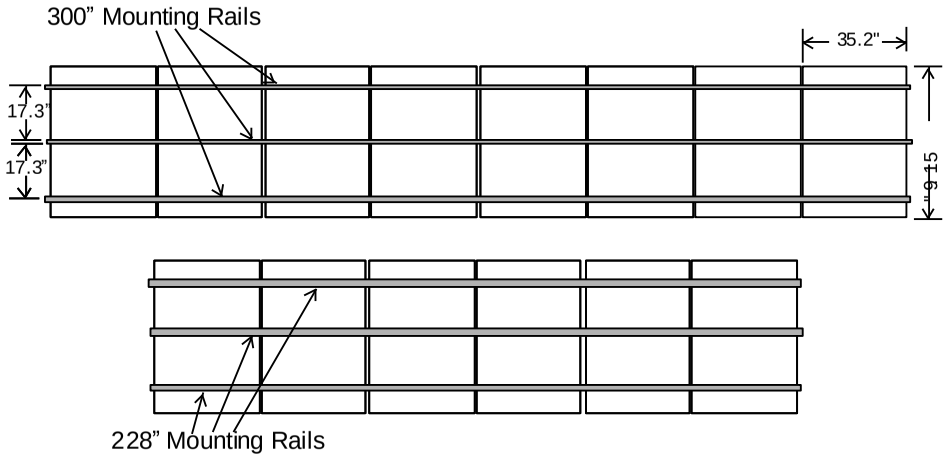
2800 W 120V UPS Utility Interactive PV System

SHEET
E-5



Mount each rail for the 8 module sections with 7 L-Brackets positioned at 6", 54",102",150”, 198”,246”, and 294” from end of rail. L-Brackets mounted either directly to roof truss or to approved extension rods attached at same locations. Using 80 psf and a total array area of 101.5 sq ft gives 8119.5 lb max pull. With 21 L-Brackets, this is 387 lb/bracket. Thus, for the worst case trusses, a 5/16" lag screw must penetrate 2.0” into the truss.

Important:
Mounting rails must be aligned so that modules will not bend when they are clamped to the rails.

To minimize wind load on array, keep array away from edges of roof as far as possible.

Withdrawal Loads for Screws in Wood (Includes safety factor of 4.5).

Lumber	White Oak	Southern Yellow Pine	White Spruce	Douglas Fir
Specific Gravity	0.71	0.58	0.45	0.41
Diameter (in)	Allowable withdrawal load, lb/in			
1/4	381	281	192	167
5/16	450	332	227	198
3/8	516	381	260	226
7/16	579	428	292	254
1/2	640	473	323	281

Mount each rail for the 6 module sections with 5 L-Brackets positioned at 6", 54",102",150”, 198”, and 222” from end of rail. L-Brackets mounted either directly to roof truss or to approved extension rods attached at same locations. Using 80 psf and a total array area of 76.12 sq ft gives 6089 lb max pull. With 15 L-Brackets, this is 406 lb/bracket. Thus, for the worst case trusses, a 5/16" lag screw must penetrate 2.1” into the truss.

Note that PV modules are rated at 50 psf, so PV array mount should be designed to withstand either 80 psf or actual wind load, whichever is greater.

See lag screw penetration calculations for minimum screw penetration depths for any specific module configuration.

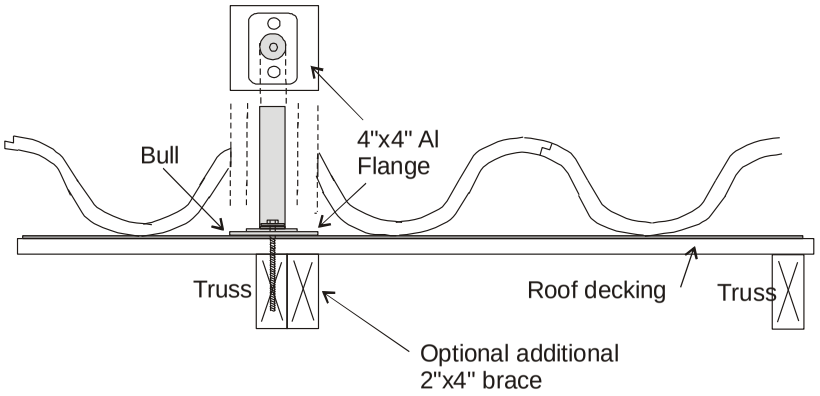
Seal all roof penetrations with UV resistant sealant approved for the specific roof surface treatment..

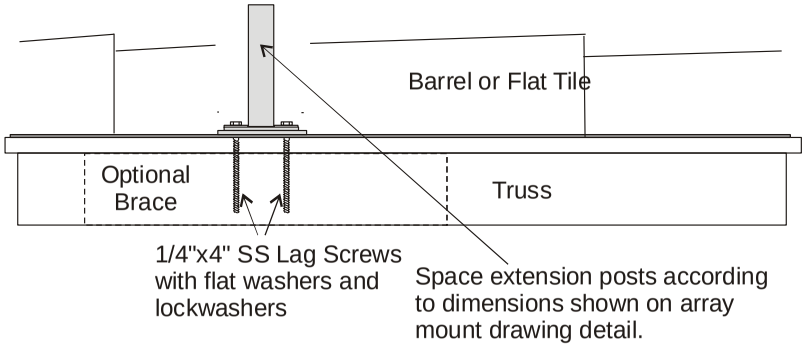
I certify that this PV system fully complies with the requirements of the Florida Building Code.

April 16, 2008

2800 W 120V UPS Utility Interactive PV System
Array Mounting Details

SHEET
M-1





Procedure for attaching Extension posts:

1. Determine location for extension post on roof by drilling through center of truss from bottom with 5/32" drill bit.
2. Saw 4" diameter hole in tile centered on locator hole drilled in step 1. Avoid cutting into underlayment.
3. Mark mounting holes for extension post base on underlayment. Mounting holes should be centered on the trusses.
4. Drill 1/4" pilot holes for SS lag screws through roof decking at locations of extension post base. Drill only to depth of non-threaded portion of screw.
5. Extend depth of holes to 4" with 3/16" drill bit.
6. Apply sealant to bottom of 4"x4" aluminum flange (5/16" holes drilled in flange at locations of extension post base holes).
7. Place flange over roof underlayment with holes aligned with holes in roof.
8. Apply sealant to bottom of extension post base, apply sealant to lag screws, and fasten extension post base securely to truss, using flat washer and lock washer under screw heads.
9. Apply additional sealant to top assembly to be sure all penetrations are sealed.
10. Install 2"x4" braces along trusses if necessary.
11. Optional: Install additional 5"x5" aluminum flashing over top of extension post and on top of tile. Bend to shape of tile and seal.
12. Attach L-Brackets for mounting PV array mounting rails to mounting posts.

Note: This same procedure may be used to install extended L-Brackets instead of extension posts. For extended L-Brackets, use 5/16" x4" SS lag screws, since L-Brackets have only one mounting hole. Drill 5/16" pilot hole to depth of screw shank and then extend hole to 4" depth with 15/64" drill bit.

Note: If mounting posts or L-Brackets are installed during new roofing or replacement roofing, coordinate sealing of attachments with roofer. For new or replacement roofing, attachment points do not need to be at peaks of tiles.

I certify that this PV system fully complies with the requirements of Chapter 16 of the Florida Building Code..

4/16/07

Alternate method for mounting extension posts to Spanish Tile or other curved roof when attic under array is accessible.

PV Circuits	I_{sc}	$1.25I_{sc}$	$1.56I_{sc}$	Conductor	30°C Ampacity	Temp	Temp Derate	Conduit Fill	Conduit Fill Derate	Derated Ampacity
Source Circuits #1-7	3.83	4.79	5.97	#12 THWN-2	30	60	0.71	14	0.5	10.65
Output Circuit #1	26.81	33.51	41.82	#6 THWN-2	75	50	0.82	2	1	61.5

Charge Cont Circuits	I	1.25I	1.56I	Conductor	30°C Ampacity	Temp	Temp Derate	Conduit Fill	Conduit Fill Derate	Derated Ampacity
Charge Cont 1 Output	26.4	33.0	41.2	#6 THWN-2	75	40	0.91	2	1	68.25

Charge controller output current limited to 60A

Inverter Circuits	I (rated)	1.25xI	conductor	ampacity	C.B.
DC Input	85.0	106.3	2/0	195	175 A
AC In	60	75	#6	75	60 A
AC Out	60	75	#6	75	60 A

Voltage Drops Circuit	V	I	L	2% V.D. Ω/kft	Wire Size	
PV Source Circuit	111.6	3.59	155	2.0056	#12	use # 8 from 58 feet to 90
PV Output Circuit	111.6	14.36	10	7.7716	#6	
Charge Cont Output	52.0	26.4	5	3.9354	#6	
Inverter AC in 1	120	46	51	0.5115	#6	
Inverter AC out	120	46	51	0.5115	#6	

Wire Size	Ω/kft	Wire Size	Ω/kft
#12	1.98	#4	0.321
#10	1.29	#3	0.254
#8	0.809	#2	0.201
#6	0.51		

Lowest Array Temp deg C	-10
Highest Array temp deg C	65
Highest Array V_{OC}	153.75
Lowest Array V_{mp}	90.62

Site Information for Wind Loading of PV Array

Owner: Rufus Barber

Address: 899 SW 14th Ave.

City: Boca Raton, FL 33486

For wind analysis, obtain information from Building Department,
Florida Building Code (Edition in force) or ASCE-7 (Edition in force).

Basic Wind Speed: 140 mph

Building Category: residential (per definition in ASCE-7)

Regular Building Shape? yes (per definition in ASCE-7)

Exposure Category: B

Mean Roof Height: 15 ft

Exposure Category C Multiplier: N/A

Importance Factor: 0.77 **1.00** 1.15 (per ASCE-7)

Height Adjustment Factor (roofs higher than 30 ft): N/A

Topographic Factor (hilly terrain): N/A

Module Area (square feet): 12.7

Roof Zone (per ASCE-7 definitions: **interior (zone 1)** end (zone 2) corner (zone 3)

Roof Slope: 23 degrees

Design Pressure: **20.3/–32.3 psf**

Design pressure obtained from: Florida Building Code ASCE-7 Other

Is roof supported by engineered trusses? **yes** no

Will the roof support an additional 3 psf dead load from the PV array? **yes** no

12/3/07

Lag Screw Truss Penetration Calculations For Southern Yellow Pine

Obtain wind loads from wind load maps or building official.

6 Sanyo HIP Modules								
Total Area (sq ft)	76.1	76.1	76.1	76.1	76.1	76.1	76.1	76.1
Wind Load (psf)	50	60	70	80	90	100	110	120
Total Wind Load (lb)	3806	4567	5328	6090	6851	7612	8373	9134
# L-Brackets	10	10	10	15	15	15	15	15
Load per L-Bracket	381	457	533	406	457	507	558	609
1/4" Lag Screw Truss Penetration (")	1.35	1.63	1.90	1.44	1.63	1.81	1.99	2.17
5/16" Lag Screw Truss Penetration (")	1.15	1.38	1.60	**1.22**	1.38	1.53	1.68	1.83
3/8" Lag Screw Truss Penetration (")	1.00	1.20	1.40	1.07	1.20	1.33	1.47	1.60

8 Sanyo HIP Modules								
Total Area (sq ft)	101.5	101.5	101.5	101.5	101.5	101.5	101.5	101.5
Wind Load (psf)	50	60	70	80	90	100	110	120
Total Wind Load (lb)	5075	6090	7105	8119	9134	10149	11164	12179
# L-Brackets	14	14	14	21	21	21	21	21
Load per L-Bracket	362	435	507	387	435	483	532	580
1/4" Lag Screw Truss Penetration (")	1.29	1.55	1.81	1.38	1.55	1.72	1.89	2.06
5/16" Lag Screw Truss Penetration (")	1.09	1.31	1.53	**1.16**	1.31	1.46	1.60	1.75
3/8" Lag Screw Truss Penetration (")	0.95	1.14	1.33	1.01	1.14	1.27	1.40	1.52

Solar Family
Battery Backup Grid-Connected Photovoltaic System Standby Load Summary

Load	VA	I, Amps	Est Daily kWh
Refrigerator	300	2.7	2.0
Lighting	900	7.5	2.0
Microwave	900	7.5	1.0
Computer & TV	360	3	1.0
Garage door & lights	1000	8.3	0.2
MBR Outlets	600	5	1.0
Totals	4060	34.0	7.2

(THIS TABLE APPLIES ONLY TO BATTERY BACKUP SYSTEMS)

Note that the Outback GVFX3648 Inverter will supply a maximum of 3600 watts if the utility grid is down. When the utility grid is up, the inverter will pass through 60A @ 120V, or 7200 VA. If the utility grid is down, the system operates as a stand-alone PV system and is thus subject to the provisions of NEC 690.10(A). When the utility grid is operational, the PV system loads are subject to NEC 220.

Note also that the PV system can be expected to generate approximately 11.2 kWh per day as long as the day is mostly sunny. In the event of a utility outage, run times of loads may need to be adjusted on a daily basis to avoid having the inverter shut down if the battery state of charge reaches the minimum allowable limit of 44 volts. The estimated daily kWh loads in the table are based on assumed standby operation.

When the utility is in operation, the kWh consumption is no longer limited by battery capacity, since the grid will supply 5760 VA continuously (60A C.B.) via the inverter if necessary.

Summary of Major Equipment Manufacturer, Model and Listing/Compliance

Item	Manufacturer	Model	Listing/Compliance
PV Modules	Sanyo	HIP-200BA3	UL
Source Ckt Combiner Box	Outback Power	PSPV	ETL
DC Component Enclosure	Outback Power	PS2DC	ETL
GFDI Device	Outback Power	OBDC-GFP2	ETL
MPPT Charge Controllers	Outback Power	MX-60	ETL
Inverter	Outback Power	GVFX3648	ETL (to UL1741)
AC Component Enclosure	Outback Power	PS2AC	ETL
Storage Batteries	DEKA	8AGC2	ЯU

Battery Backup Grid-Connected Photovoltaic Standby Power System Installation Notes

Following is a brief summary of equipment installation notes. The owner and the installer will be provided with all manufacturers' instruction manuals as well as a copy of the materials that have been submitted to the Florida Solar Energy Center for design review of the system.

I. PV Module Installation

A. Electrical Notes

1. Modules are prewired with #10 USE-2 conductors with molded W/P connectors. Use only the connectors provided for connecting modules in series. Do not cut connectors off except when connectors are terminated in junction boxes where conductors transition from USE-2 to THWN-2. **Do not disconnect connectors under load.**
2. Module output is DC. Twist-on connectors are not suitable for use with DC. Use only the terminal strips provided in the junction boxes for wire junctions.
3. Use cord connector strain relief at junction box entries of module open wiring conductors. Be sure connectors are tightened sufficiently to prevent water entry into the junction box along the wires.
4. Use lay-in ground lugs provided for grounding modules. Mount ground lugs to modules using #10-32 self-threading stainless steel bolts, nuts and lockwashers that are provided with the lugs. Use #10 solid bare wire in continuous runs to ground modules. Removal of any module from the system must not affect the grounding of the remaining modules. The ground wire is junctioned to a #10 green grounding conductor in a junction box as shown on the system electrical schematic diagram.
5. Bond all array mounting structure to modules using approved bonding clips. Use one clip for each individual length of mounting rail.
6. Strap all module open wiring neatly to the mounting frame using UV resistant wire straps.
7. Follow Florida Building Code requirements for any electrical conduit that may be run along the roof.
8. If DC wiring passes through building interior space, NEC690.31(E) requires that the wiring be enclosed in metallic conduit up to the first readily accessible disconnecting means.

B. Mechanical Notes

1. Use Stainless Steel hardware to attach PV Modules to PV Array mounting frame.
2. Follow module mounting detail shown in mechanical drawings of mounting frame.
3. Use anti-seize compound on all stainless steel threads.
4. Coordinate sealing of all roof penetrations with roofing contractor.
5. Use Stainless Steel hardware to mount array frame to roof trusses.

II. Source Circuit Combiner Box Installation

Follow manufacturer's instructions.

III. DC Disconnect Enclosure Installation

Follow manufacturer's instructions.

IV. System Batteries Installation

Follow manufacturer's instructions and install in accordance with NEC requirements. Maintenance free batteries will only need to be vented at the top and bottom of battery container to keep the batteries cool, as per IEEE 1187 and the terminals will need to be protected from accidental short circuits. Flooded lead acid batteries must be vented to the outside at the top of the container with additional vents at the bottom to let air into the enclosure. For flooded batteries, seal off conduit leading to the DC equipment enclosure.

Use only UL listed cables and cable lugs crimped with approved UL crimping tool.

V. GVFX 3648 Inverter Installation

Follow manufacturer's instructions for installation and programming via the MATE system controller.

VI. MX-60 MPPT Charge Controller Installation

Follow manufacturer's instructions for installation and programming via the MATE system controller.

VII. Balance of System (BOS) Component Installation

The balance of system components are shown on the electrical schematic diagram. These are standard AC components that require wiring according to NEC, using standard wiring practices. In particular, the point of utility connection (PUC) has been designed to meet the requirements of NEC 690.64(B).

PVWatts

AC Energy & Cost Savings

Station Identification	
City:	West_Palm_Beach
State:	Florida
Latitude:	26.68° N
Longitude:	80.10° W
Elevation:	6 m
PV System Specifications	
DC Rating:	2.8 kW
DC to AC Derate Factor:	0.770
AC Rating:	2.2 kW
Array Type:	Fixed Tilt
Array Tilt:	22.0°
Array Azimuth:	90.0°
Energy Specifications	
Cost of Electricity:	9.0 ¢/kWh

Results			
Month	Solar Radiation ($kWh/m^2/day$)	AC Energy (kWh)	Energy Value ($)
1	3.31	201	18.09
2	3.88	217	19.53
3	4.77	289	26.01
4	5.46	319	28.71
5	5.73	348	31.32
6	5.46	313	28.17
7	5.68	336	30.24
8	5.38	318	28.62
9	4.87	279	25.11
10	4.16	247	22.23
11	3.46	200	18.00
12	3.03	181	16.29
Year	4.60	3247	292.23