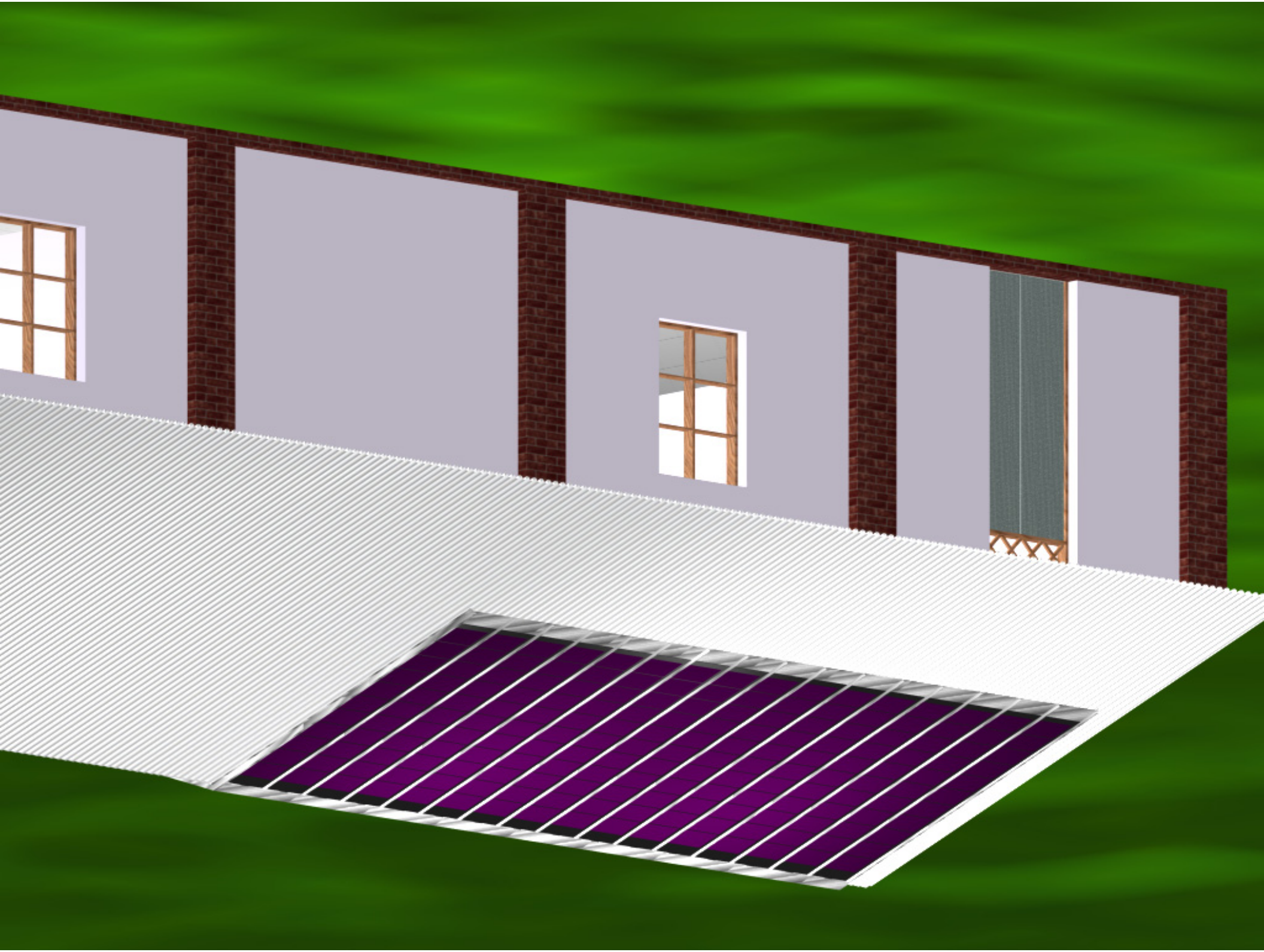


1 MATERIALS

INTRODUCTION:

This section divides up the materials for the five sites.

BACKGROUND INFORMATION:

TOOLS REQUIRED:

MATERIALS / SUPPLIES REQUIRED:

1. All Materials Shipped.

OPERATION MANUALS:

There are five sets of Operation/Owner's Manuals included in the shipment. Each set consist of the following.

1. Phoenix Multi Installation Manual
2. Phoenix Multi User Manual
3. Zantrex Link 10 Battery Monitor Owner's Manual
4. TriStar Installation & Operation Manual
5. Remote Temperature Sensor (RTS) Operator's Manual

INVERTER COMMUNICATIONS:

Accessories required to program with the inverter. Communication with the inverter is not recommended, the programming can be changed.

1. Inverter Programming Disk
2. 25 ft. Cat5 Cable
3. MK.1b Interface

TOOLS SHIPPED:

Tools included in the shipment.

Qty.	Component	Description
1	Hammer Drill	18V 1/2" XPR Hammer Driver/Drill
3	Hammer Drill bits	1" x 12" Concrete Bit
1	Auto Battery Charger	DW9116
1	Extra Battery	XPR 18V (DC9062-6) 2pk
2	1/4" Magnetic Nutdriver	Tapcons @ #2Philips
2	5/16" Magnetic Nutdriver	
10	#2 Philips Tips	
1	Tin Snips	Cutting Steel Roofing
1	Caulk Gun	Caulking Roofing/holes
1	Rivet Gun, 1/8" rivets	Roofing
1	701030, Crimpier	Solar Wiring
1	MC12NG Combo Cutting Snip	Solar Wiring
1	5/8"-2-1/8" Conduit Cutter	Electrical

ADDITIONAL TOOLS REQUIRED:

Tools not included in the shipment, but required for the installation.

Qty.	Component	Description
1	7/16” Deep Socket	Inverter Shipping Bolts
1	Socket Driver	For 7/16” Deep Socket
1	7-8” Socket extension	For 7/16” Deep Socket
1	½” Wrench	Battery
1	7/16” Wrench	Inverter Shipping Bolts
1	Snips	Cable Tie Cutting
4-6	1/8” Drill Bits	Holes for Rivets in Roof
1	#2 Philips Screwdriver	
1	Regular Screwdriver	
100	3-1/2” to 4” Sealtite screws	To replace 2” Sealtite screws

EXTRA MATERIALS:

Extra Materials included in the shipment.

Qty.	Component	Description
~200	#10X3/4" Screws	Misc. Screws
~50	#10X1" Screws	Misc. Screws
~100	#8X3/4" Screws	Misc. Screws
~80	#6X3/4" Screws	Misc. Screws
~40	#6X1/2" Screws	Misc. Screws
2	2 Amp, 1-1/4 x 1/4 Fuse	Extra Fuse
4	3/8" 22-18AWG, Nylon Ring Connector	Spare Parts
4	5/16" 22-18AWG, Nylon Ring Connector	Spare Parts
8	4" Cable Tie	Spare Parts

CONTROL MODULE & BATTERY INSTALLATION:

List of all of the materials required to install the Control Modules and batteries.

Total Needed	Gisenyi	Mutura	Nyabishongo	Rushashi	Rutsiro	Extra	Qty	Unit	Qty	Unit	Component	Description
28	6	6	4	6	6	0	28	Each	28	Each	Batteries	8G8D, 12V 225AH
4	1	1	0	1	1	0	4	Each	2	Each	Panel Crate	4 Identical Control Panels
1	0	0	1	0	0	0	1	Each	1	Each	Panel Crate	1 Control Panel & Wiring Sample
50	10	10	10	10	10	25	75	Each	1	Box	Mounting Board	Tapcons 2-1/2" 75pc
10	2	2	2	2	2	2	12	Each	12	Each	Inverter Mounting	2" x 1/4 SS Lag bolts
10	2	2	2	2	2	2	12	Each	12	Each	Inverter Mounting	1/4" SS Washers
10	2	2	2	2	2	2	12	Each	12	Each	Inverter Mounting	1/4" SS Locking Washers
10	2	2	2	2	2	2	12	Each	12	Each	Inverter Mounting	1/4" SS Nuts

SOLAR ROOFING, SOLAR WIRING & CONTROL PANELS:

List of materials required in installing the solar panels and controlling Modules.

Total Needed	Gisenyi	Mutura	Nyabishongo	Rushashi	Rutsiro	Extra	Qty	Unit	Qty	Unit	Component	Description
144	32	32	20	28	32	2	146	Each	146	Each	Solar Panels	US-PLV64TM
144	32	32	20	28	32	0	144	Each	144	Each	Steel	16"x10' Gal Image II
9.9	2.2	2.2	1.4	1.9	2.2	0.1	10	Each	10	Each	Steel	Ridge 10'2"
20	4	4	4	4	4	0	20	Each	20	Each	Steel	Custome Z Gal 12'
20.7	4.6	4.6	2.9	4	4.6	0.3	21	Each	21	Each	Steel	Ridge Z Closure 10'2"
1008	224	224	140	196	224	1492	2500	Each	2500	Each	Screws	Mod Truss Screws
632	136	136	100	124	136	368	1000	Each	1000	Each	Rivots	1/8" Rivots
1000	222	222	140	193	222	0	1000	Each	1000	Each	Screws	DekFast 2" Screws
125	28	28	17	24	28	31	156	Each	156	Each	Firring	1x3-8' Firring Srips
									2	Box	Screws, Furring	3-1/2 Coarse Drywall screws (5#)
216	48	48	30	42	48	84	300	Ft	12	Rolls	Sealant	Tape Sealant 25' rolls
							10	Each	10	Each	Steel Sealant	Tube Sealant
							4	Each	4	Each	Sealent	Silicone Sealant
							4	Each	4	Each	Sealent	Silicone Sealant
							500	Each	1	Box	Screws	2" Sealtite Screw White 500Ct
1426	330	330	166	270	330	574	2000	Ft	4	Rolls	Solar Wire	10AWG BK Strd 500ft
1426	330	330	166	270	330	574	2000	Ft	4	Rolls	Solar Wire	10AWG RED Strd 500ft
144	32	32	20	28	32	6	150	Each	150	Each	Solar Wiring	Nylon Butt Connectors 12-10AWG
144	32	32	20	28	32	6	150	Each	150	Each	Solar Wiring	Nylon Ring Terminals, 12-10AWG
							900	Each	1	Bag	Wire Management	7" BLK Cable Tie, 1000
							160	Each	2	Bag	Wire Management	1" UV BLK Mounting Base
									1	Box	Extra Screws	1-1/4" Drywall (5#)
									1	Box	Extra Screws	2-1/4" Drywall (1#)

Red indicates estimate.

ELECTRICAL WIRING:

List of all of the materials required for electrical wiring.

Total Needed	Gisenyi	Mutura	Nyabishongo	Rushashi	Rutsiro	Extra	Qty	Unit	Qty	Unit	Component	Description
400	80	80	80	80	80	146	546	Ft	3	Rolls	GRN Wire	4 Stranded Bare copper 198f
5	1	1	1	1	1	1	6	Each	6	Each	GRN Rod	5/8 in 8ft Bonding Grd Rod
5	1	1	1	1	1	1	6	Each	6	Each	GRN Rod Clamp	5/8 in Ground Rod Clamp
44	8	14	4	6	12	0	44	Each	44	Each	Service	3/4" ENT Conduit 10'
132	24	42	12	18	36	8	140	Each	7	Each	Service	3/4" 1 Hole strap 20pk
44	8	14	4	6	12	0	44	Each	44	Each	Service	3/4" SLB Cond Body w/cover
44	8	14	4	6	12	0	44	Each	44	Each	Service	3/4" Rigid Conduit Nipple
2382	400	1171	125	110	576	118	2500	Each	2	Rolls	10AWG-2,	10-2UF Outdoor 1000'
									2	Rolls	10AWG-2,	10-2UF Outdoor 250'
289	59	110	10	20	90	106	395	Each	2	Box	Wire Staples	3/4" Plastic Staples 175pc
27	5	7	3	5	7	0	27	Each	27	Each	Elec Box	Ceiling Box 4"x1-1/2
27	5	7	3	5	7	0	27	Each	27	Each	Elec Box cover	Ceiling Box Cover
2765	525	735	385	455	665	235	3000	Each	3	Rolls	14AWG-3	14-3 NMWG 1000'
4729	930	1072	748	1014	965	271	5000	Each	5	Rolls	14AWG-2	14-2 NMWG 1000'
1080	200	320	120	160	280	95	1175	Each	5	Box	Wire Staples	1/2" Plastic Staples 225pc
161	31	40	25	28	37	39	200	Each	2	Bag	3/8"wire clamps	3/8" Clamp Connector 100pk
10	2	2	2	2	2	0	10	Each	2	Bag	3/4" wire clamps	3/4" Clamp Connector 5pk
						5	5	Each	5	Each	1" wire clamps	1" Clamp Connector each
167	32	44	23	28	40	10	177	Each	177	Each	Single Box	Handy Box 4"x2"x1-7/8" 1/2"no
88	17	23	12	15	21	5	93	Each	93	Each	Inside Conduit	1/2" ENT conduit 10'
246	47	65	34	41	59	164	410	Each	4	Bag	Conduit-to-box	Set Screw Connector 100pk
264	51	69	36	45	63	251	515	Each	5	Bag	Conduit Clips	1/2" 1 hole strap 100pk
932	179	245	128	157	223	43	975	Each	13	Box	Tapcons, 75pk	3/16"x1-1/4" Concrete Anchors
132	24	42	12	18	36	243	375	Each	5	Box	Tapcons75pk	3/16"x1-3/4" Concrete Anchors
88	17	23	12	15	21	5	93	Each	93	Each	15A Plugs	15A Self GRND Duplex White
79	15	21	11	13	19	5	84	Each	84	Each	Light Switch	15A 120V Grnd Switch White
88	17	23	12	15	21	5	93	Each	93	Each	Plug Covers	Box Cover, Duplex
79	15	21	11	13	19	5	84	Each	84	Each	Light Covers	Box Cover, Single Toggle Switch
79	15	21	11	13	19	1	80	Each	80	Each	Fluorescent Bulb	2FT T12 20W Natural Sunlight
79	15	21	11	13	19	1	80	Each	80	Each	Light Fixture	2FT LT Strip Comm (JLQ24)
257	49	67	37	43	61	43	300	Each	3	Box	CeilingBox&Light	#8 screws, 100pc.
291	55	79	39	47	71	109	400	Each	5	Box	Wire Nuts	76B Red Wire Nuts 100ct
185	35	47	25	33	45	115	300	Each	4	Box	Wire Nuts	74B Yellow Wire Nuts 100ct
							10	Rolls	1	Pack	Black Elec Tape	Vinyl Electrical Tape 10ct
							1	Rolls	1	Rolls	Red Elec Tape	Red color elec tape

2 INSTALLATION LOCATION

INTRODUCTION:

This section describes the design considerations for what building to install the Solar Panels on, where to place the Control Module and Batteries, and the best location for electrical equipment with high power requirements (like multiple computers). Power Building will be used henceforth to identify this building.

BUILDING SELECTION:

Each of these design considerations is listed in order of priority. If conditions A & D both cannot be meet, condition A should be meet and E over-looked.

A. The Solar Panels, Control Module, Batteries, and computers should be in the same building.

   NOTE: A computer can be used in any building. Power consumption is linearly proportional to the distance traveled (length of wire used) therefore; placing multiple computers at great distances from the power source (inverter/batteries/Solar Panel) will put a greater strain on the system.

B. The building selected should be in the center of all buildings being powered.

C. The Batteries will NEED to be within 6_feet (1.8_meters) of the Control Module in a ventilated room, not in a completely sealed room.

D. The Control Module should be directly below the Solar Panels.

E. The building's peak should have an East-West orientation so the Solar Panels will be oriented North-South.

F. The Control Module should be located on an Out-side wall. There will be a grounding wire running from the Main to a bonding grounding bar.

G. The refrigerators and other continuously running high power consumption devices should be located in the Power Building or an adjacent building.

3 CONTROL MODULE & BATTERY INSTALLATION

INTRODUCTION:

This section describes the un-packing and mounting of the Control Module, the placement and connection of the Batteries, and turning on the Inverter. At the end of this section, 110VAC should be available from stored energy in the Battery.

BACKGROUND INFORMATION:

TOOLS REQUIRED:

1. #2 Philips Bit.
2. ¼" Magnetic Nutdriver
3. DeWalt Screw Gun.
4. #2 Philips Screwdriver.
5. 7/16 deep Socket.
6. Socket Driver.
7. 7-8" Socket Extension.
8. ½" Wrench.
9. 7/16" Wrench.
10. Snips.

UN-PACKING THE CONTROL MODULES:

There are three (3) crates with five (5) Control Modules and a wiring example. Two of the crates have four (4) identical Control Modules. The third crate has the Control Module for Nyabishongo and a wiring example. Each of the Control Modules has its corresponding battery cable connected and pre-assembled. The battery cable assemblies are attached to the plywood adjacent to its corresponding Control Module. Therefore, care needs to be taken in un-crating the Control Modules.

A. Separate a crate to get two separate Control Modules.

Step 1: Tip the crate on its side.

Step 2: Unscrew the Bottom 2x4 plywood sheet and remove it.

Step 3: Tip the crate upright.

Step 4: Unscrew the Top 2x4 plywood sheet and remove it.

NOTE: Looking inside the crate, you can see how the battery cable assemblies are attached to the Control Module and to the side of the crate.

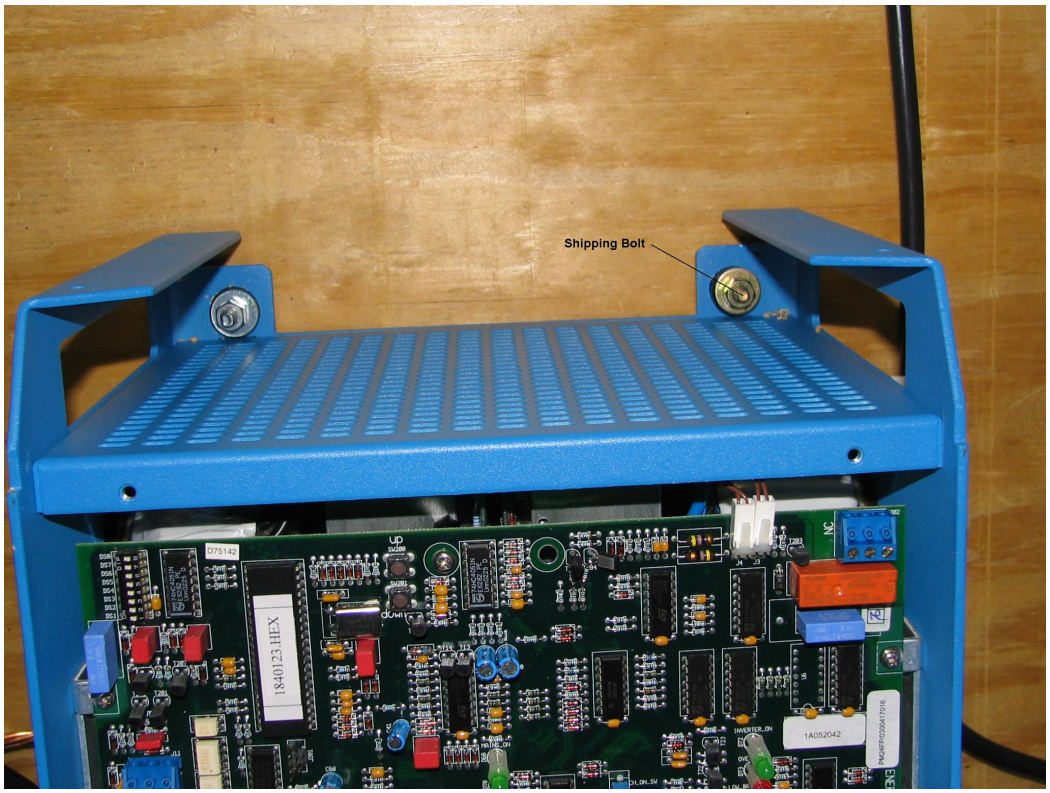
Step 5: Move to the side of the crate so a 2x4 plywood sheet is in front of you.

Step 6: Remove the screws on the LEFT side of the 2x4 plywood sheet.

Step 7: Move to the opposite side of the crate of 2x4 plywood sheet just removed.

Step 8: Remove the screws on the LEFT side of the other 2x4 plywood sheet.

Step 9: Pull the two Control Modules apart.



Picture 3.1; Inverter Shipping Bolts.

B. Remove the two shipping bolts on the inverter and replace with carriage bolts.

NOTE: The Control Modules can be mounted to the wall with the 2x4 studs on the back of the 4x4 plywood sheets (not preferred). If the 2x4 studs are not removed, the shipping bolts do not need to be replaced. The 2x4 studs may be needed for blocks for the furring strips; see Section 4.

Step 1: Unscrew the 4 screws on the top cover of the inverter and remove cover.

Step 2: Unscrew and Remove the shipping bolt on the top Right of the inverter.

Step 3: Push the carriage bolt through the hole on the backside of the 4x4 plywood sheet and through the inverter-mounting hole. Verify that the two black spacers are still in place.

NOTE: The carriage bolts have a rounded head.

Step 3: Install the nut, washer, and lock washer on the carriage bolt. Do not over tighten the nut. Go about ½ turn after snug.

Step 4: Replace the cover on the inverter.

Step 5: Repeat steps 2-3 for the shipping bolt on the bottom Left of the inverter.

C. Remove the battery cable assemblies and the 2x4 plywood.

Step 1: Snip the cable ties holding the battery cable assembly to the 2x4 plywood.

WARNING: The cable ties that go through the black mounting bases are the ones that need to be snipped. Also, these cable ties have not been trimmed. The cable ties that are holding the battery cable assembly together are trimmed and Should NOT BE Snipped.

Step 2: Tip the Control Module on its back so that the components are facing up.

Step 3: Unscrew the 2x4 plywood sheet the battery cable assembly was mounted to and remove it.

D. Remove the 2x4 studs from the Control Module.

Step 1: Unscrew the black drywall screws that are on the face of the Control Module. They will be along the edge within the first 2.5_inches (6.35_cm).

Step 2: Remove the 2x4 studs from under the Control Module.

CONTROL MODULE COMPONENTS:

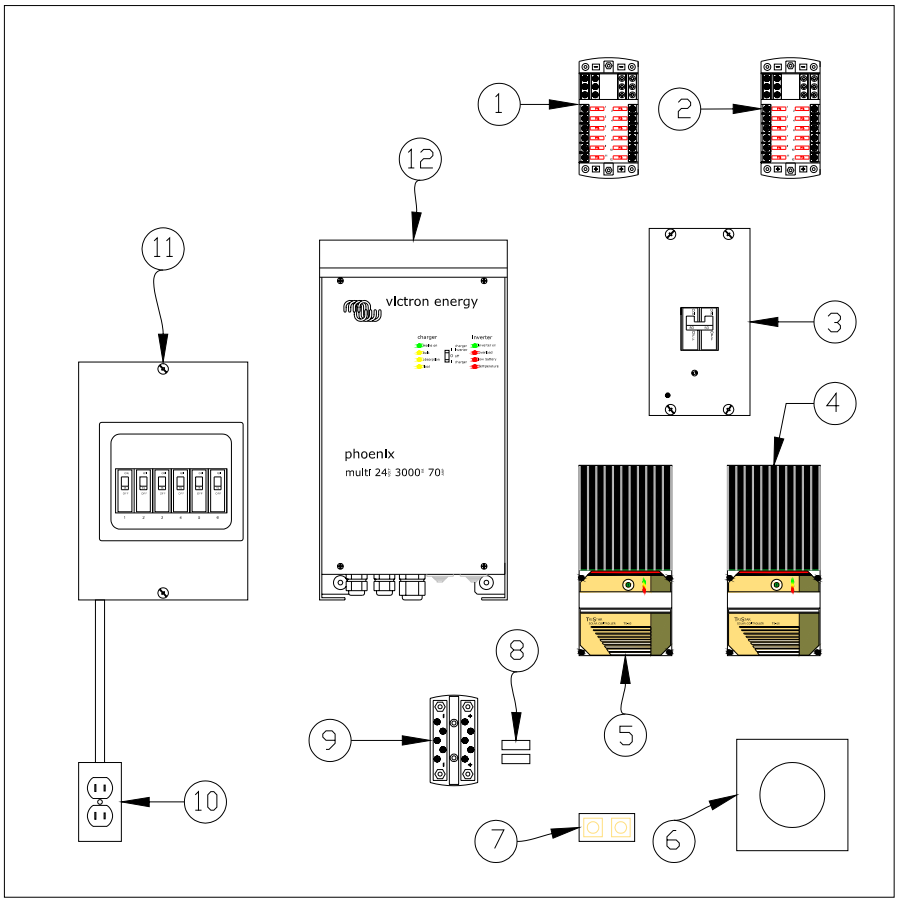


Figure 3.2: Control Module

1. Combiner Box 1, for Solar Array One
2. Combiner Box 2, for Solar Array Two
3. Solar Disconnect
4. Charge Controller 2, for Solar Array Two
5. Charge Controller 1, for Solar Array One
6. Battery Monitor
7. Battery Monitor's Sense Resistor
8. Battery Monitor's Fuse Holder, 2-Fuzes
9. DC Lug
10. 110_VAC Plug
11. Main AC Lug
12. Inverter

1. Combiner Box 1 combines all of the wires from Solar Array One. All of the Negative (black) wires are connected to a common terminal. Each of the Positive (red) wires is connected to individual terminals. Individual positive terminals are fused.

2. Combiner Box 2 combines all of the wires from Solar Array Two. Same as Combiner Box 1.

3. Solar Disconnect is a circuit breaker that connects-disconnects both Solar Arrays to-from the Control Module.

4. Charge Controller Two is a battery charge controller that regulates the energy from Solar Array Two to the Battery.

5. Charge Controller One is a battery charge controller that regulates the energy from Solar Array One to the Battery.

6. Battery Monitor measures the energy stored-removed from the battery. The Battery Monitor has a display enabling a user to view the present state of the battery.

7. Battery Monitor's Sense Resistor enables the Battery Monitor to measure the current being stored-removed from the battery.

8. Battery Monitor's Fuse Holder protects the Battery Monitor.

9. DC Lug is Positive (red) and Negative (black) connection for the Inverter, Charge Controllers, and the Battery. This is a 24_VDC Lug with isolated Positive and Negative terminals.

10. 110_VAC Plug is an AC outlet plug.

11. Main AC Lug is the power distribution box for the AC circuits. There are 6 circuit breakers in the Main AC Lug to distribute AC power.

12. Inverter takes 24_VDC power from the Solar Panels and/or Batteries and creates 120_VAC, 60_Hz power.

MOUNTING THE CONTROL MODULES:

The Control Modules are heavy. Mounting the modules will take at least four people. Mount the module on the wall about 3_ft (0.9_m) from the floor. An easy way to do this is to place the module on 2x4 studs that have been cut to 3-ft (0.9_m), see Figure 3-2. This will help keep the module in place while Tapconning it to the wall. If the 2x4 studs were left on the back of the Control Module, use the 3-1/2" Tapcons. If the 2x4 studs were removed (preferred), use the 1-3/4" Tapcons.

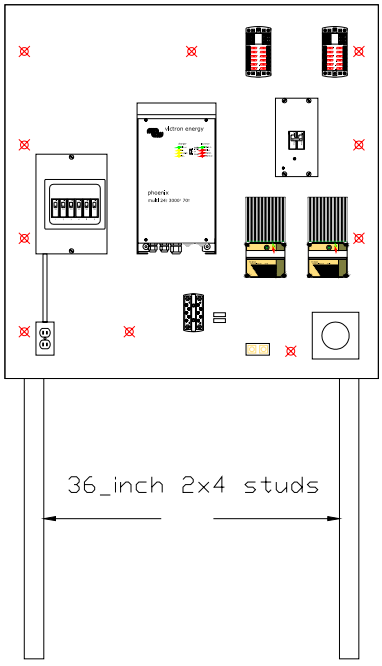


Figure 3.3: Control Module Mounting.

A. Get all the material ready for mounting the Control Module.

Step 1: Get two 2x4 studs cut to 36_inches (0.9_m).

Step 2: Get the Tapcons (3-1/2" for 2x4 stud on the back of the Control Module, 1-3/4" for not studs) and the concrete drill bit. There is a concrete drill bits in each box of Tapcons.

Step 3: Get the DeWalt Hammer Drill and ¼" Magnetic Driver.

B. Mount the Control Module to the wall by installing ~10 Tapcons through the Control Module's 4x4 plywood mounting board to the brick wall. Figure 3-3 shows 10 red circled X's for ideal Tapcon locations. It will be easiest to install module in a three-step process. One; drill the first hole and then install the first Tapcon in the bottom-left, two; drill the second hole and then install the second Tapcon in the top-right, third: drill all the remaining holes and then install all the remaining Tapcons.

NOTE: The following steps assume that the Control Module will be mounted on a brick/concrete wall. If the Control Module is to be mounted to a wood stud wall, the following steps should be ignored and the screws will need to go through the mounting board and into wall studs.

Step 1: Place the 36_inch (0.9_m) 2x4 studs on the floor against the wall, see figure 3.3.

Step 2: Place the Control Module on top of the 36_inch (0.9_m) 2x4 studs.

Step 3: Install the concrete bit in the Hammer drill and set the drill to hammer. Turn the arrow to the picture of a hammer on the drill.

Step 4: Drill a 3/16" hole in the bottom left corner of the mounting board. The hole MUST go through the mounting board and brick to a depth of the length of the Tapcon screw used, 3-1/2" or 1-3/4".

Step 5: Install the ¼" Magnetic Nutdriver in the Hammer drill and set the drill to drill. Turn the arrow to the picture of the drill bit on the drill.

Step 6: Screw the Tapcon into the hole in the mounting board until it is flush with the surface.

NOTE: The best way to screw Tapcons is to start pushing with a medium pushing force and increase the force as the screw enters the hole.

Step 7: Repeat Steps 3-6 in the upper right corner of the mounting board.

Step 8: Re-install the concrete bit in the Hammer drill and set the drill to hammer. Turn the arrow to the picture of a hammer on the drill.

Step 9: Drill the remaining 8, 3/16" holes in the mounting board.

Step 10: Re-install the ¼" Magnetic Nutdriver in the Hammer drill and set the drill to drill. Turn the arrow to the picture of the drill bit on the drill.

Step 11: Screw the remaining Tapcons into the holes in the mounting board until they are flush with the surface.

Step 12: Remove the two 36_inch (0.9_m) 2x4 studs holding the Control Module in place.

CONNECTING THE BATTERY:

Great care needs to be taken in handling the batteries. First, the batteries store energy. Be careful not to touch the terminals of the battery together. This is very easy to do when working with tools around the battery. Second, the batteries are very heavy. Each battery weighs 160.8_Lbs (72.9_Kgs.)

A. The Solar Disconnect, Inverter, and Main AC Lug all need to be turned off and the fuses in the Battery Monitor's Fuse Holder need to be removed before connecting the batteries. See Figure 3.2 on Page 3-5.

Step 1: Verify that the Solar Disconnect (3) is OFF, circuit breaker is in the down position.

Step 2: Verify that the Inverter (12) is in the OFF position, switch in the center position.

Step 3: Verify that all six circuit breakers are OFF in the Main AC Lug (11), circuit breakers are in the down position.

Step 4: Verify that both fuses are removed from the Battery Monitor's Fuse Holder (8).

B. Placing the batteries to the right of the Control Module will insure that the Battery Cable Assembly is out of the way when working on the Control Module. The Batteries need to be oriented with three columns of two-batteries. Each of the batteries will need about 1_inch (2.54_cm) space between them and 1-4_inches (10.2_cm) from the wall. See Figure, 3.4.

NOTE: Nyabishongo will only have four batteries, two columns of two.

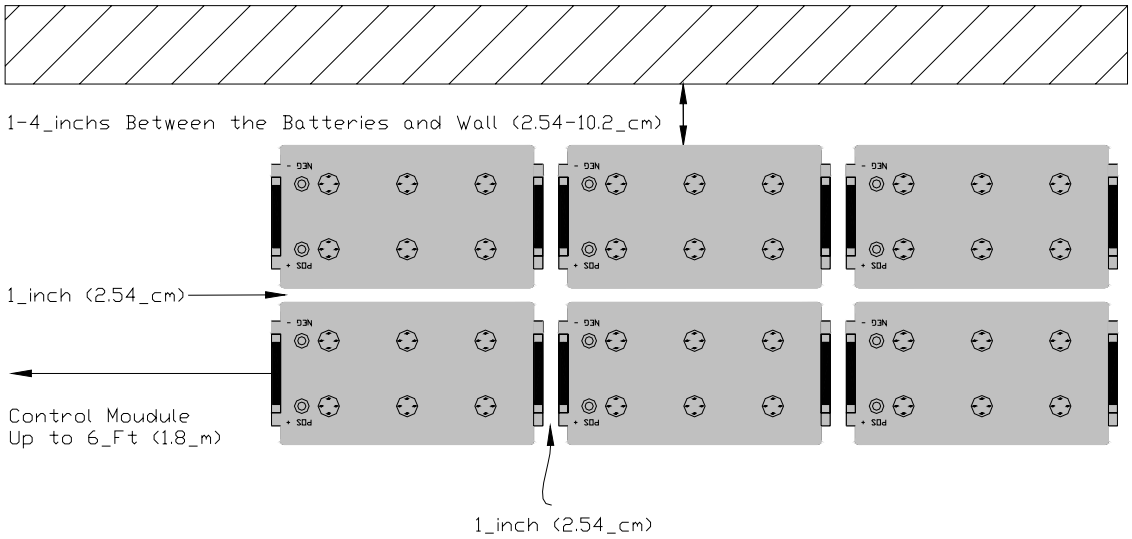


Figure 3.4: Battery Placement

C. Connect the Battery Cable Assembly to the batteries. The Battery Cable Assembly is pre-assembled. It will be easier to connect the cable to the batteries by disassembling the cable and then re-assembling the cable on the batteries.

Step 1: Spread the Battery Cable Assembly out on the floor such that it can be disassembled with all of the pieces left in their proper position.

Step 2: Remove the three wing nuts on the Negative (Black) cable. This will remove the Negative Battery Lugs from the cable assembly.

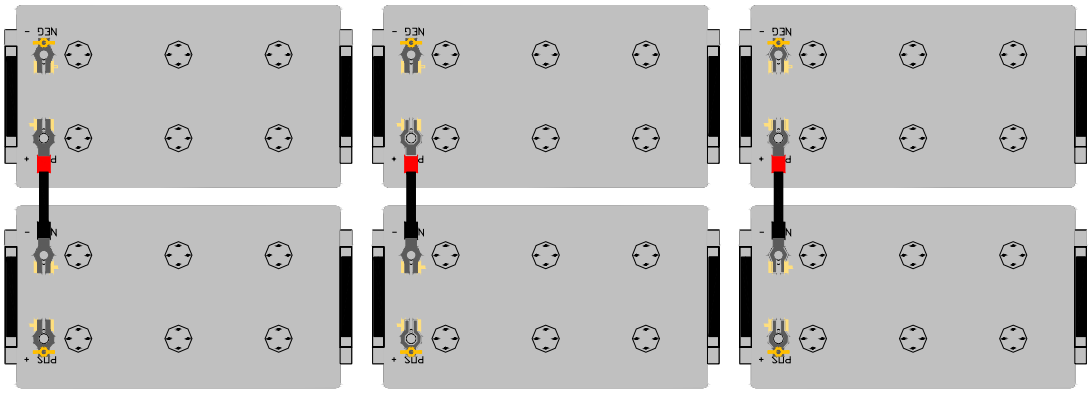


Figure 3.5: Battery Lug & Series Battery Cable Installation

NOTE: The Negative & Positive Battery Lugs are different size. The Positive Battery Lugs are for a larger post (3/8") than the Negative Battery Lugs (5/16").

Step 3: Install the Battery lugs just removed on the NEG Battery Post closest to the wall, See Figure 3.5. The nuts on the Battery lugs require a ½" wrench.

Step 4: Remove the three wing nuts on the Positive (Red) cable. This will remove the Positive Battery Lugs from the cable assembly.

Step 5: Install the Battery lugs just removed on the POS Battery Post, See Figure 3.5. The nuts on the Battery lugs are ½".

Step 6: Install the three Series Battery Cables. These cables are about 9_inches (23_cm) long with a battery lug on both ends with Red shrink on one end (Positive) and Black shrink on the other end (Negative). The end with Red shrink goes on the POS of the battery and the Black on the NEG; see Figure 3.5.

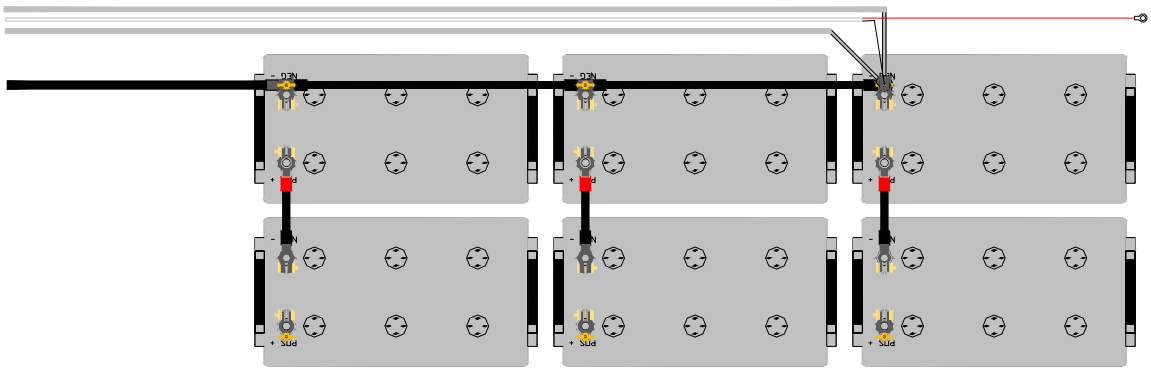


Figure 3.6: Negative Battery Cable Installation

Step 7: Place the negative cables on the Negative Battery Lug, NEG post to the far right (last, farthest from the Control Module). This post will have four wires on it.

1. 1AWG Black Wire.
2. 2-Remote Temperature Sense wires, Gray.
3. Voltage Sense wire, Black

Step 8: Screw the wing nut on the Negative Battery Lug.

Step 9: Place the negative cables on the middle batteries Negative Battery Lug, NEG post. This post will have two 1AWG Black wires.

Step 10: Screw the wing nut on the Negative Battery Lug.

Step 11: Repeat Steps 9-10 for the negative cables on the Negative Battery Lug, NEG post to the far left (first, closest to Control Module). This post will also have two 1AWG Black wires.

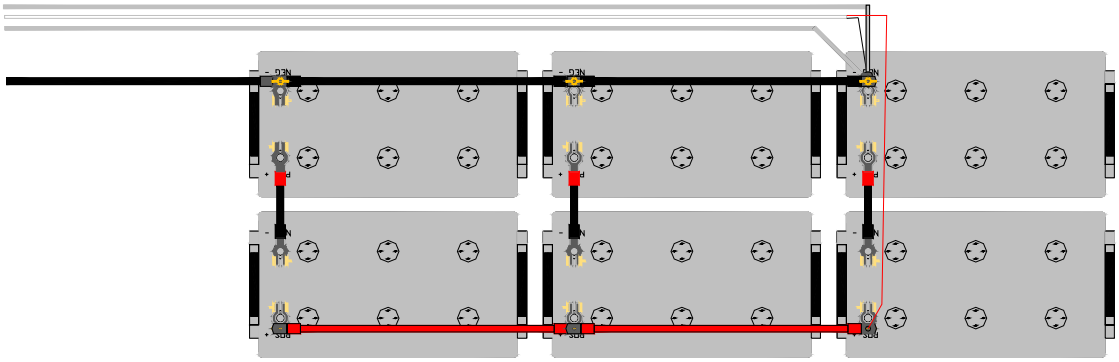


Figure 3.7, Positive Battery Cable Assembly

Step 12: Place the Positive cables on the Positive Battery Lug, POS post to the far right (last, farthest from the Control Module). This post will have two wires on it.

1. 1AWG Red Wire.
2. Voltage Sense wire, Red

Step 13: Screw the wing nut on the Positive Battery Lug.

Step 14: Place the Positive cables on the middle batteries Positive Battery Lug, POS post. This post will have two 1AWG Red wires.

Step 15: Screw the wing nut on the Positive Battery Lug.

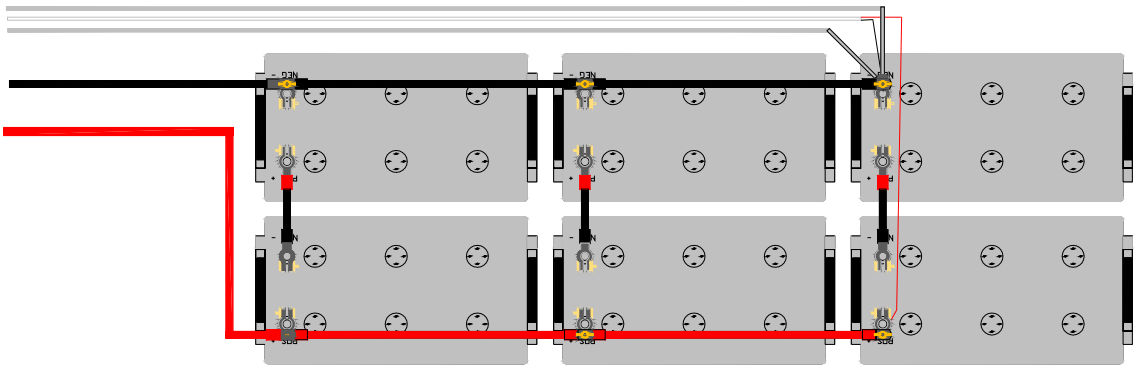


Figure 3.8, Connecting Power to the Control Module

WARNING: Connecting the Positive (Red) wire from the Control Module to the Battery will cause a SPARK, a Very Loud SPARK. Once you have the Positive wire from the Control Module in contact with the Battery, KEEP it connected!!

Step 16: Grab the Positive cable from the middle battery in your right hand. Grab the Positive cable from the Control Module in your left hand.

Step 17: Place the Positive cable from the middle battery on the Positive Battery Lug, POS post to the far left (first, closest to Control Module).

Step 18: While holding the battery cable from Step 17 in place, Quickly, Place the Positive cable from the Control Module onto the post (loud Spark). KEEP THE CABLE IN CONTACT WITH THE POST!!

Step 19: Screw the wing nut on the Positive Battery Lug with your right hand while holding the Positive cable from the Control Module on the battery post with your left.

TESTING THE INVERTER:

The Inverter can be run with battery power. If there is enough energy stored in the batteries, the Inverter will run. Do not get too over-concerned if the Inverter does not operate at this time!

A. Install the fuses in the Battery Monitor's Fuse Holder. The bottom Fuse MUST be installed first. See Figure 3-2 on Page 3-5.

Step 1: Install the bottom fuse in the Battery Monitor's Fuse Holder.

Step 2: Install the top fuse in the Battery Monitor's Fuse Holder. The Battery Monitor will turn ON.

B. Turn ON the Inverter and the AC Plug for the test.

Step 1: Toggle the Inverter's control switch to the CHARGER INVERTER Position. Push the topside of the switch in.

NOTE: The GREEN (INVERTER ON) Led should light up.

Step 2: Flip circuit number 6 on the Main AC Lug to the ON position. ON is up.

Step 3: Plug an electric device into the AC Plug to verify AC power.

Step 4: Flip circuit number 6 on the Main AC Lug to the OFF position. OFF is down.

Step 5: Toggle the Inverter's control switch to the OFF Position. Push the switch to the center position.

NOTE: The GREEN (INVERTER ON) Led should turn off.

4 SOLAR PANEL AND ROOF INSTALLATION

INTRODUCTION:

This section describes the installation of the Solar Panels and Roof. From the pictures I have seen, I have made the assumption that the roofing construction technique used is of Truss-Beam and Purlin. These are Truss-Beams every 10-12_feet (3-3.6_m) and Purlin running between the Truss-Beams every 16-24_inches (40.6-61_cm). The existing steel roof should be screwed/nailed into the Purlins. Therefore, determining the location of the Purlins should be easy.

Whatever roofing construction technique used, the Furring Strips need to be screwed into wood every 16-24_inches (40.6-61_cm). The Solar Panels and new roof will be installed at the peak of the existing roof with one-half of the panels on one side (Solar Array One) and one-half of the panels on the other side (Solar Array Two). These two Solar Arrays need to line up so a ridge cap can environmentally seal the top of the roof and wiring.

The Solar Panels should be installed directly above the Control Module. This will make the solar panel wires (Positive & Negative) running between the Solar Panels and the Combiner Boxes (Combiner Box 1 for Solar Array One & Combiner Box 2 for Solar Array Two) as short as possible.

BACKGROUND INFORMATION:

TOOLS REQUIRED:

1. #2 Philips Bit.
2. DeWalt Screw Gun.
3. ¼" Magnetic Nut Driver.
4. Tin Snips.
5. Caulk Gun.
6. Terminal Crimp.
7. Rivet Gun.
8. Combo Cutting/Snip.
9. Wood Saw.
10. Chalk Line.
11. Chalk.
12. 30' Tape Measure.
13. 1/8" Drill Bit

FURRING STRIP INSTALLATION:

Five rows of Furring Strips need to be installed on both sides of the roof (ten total). It is critical that the Furring Strips be straight and square. The roofing panels will follow the Top Furring Strip and control the alignment of the new roof, especially the first roofing panel on each side. At the peak of the roof, the Top two Furring Strips need to be parallel to insure that the Ridge Cap will fit on the ridge. There is a Customized Z-Closure for both rakes of the new roof (right & left) to seal the both ends of the new roof. Each rake closure will run along the edge of the roofing panel on the front of the building and continue over the peak to the roofing panel on the back of the building. Therefore, the roofing panels on both sides need to be lined up with each other, thus the ends of the furring strips on both sides of the roof need to be lined up.

Location	# Panel	Panels/ Array	Length of Furring Strips	
			Feet/Inch	Meters
Gisenyi	32	16	21' 4-3/8"	6.51
Mutura	32	16	21' 4-3/8"	6.51
Nyabishongo	20	10	13' 4-3/8"	4.07
Rushashi	28	14	18' 8-3/8"	5.7
Rutsiro	32	16	21' 4-3/8"	6.51

Table 4.1; Furring Strip Length

A. Install the Top Furring Strips at the peak of the roof. The Furring Strips need to be 2-3/4_inches (6.985_cm) from the peak, see Figure 4.1 on this page & Figure 4.2 on page 4-3.

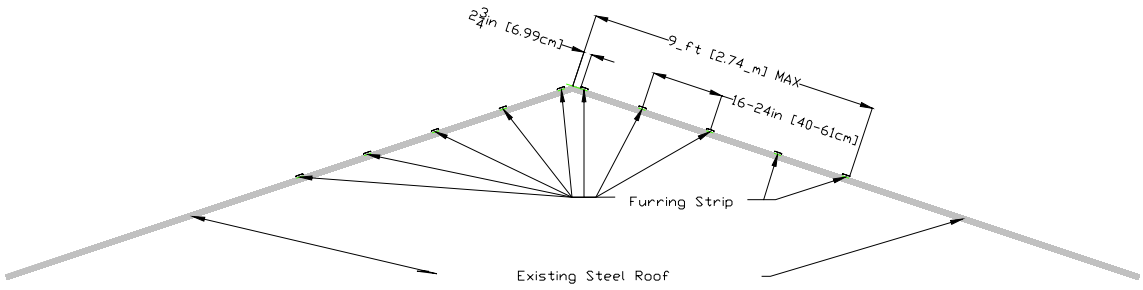


Figure 4.2; Furring Strip Diagram

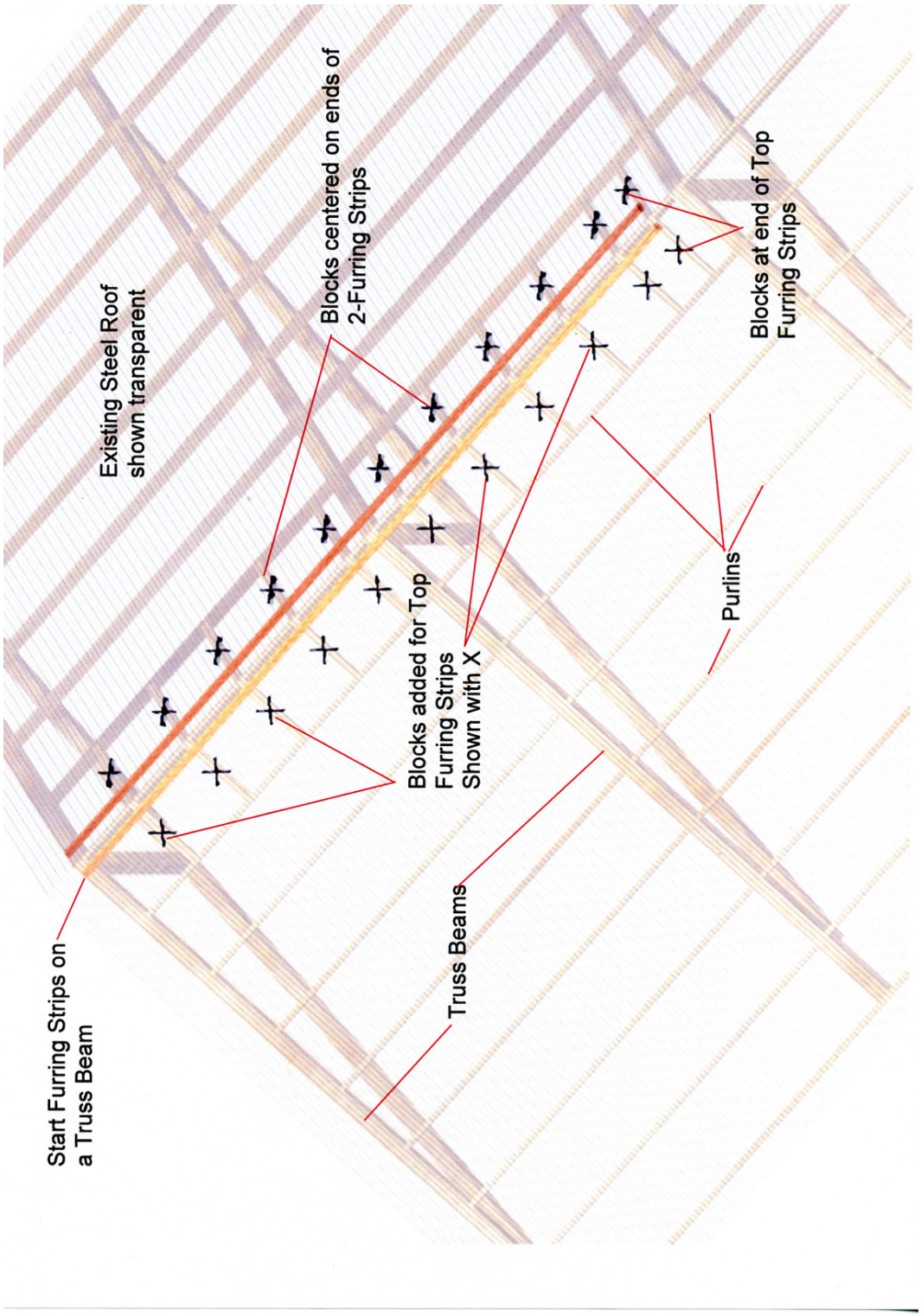


Figure 4.3; Furring Strip Location

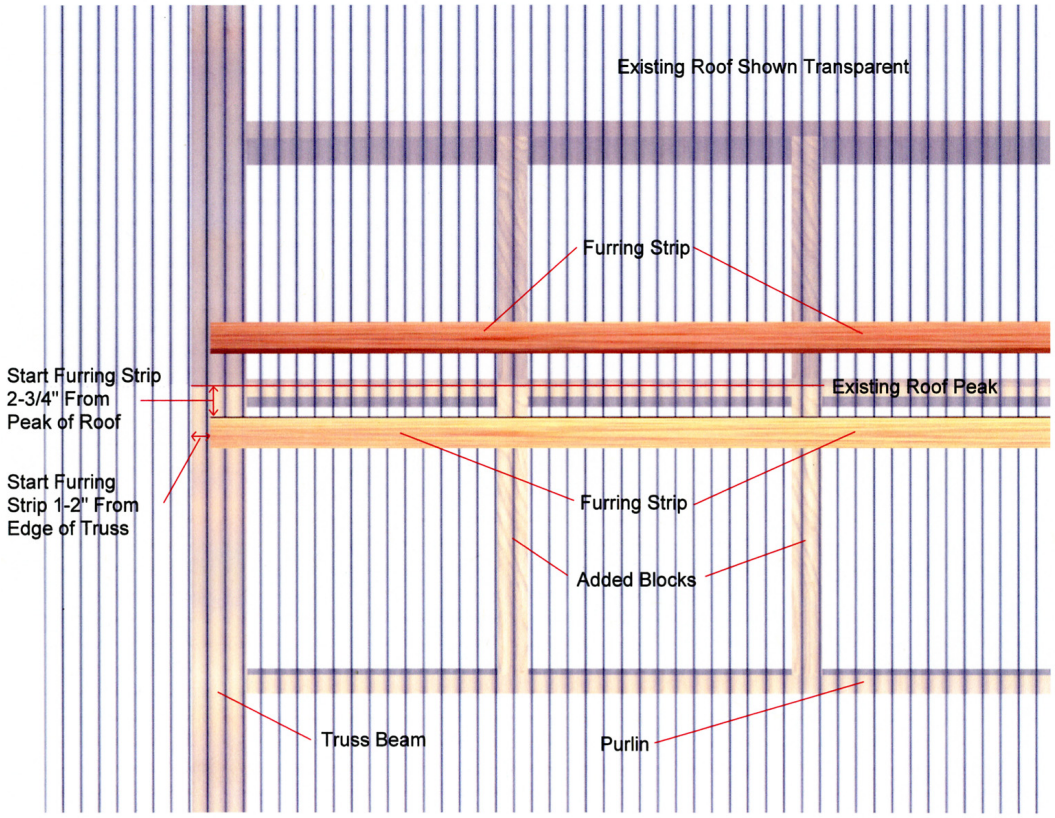


Figure 4.4: Top Furring Strip Detail

Step 1: Install blocks on the underside of the roof (inside) for the Top Furring Strip; see Figure 4.3 on page 4-3. These blocks should be 16-24_inches (40.6-61_cm) apart.

NOTE: Each board used for the furring strips are 8_ft (2.44_m) long and need to span a greater distance. Three boards (two for Nyabishongo) will be used for each complete Furring Strip. Centering a block 8_ft from the starting end of the Furring Strip will enable securing the end of one board and the beginning of the next on the same block.

Step 2: Snap a chalk line at the peak of the roof. The line needs to be longer than the length of the furring strips, see Table 4.1 on page 4-2. It is better to snap one line from two points than multiple lines from multiple points.

NOTE: This step can be replace with making two marks on the peak. Placing one mark on each side of the roof, outside (greater distance apart than the Furring Strip length, Table 4.1, page 4-2) of where the Furring Strips will be installed.

Step 3: Snap a line 2-3/4" (6.99_cm) below the chalk line at the peak (or marks). This is the line that the Top Furring Strip will follow.

NOTE: A Top Furring Strip will be installed on the opposite side of the roof. It is important that the same point at the peak used for the 2-3/4" (6.99_cm) measurement in this step is used for the opposite side of the roof. Thus, making the Top two Furring Strips parallel.

Step 4: Screw 3-1/2" Drywall Screws every 16-24_inches (40.6-61_cm) into the furring strip boards. These screws MUST go through the furring strips and into wood (blocks).

Step 5: Repeat Steps 3-4 on the other side of the roof with the other Top Furring Strip. Both Top Furring Strips MUST be parallel and the ends flush.

NOTE: By measuring the distance between the two furring strips, you can determine parallel. This distance should be around 5-11/16" (14.45_cm).

B. Install the bottom Furring Strips. These Furring Strips should follow a Purlin. The ends of the bottom Furring Strips MUST be perpendicular to the Top Furring Strips. By following a Purlin, it may be impossible to keep the bottom Furring Strips parallel with the Top Furring Strips, see Figure 4.5 on the next page.

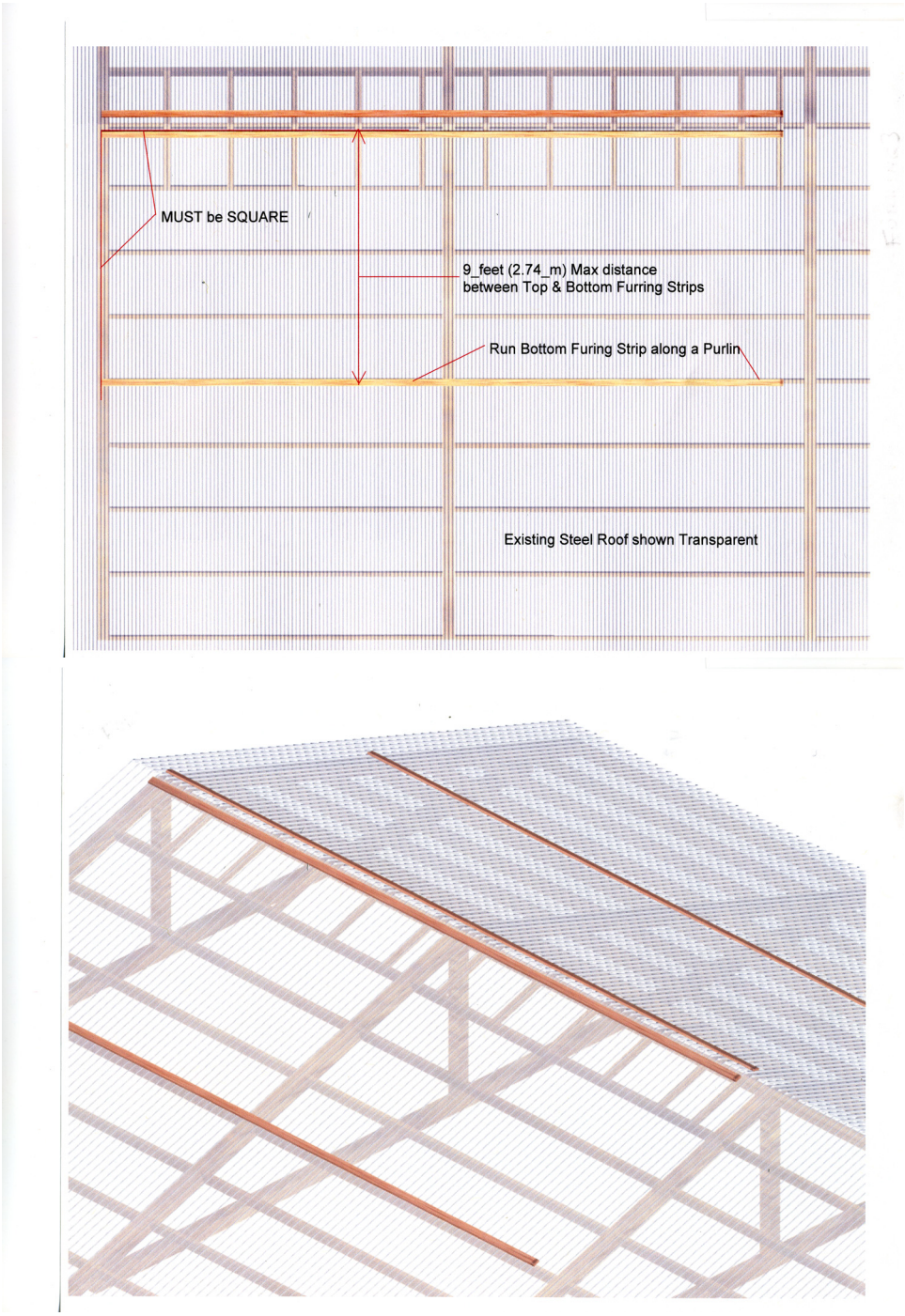


Figure 4.5; Bottom Furring Strip Detail

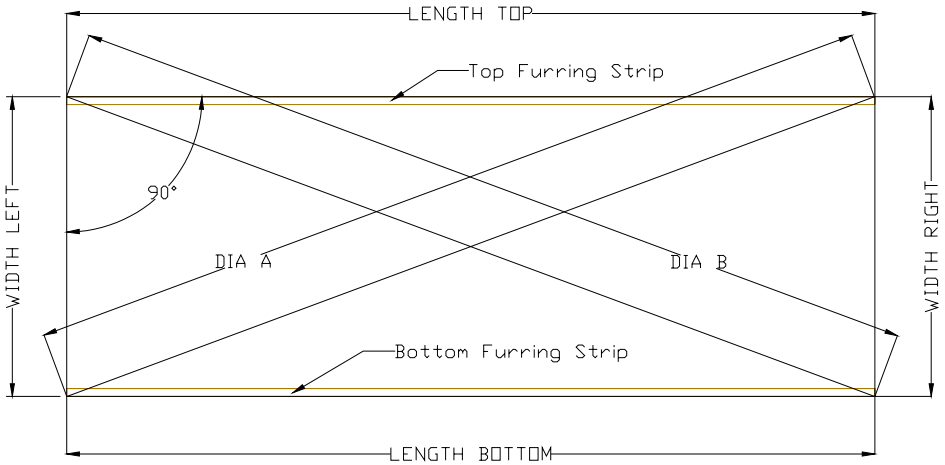


Figure 4.6; Perpendicular Diagram

The idea is for the furring strips to be perpendicular (90º). If the Purlin is not parallel with the peak, Width Left will not equal Width Right, Width Right can be replace with a mark equal to Width Left.

Thus, if all conditions are meet;

1. Length Top = Length Bottom (or measurement from left side to mark)
2. Width Left = Width Right (or mark)
3. Dia. A = Dia. B

Then, Furring Strips are perpendicular

a. Dia. A > Dia. B
   Move bottom Furring Strip Right.

b. Dia. A < Dia. B
   Move bottom Furring Strip Left.

Step 1: Place a mark 1-3/4" (4.45_cn) below the middle of a Purlin about 8-9_feet (2.44-2.74_m) down from the Left side of the top furring strip. You should see screws/nails in the middle of the Purling attaching the existing roof.

Step 2: Place a mark 1-3/4" (4.45_cn) below the middle of the same Purlin in Step 1 from the Right side of the top furring strip.

NOTE: These two marks will be the bottom edge of the bottom-furring strip.

Step 3: Align three furring strip boards (two for Nyabishongo) end to end and screw blocks in top of the boards to hold them together. Do not cut the boards to the Furring Strip length. Do not screw the boards into the roof.

Step 4: Align the bottom of the boards up with the two marks in Steps 1-2.

Step 5: Measure the distance on the Left from the top of the top furring strip to the bottom of the bottom furring strip. WIDTH LEFT in Figure 4.6 on Page 4-7.

Step 6: Mark this distance on the Right of the bottom furring strip. WIDTH RIGHT in Figure 4.6 on Page 4-7.

Step 7: Measure and mark the Furring Strip Length on the bottom-furring strip, see Table 4.1 on Page 2. This measurement should go from the bottom edge Left to the mark (Step 6) Right. LENGTH BOTTOM in Figure 4.6 on Page 4-7.

NOTE: At this point, you should have an "X" on the Right side. This point is for Dia B in Figure 4.6 on Page 4-7.

Step 8: Align the Bottom Furring Strip with the Top Furring Strip.

Step 9: Cut the Bottom Furring Strip to the correct length, mark in Step 7.

Step 10: Screw 3-1/2" Drywall Screws every 16-24_inches (40.6-61_cm) in the furring strip boards. These screws MUST go into the Purlin (wood).

Step 11: Repeat Steps 1-10 for the other side of the roof.

C. Install the middle three Furring Strips. These Furring Strips can follow a Purlin. The ends of these furring strips need to be flush with the ends Top & Bottom Furring Strips. If the Purlins are 24" OC, there will be a furring strip on each Purlin. If the Purlins are closer, space the furring strips on the bottom & top Purlins and one in the center.

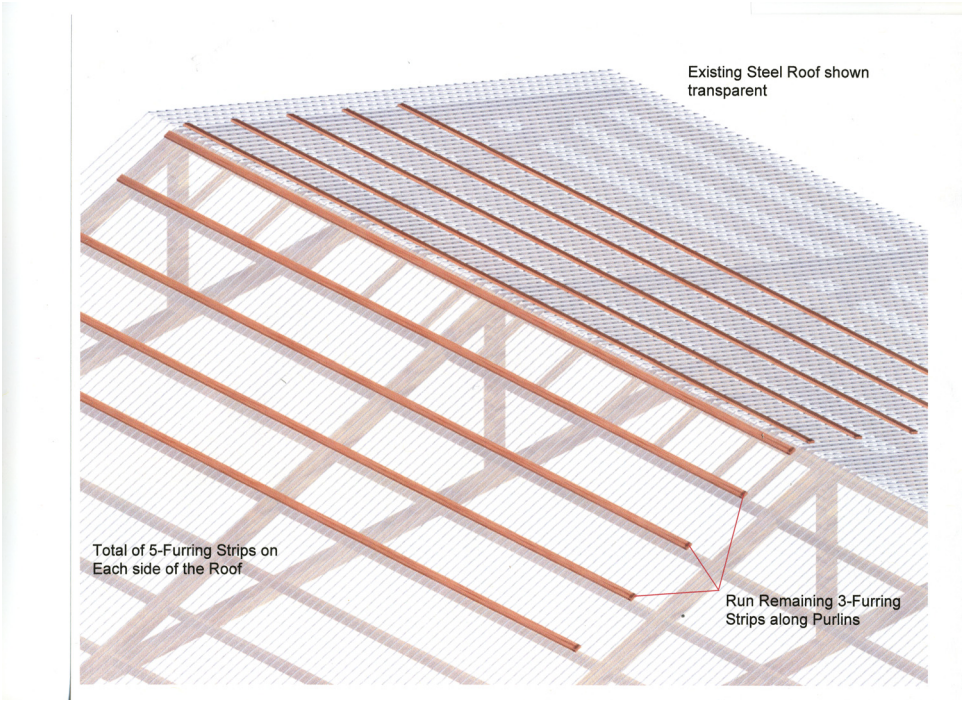


Figure 4.7; Remaining Furring Strips

Step 1: Cut the furring strips to the correct length.

Step 2: Lay the furring strips about 1-3/4" (4.45_cn) below the middle of the Purlin (furring strip centered on the Purlin). You should see screws/nails in the middle of the Purlin attaching the existing roof.

Step 3: Screw 3-1/2" Drywall Screws every 16-24_inches (40.6-61_cm) in the furring strip boards. These screws MUST go into the Purlin (wood).

Step 4: Repeat Steps 1-3 for the remaining furring strips.

SOLAR PANELS TO ROOFING PANELS:

This section prepares the Solar Panels/Roofing Panels for installation. Panels on opposite sides of the roof have mirror image orientations. Therefore, the Solar Panels will be attached to the Roofing Panels with two different orientations, mirror images. Also, the Roofing Panels MUST be clean before the Solar Panels are attached. On the first and last panels installed, there will be a Custom Z-Closure. On one end of the roof, the closure will be attached to the Male Leg of the panel; therefore, the flange on two panels (one for each side) needs to be removed.

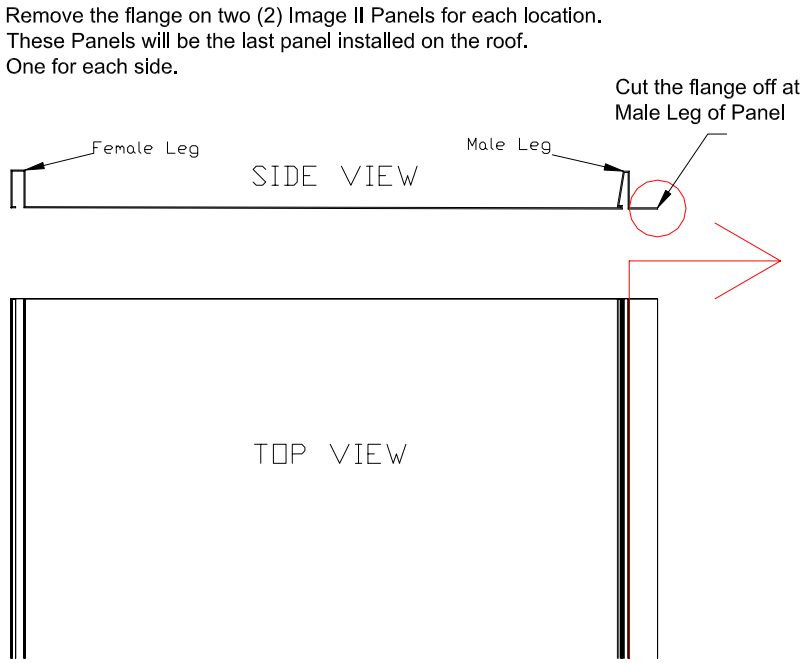


Figure 4.8; Roofing Panel Flange Removal.

A. Removing the flange from two panels (one for each side).

Step 1. Cut the flange off two Roofing Panels.

B. Attach the Solar Panels to the Roofing Panels.

Step 1: Get the number of Solar Panels and Roofing Panels required for the location, see Table 4.1 on Page 4-2.

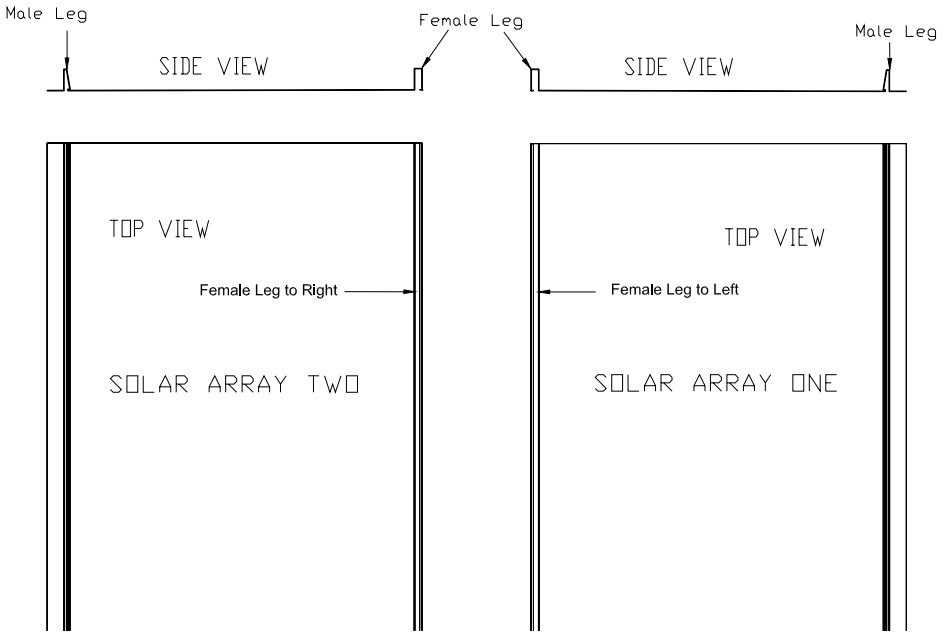


Figure 4.9; Roofing Panel Orientation

Step 2: Verify that the Roofing Panels are clean and dry.

Step 3: Orient the Roofing Panels for Solar Array One with the Female Leg to the Left. This will be one-half of the panels including one Roofing Panel with the flange removed.

Step 4: Orient the Roofing Panels for Solar Array Two with the Female Leg to the Right. This will be one-half of the panels including one Roofing Panel with the flange removed.

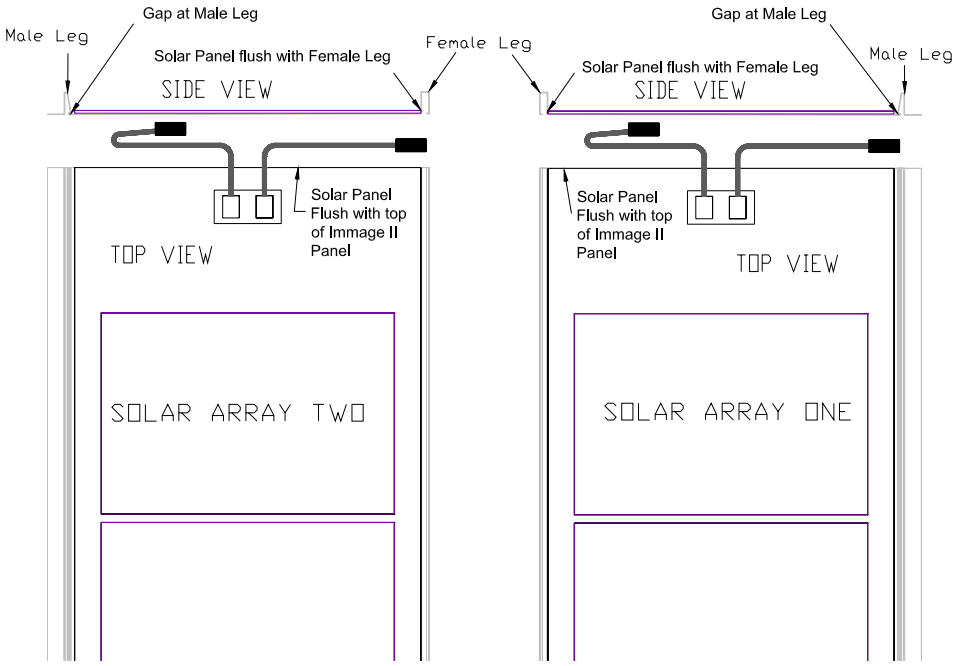


Figure 4.10; Solar Panel Orientation

Step 5: Attach the Solar Panels for Solar Array One to the Roofing Panels. The Solar Panels need to be flush with the top of the Roofing Panel and flush with the Female Leg on the left side. There will be a gap on the right side next to the Male Leg.

WARNING: Once the adhesive on the back of the Solar Panel comes in contact with ANY surface, the Solar Panel will be stuck. After the Solar Panel is installed, you will not be able to remove it from the Roofing Panel. Great care needs to be taken to line the Solar Panel up with the Roofing Panel.

Step 6: Attach the Solar Panels for Solar Array Two to the Roofing Panels. The Solar Panels need to be flush with the top of the Roofing Panel and flush with the Female Leg on the right side. There will be a gap on the left side next to the Male Leg.

Step 7: Apply Silicone Sealant to any gaps between the Solar Panel and Roofing Panel.

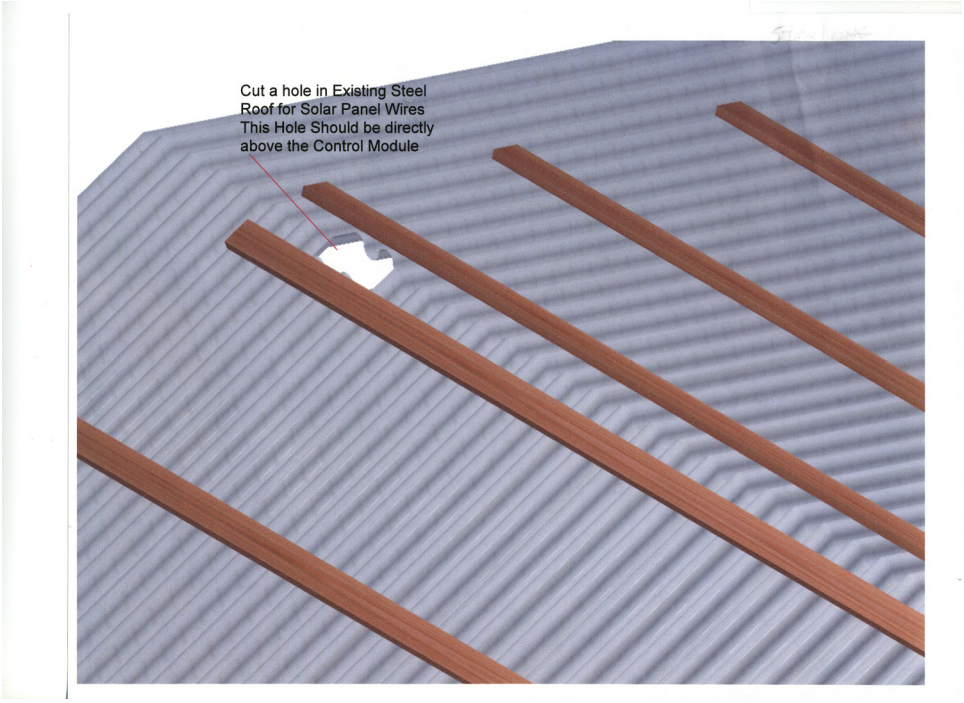


Figure 4.11; Hole for Solar Panel Wires.

C. Cut a hole in the existing roof. There will be approximately 32-10AWG wires running through the hole. A 3" hole or bigger will work. This hole should be directly above the Control Module. It can be anywhere between the two top furring strips.

Step 1: Cut Hole and remove any burs.

D. Install the first Panel. It is critical that the first panel be straight and square with the peak as it controls the alignment of all the panels. Only the first and last panels will have screws on both sides! See Figure 4.12 & 4.13 on Page 4-14.

Step 1: Align the panel of Solar Array One with the Top Furring Strip.

Step 2: Fasten in the center of panel slot (flange) with Mod Truss screw. One screw on each furring strip, 5-screws total.

Step 3: Fasten the Female Leg side of the Panel with 2" Sealtite screws. These screws MUST be screwed into the Solar Panel within a ¼" of the edge (1/4" from the Female Leg). One screw in the bottom four furring strips, 4-screws; see Figure 4.27 on Page 4-30.

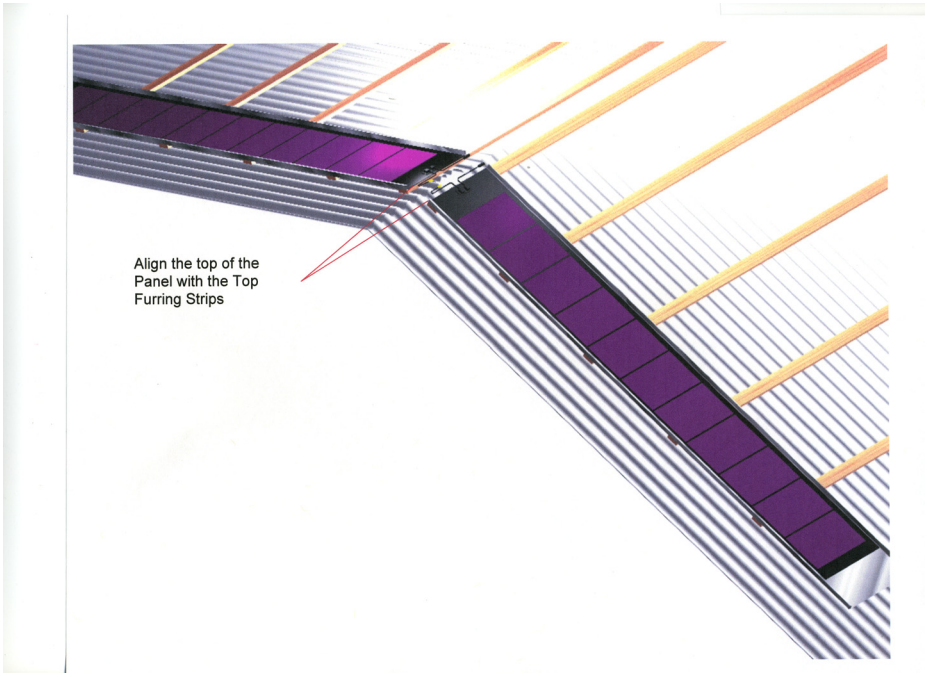


Figure 4.12; First Panel Alignment

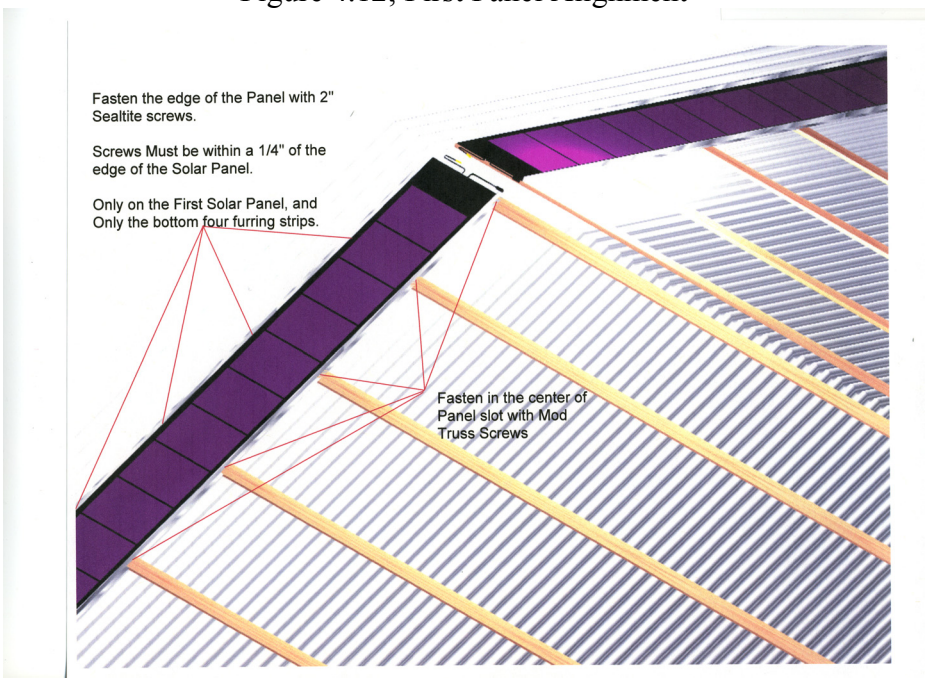


Figure 4.13; First Panel Screws

WARNING: Putting a screw through the Solar Panel more than ¼" from the edge could damage the panel.

Step 4: Repeat Steps 1-4 for the other side of the roof (first panel of Solar Array Two).

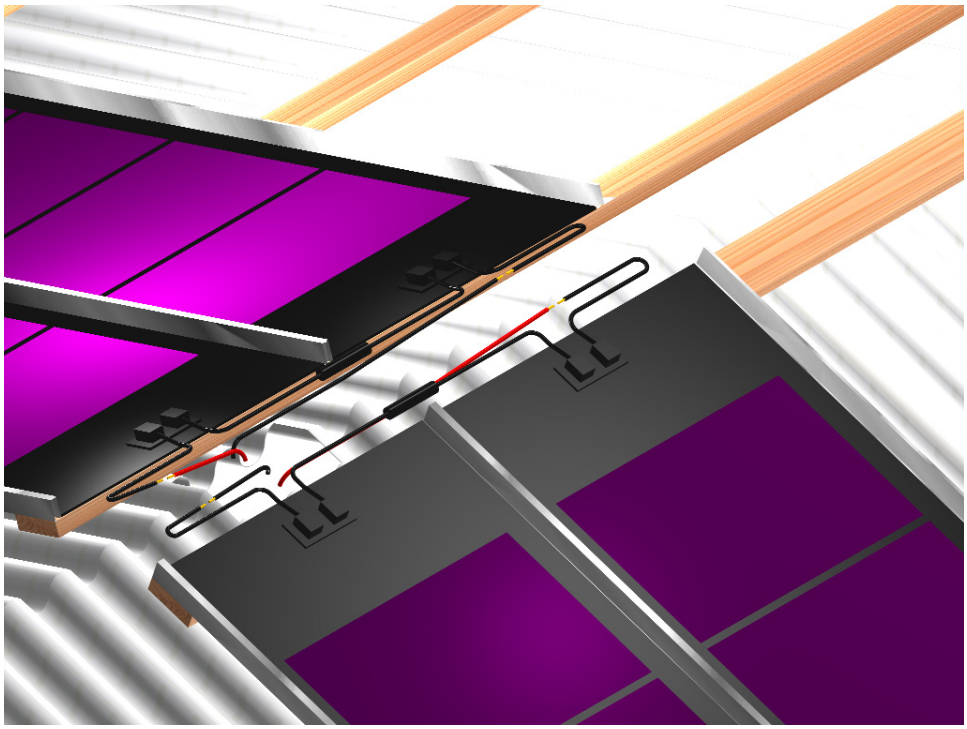


Figure 4.14: Second Panel Installation

E. Install the second Panel. Make sure that the Panels installed together (same side of the roof) have the same Solar Panel Orientation. Solar Array One is on one side of the roof and Solar Array Two is on the other.

Step 1: Align the panel of Solar Array One with the Top Furring Strip.

Step 2: Snap the Female Leg of the second Panel on the Male Leg of the first Panel.

Step 3: Fasten in the center of panel slot (flange) with Mod Truss screw. One screw on each furring strip, 5-screws total.

Step 4: Connect the Positive of the first Solar Panel with the Negative of the second Solar Panel (Solar Array One). For Solar Array Two, connect the Negative of the first Solar Panel to the Positive of the second Solar Panel. Connect the leads closest together-together!

NOTE: In Figure 4.14, the Solar Panels on the bottom (Solar Array One) the Positive is on the Right and the Negative is on the Left. The top Solar Panels (Solar Array Two) the Positive is on the Left and the Negative is on the Right.

NOTE: The Solar Panels are being configured with 2-Solar Panels in series to acquire the proper operating voltage for the system, 24_VDC.

Step 5: Repeat Steps 1-4 for the second panel of Solar Array Two, opposite side of the roof.

F. Wire the Solar Panels to the Combiner Box. Make sure that the Solar Panels installed together (same side of the roof) are connected to the same Combiner Box. Solar Array One to Combiner Box One & Solar Array Two to Combiner Box Two.

Step 1: Verify that the Solar Disconnect is in the OFF position (down); see Figure 3.2 on Page 3-5.

Step 2: Cut the black connector off the Positive lead of the second Solar Panel (Array One); see Figure 4.14 on Page 4-15. In Solar Array Two, the Positive Lead will be on the first Panel.

Step 3: Crimp a Butt-Connector to the Positive Lead (Panel 2, Array One).

NOTE: The Crimping Tool is ratcheted to insure proper crimp. To open the tool, close the handles past the ratchet release position, which will allow the jaws to open fully.

a. Strip 5/16" (0.79_cm) of insulation off the wire exposing the conductor.

b. Place the Butt-Connector in the "10-12" nest such that the one side of the Butt-connector's terminal is positioned over the nest. Close the tool carefully until the jaws grip the Butt-Connector lightly and hold it in place without distortion.

c. Insert the stripped wire into the terminal. The conductor needs to be in the terminal, but no insulation can be in the terminal. The terminal is the metal part of the Butt-Connector that is crimped over the wire conductor.

d. While holding the wire in place, squeeze the handles past the ratchet release position and allow the jaws to spring open.

Step 4: Cut the black connector off the Negative lead of the first Solar Panel (Array One); see Figure 4.14 on Page 4-15. In Solar Array Two, the Negative Lead will be on the second Panel.

Step 5: Crimp a Butt-Connector to the Negative Lead, Array One. This is repeating Step 3, for the Negative Lead.

Step 6: Run a Positive Wire (10AWG Red) up through the hole in the roof to the Positive Lead, Array One; see Figure 4.14 on Page 4-15.

Step 7: Crimp the Positive Wire to the Butt-Connector on the Positive Lead, Array One.

a. Strip 5/16" (0.79_cm) of insulation off the wire exposing the conductor.

b. Place the Butt-Connector in the "10-12" nest such that the empty side of the Butt-connector's terminal is positioned over the nest. Close the tool carefully until the jaws grip the Butt-Connector lightly and hold it in place without distortion.

c. Insert the stripped wire into the terminal. The conductor needs to be in the terminal, but no insulation can be in the terminal. The terminal is the metal part of the Butt-Connector that is crimped over the wire conductor.

d. While holding the wire in place, squeeze the handles past the ratchet release position and allow the jaws to spring open.

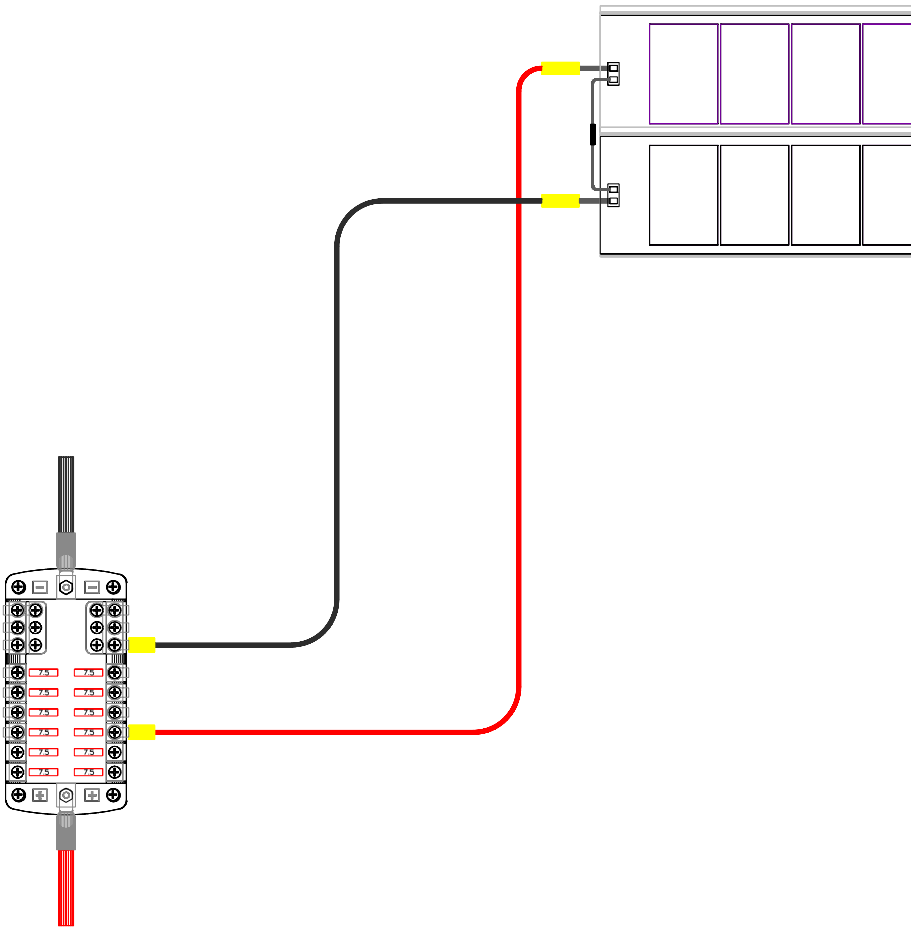


Figure 4.15; Solar Panel 1, Array One Wiring Diagram

Step 8: Run the other end of the Positive Wire (10AWG Red) to Combiner Box One. Make sure that there is enough wire to run the wire down the wall, or a truss, etc. You do not what any strain on the wire.

NOTE: There are 7" Black Cable Ties and Black Mounting Bases that can be used to secure the wires to the wall/trusses for wire management and strain relieve. Run the wires such that all the wires can be tied together and secured when done.

Step 9: Cut the wire to the appropriate length.

Step 10: Crimp a Ring-Connector to the Positive Wire, Array One).

e. Strip 5/16” (0.79_cm) of insulation off the wire exposing the conductor.

f. Place the Ring-Connector in the “10-12” nest such that the Ring-connector’s terminal is positioned over the nest. Close the tool carefully until the jaws grip the Ring-Connector lightly and hold it in place without distortion.

g. Insert the stripped wire into the terminal such that 1/32” (0.08_cm) of the conductor sticks out beyond the edge of the terminal. The conductor needs to be in the terminal, but no insulation can be in the terminal. The terminal is the metal part of the Ring-Connector that is crimped over the wire conductor.

h. While holding the wire in place, squeeze the handles past the ratchet release position and allow the jaws to spring open.

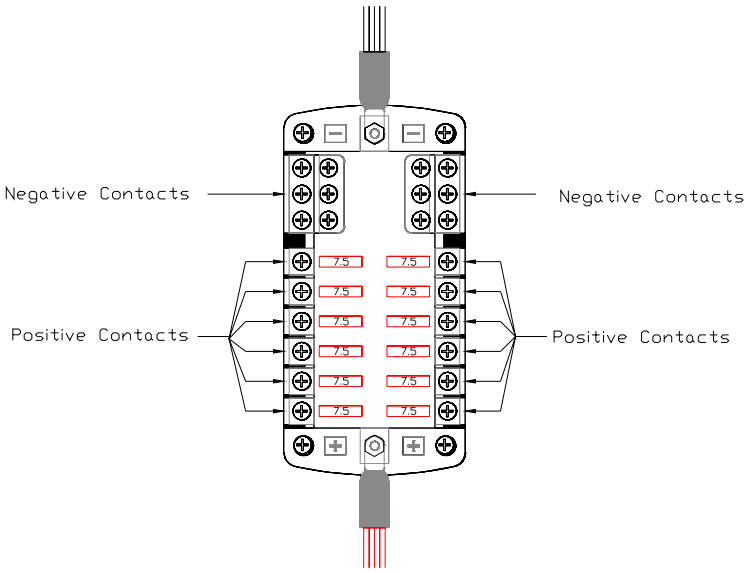


Figure 4.15; Combiner Box

Step 11: Screw the Ring Terminal, Array One, to a Positive Contact on of Combiner Box One. In Figure 4.15 on Page 4-18, the Solar Panel 1 is connected to the fourth positive contact on the right side. This is position is not important.

Step 12: Repeat Steps 8-11 for the Negative Wire (10AWG Black) to Combiner Box One, Array One.

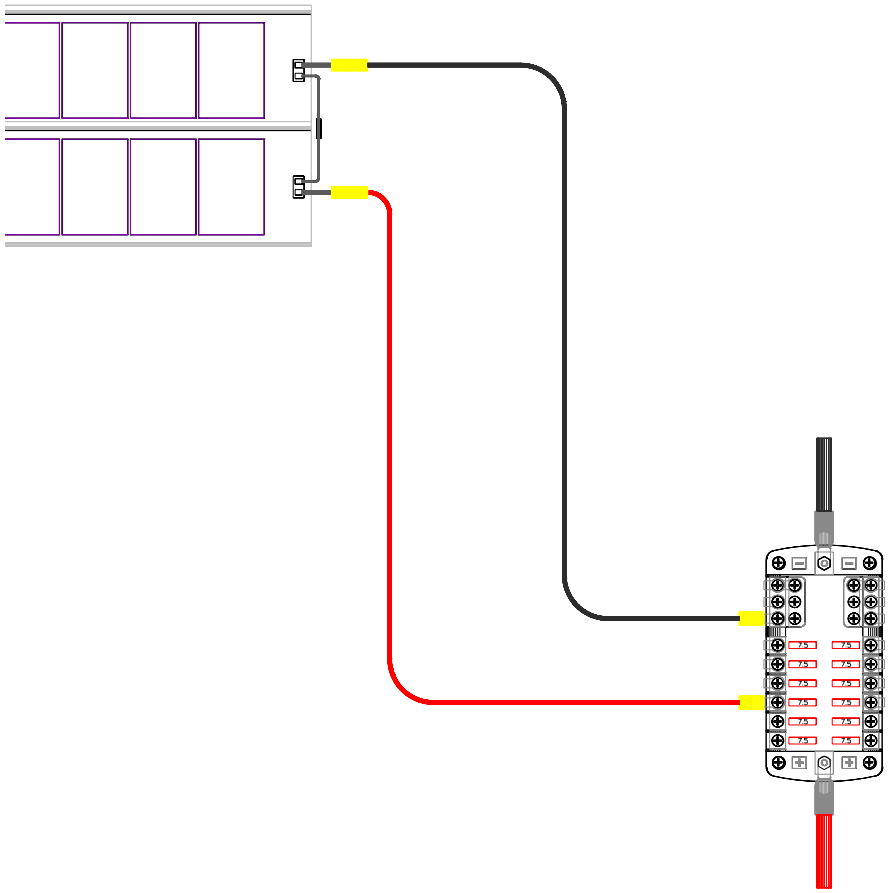


Figure 4.17; Solar Panel 1, Array Two Wiring Diagram

Step 13: Repeat Steps 2-12 for the first two Solar Panels of Array Two, both the Positive Wire (10AWG Red) and Negative Wire (10AWG Black) to Combiner Box Two.

G. In this section install and wire the panels in sets of two, two panels on Solar Array One and then two panels on Solar Array Two. Keep doing this until the very last Panel, which has the flange removed. Make sure that the Panels installed together (same side of the roof) have the same Solar Panel Orientation. Solar Array One is on one side of the roof and Solar Array Two is on the other.

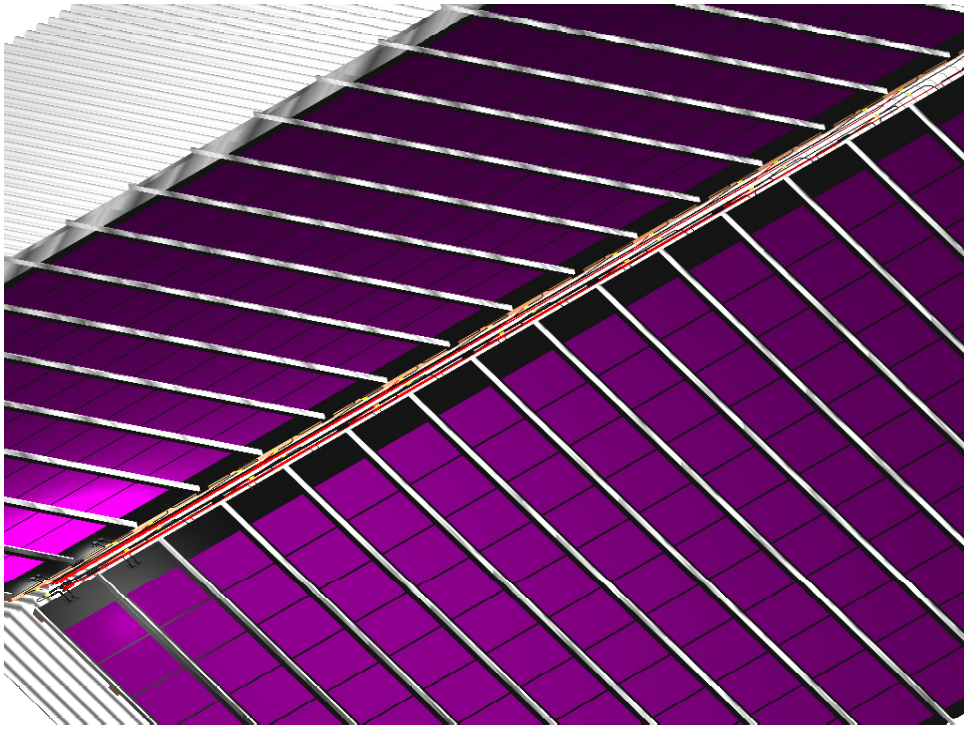


Figure 4.18; All the Panels installed

Step 1: Align the next panel of Solar Array One with the Top Furring Strip.

Step 2: Snap the Female Leg of this Panel on the Male Leg of the last Panel installed.

Step 3: Fasten in the center of panel slot (flange) with Mod Truss screw. One screw on each furring strip, 5-screws total.

Step 4: Repeat Steps 1-3 so there are two new panels installed on Solar Array One.

Step 5: Connect the Positive of the first Solar Panel with the Negative of the second Solar Panel (Solar Array One). For Solar Array Two, connect the Negative of the first Solar Panel to the Positive of the second Solar Panel. Connect the leads closest together, together!

Step 6: Cut the black connector off the Positive lead of the 2-Solar Panel, Array One; see Figure 4.14 on Page 4-15.

Step 7: Crimp a Butt-Connector to the Positive Lead 2-Solar Panels, Array One; see Section F, Step 3 on Page 4-16.

Step 8: Cut the black connector off the Negative Lead 2-Solar Panels, Array One; see Figure 4.14 on Page 4-15.

Step 9: Crimp a Butt-Connector to the Negative Lead 2-Solar Panels, Array One; see Section F, Step 3 on Page 4-16.

Step 10: Run a Positive Wire (10AWG Red) up through the hole in the roof to the Positive Lead of the 2-Solar Panels, Array One; see Figure 4.14 on Page 4-15.

Step 11: Crimp the Positive Wire to the Butt-Connector on the Positive Lead of the 2-Solar Panels, Array One; see Section F, Step 7 on Page 4-17.

Step 12: Run a Positive Wire (10AWG Red) to Combiner Box One. Make sure that there is enough wire to run the wire down the wall, or a truss, etc. You do not what any strain on the wire.

Step 13: Cut the wire to the appropriate length.

Step 14: Crimp a Ring-Connector to the Positive Wire; see Section F, Step 10 on Page 4-19.

Step 15: Screw the Ring Terminal to a Positive Contact on Combiner Box One.

Step 16: Repeat Steps 10-15 for the Negative Wire (10AWG Black) to Combiner Box One.

Step 17: Repeat Steps 1-16 for 2-Solar Panels on Array Two. Both the Positive Wire (10AWG Red) and Negative Wire (10AWG Black) will go to Combiner Box Two.

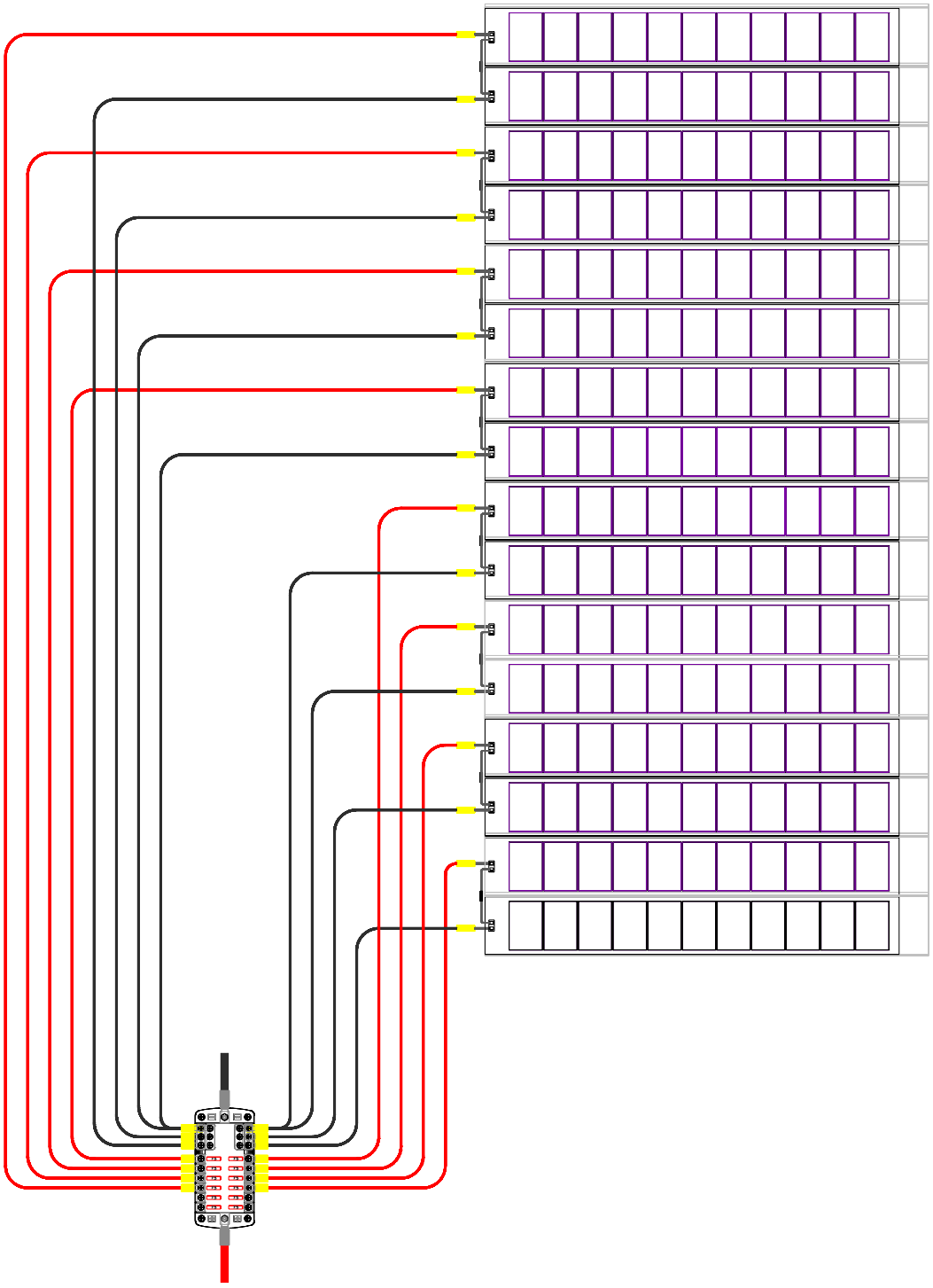


Figure 4.19; Solar Array One Wiring Diagram

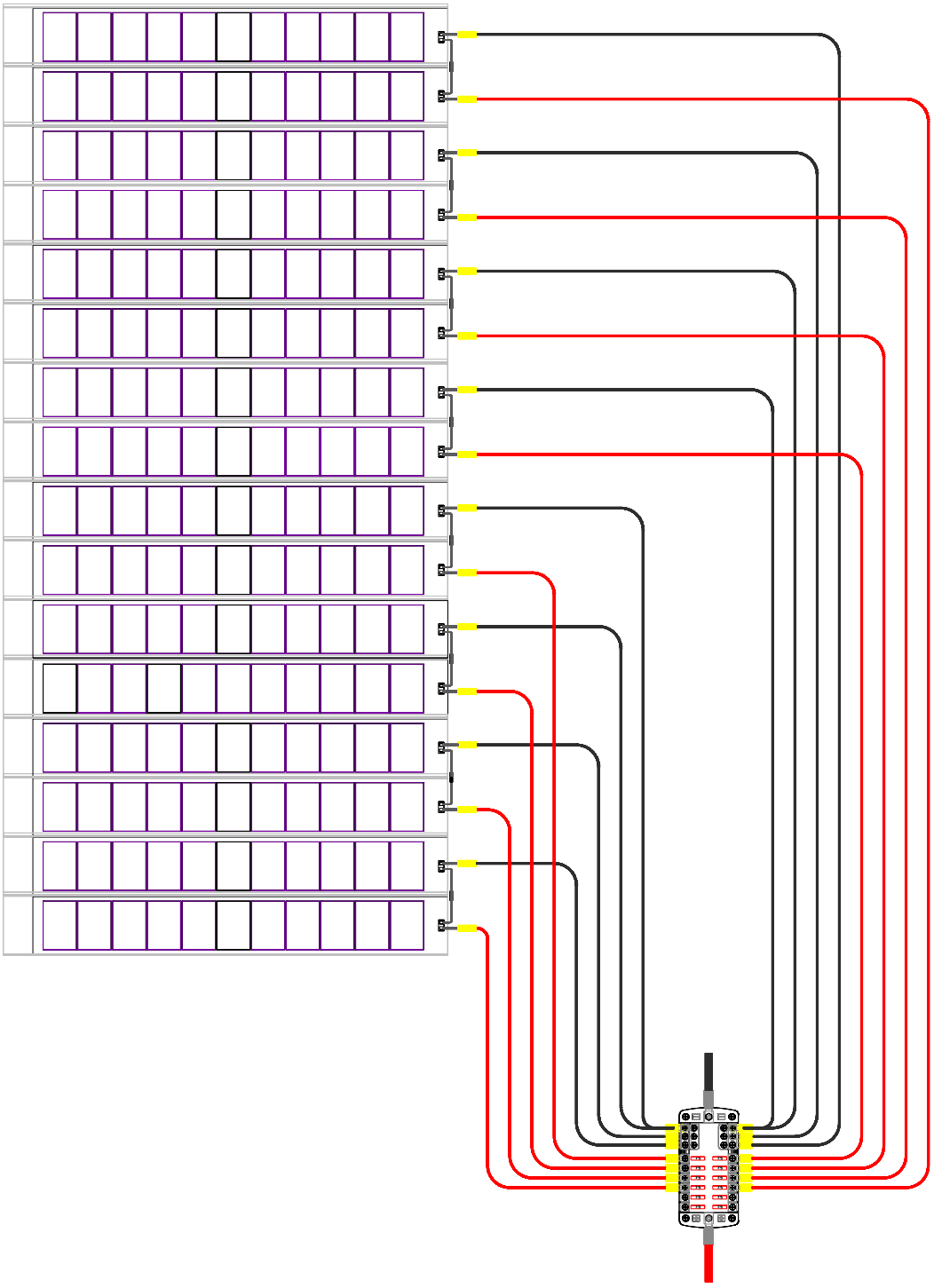


Figure 4.20; Solar Array Two Wiring Diagram

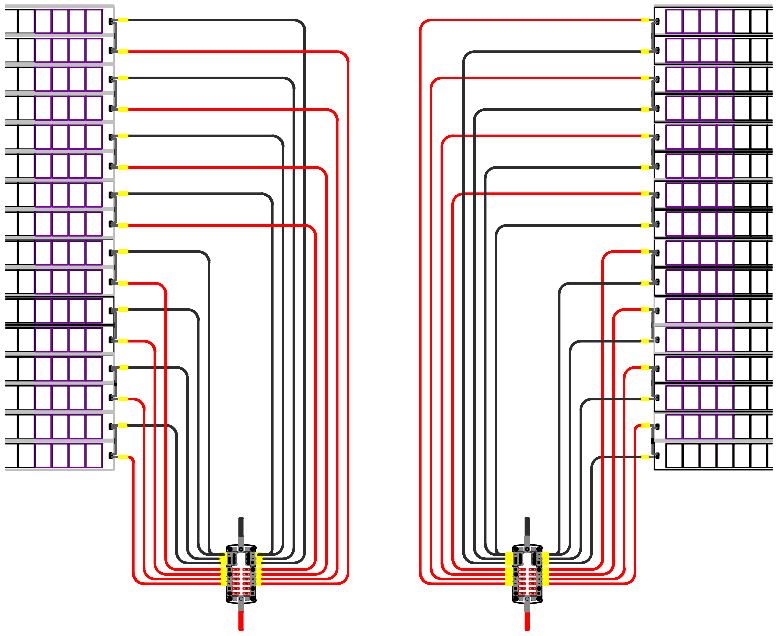


Figure 4.21; Solar Array Diagram

F. In this section, install the very last Panel with the flange removed. There will be one panel for each side of the roof.

Step 1: Align the panel of Solar Array One with the Top Furring Strip and snap the Female Leg of this Panel on the Male Leg of the last Panel installed.

Step 2: Fasten the Male Leg side of the Panel with 2" Sealtite screws. These screws MUST be screwed into the Solar Panel within a ¼" of the edge of the Solar Panel. One screw in each of the bottom four furring strips, 4-screws; see Figure 4.28 on Page 4-30.

WARNING: Putting a screw through the Solar Panel more than ¼" from the edge could damage the panel.

Step 3: Wire the last 2-Solar Panels of Solar Array One to Combiner Box One.

Step 4: Repeat Steps 1-3 for the last 2-Solar Panels of Solar Array Two.

CAPPING OFF THE STEEL ROOF:

This section caps off the new steel roof to create a watertight seal. There are three components to this section; installing the Ridge Z-Closure along the new roof's ridge, installing the Custom Z-Closure along the rake (sides of the new steel panels), and last installing the ridge.

A. Install the Ridge Z-Closures along the new roof's ridge. First, tape sealant is placed on top of the Solar Panel alone the top edge, and then Z-Closures are installed along the top edge. The Z-Closures are 1x1x1_inch (2.54x2.54x2.54_cm) "Z" that are 10'-2" (3.1_m) long. These strips need to be cut and bent. Cutting the Z-Closure into 17-3/8_inch (44.13_cm) Ridge Z-Closure strips will enable you to get 7 pieces from each strip.

NOTE: You will need to cut and bend one Ridge Z-Closure to verify proper dimensions before cutting the remainder of the Ridge Z-Closure strips.

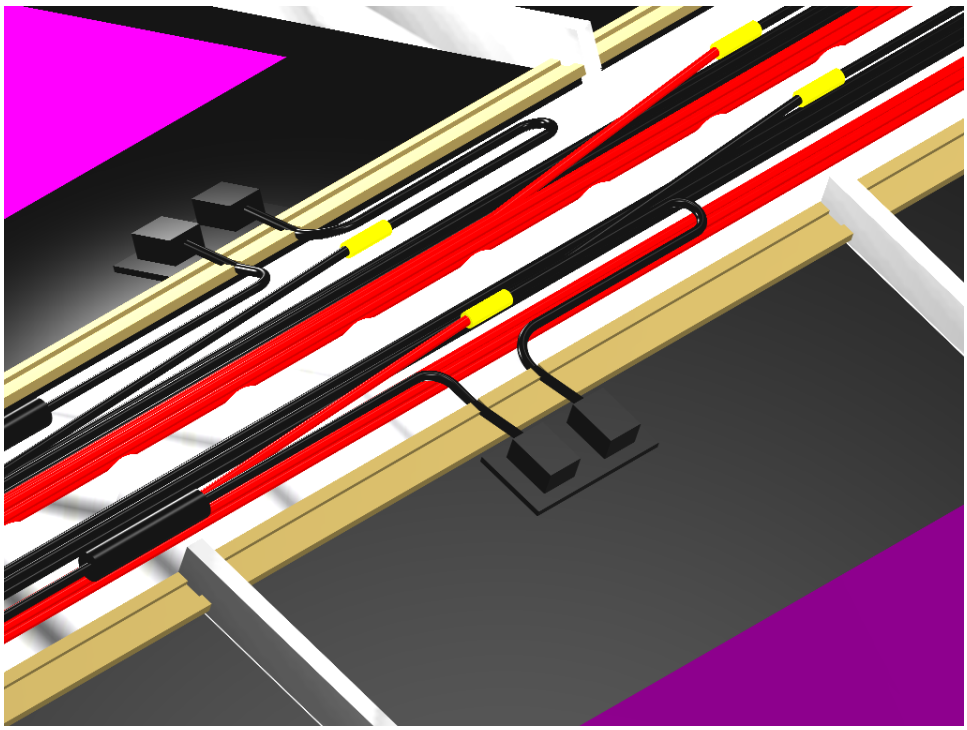


Figure 4.22; Tape Sealant

Step 1: Apply the Tape Sealant to the top edge of the Solar Panel.

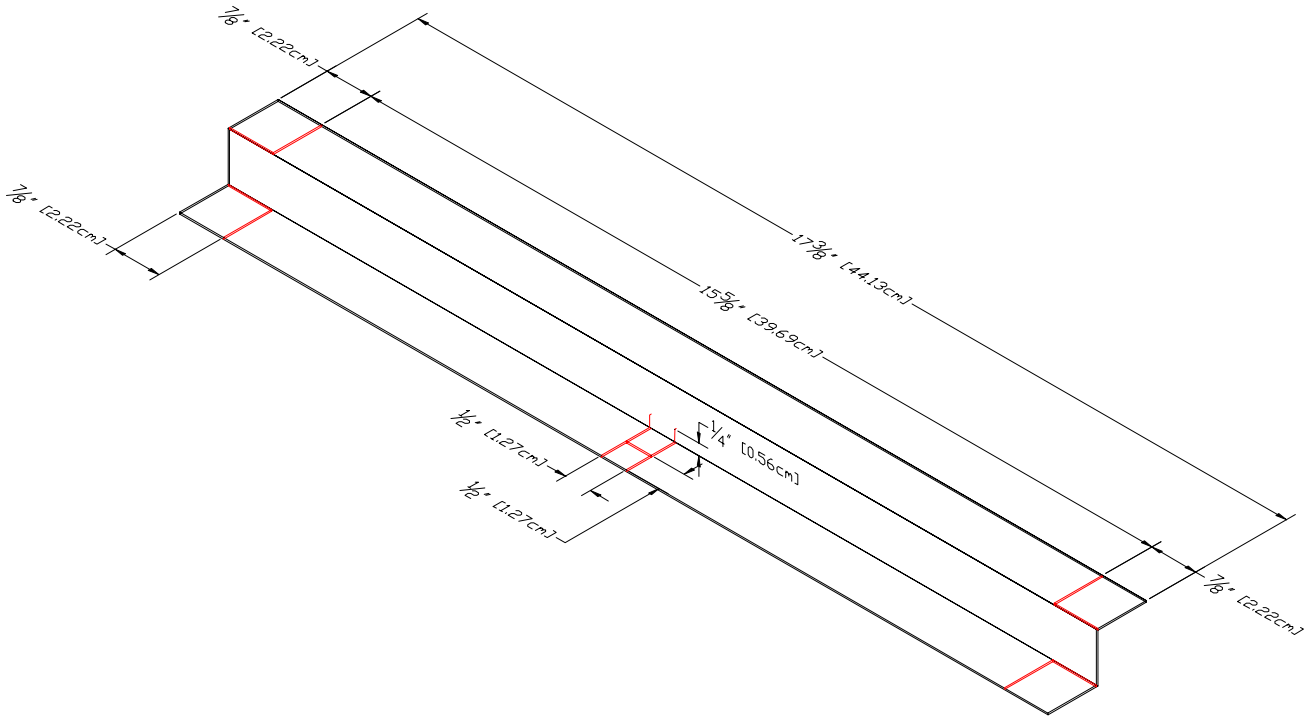


Figure 4.23; Ridge Z-Closure Cut, RED indicates CUT

Step 2: Cut ONE 17-3/8_inch (44.13_cm) long Ridge Z-Closure strip from a 10'-2" (3.1_m) long Z-Closure.

Step 3: Cut 7/8_inch (2.22_cm) off both sides of the bottom and top of the Ridge Z-Closure. This will make two 7/8_inch (2.22_cm) tabs.

NOTE: The width of the flat part of an installed Image II panel is 15-5/8_inches (39.69_cm). Cutting off 7/8_inches (2.22_cm) from both sides' leaves 15-5/8_inches (39.69_cm), this is the important distance.

Step 4: Cut a ½_inch (1.27_cm) strip through the bottom and ¼_inch (0.56_cm) up the middle of the "Z". This cut needs to be centered on the Ridge Z-Closure.

Step 5: Cut off ½_inch (1.27_cm) of this center strip.

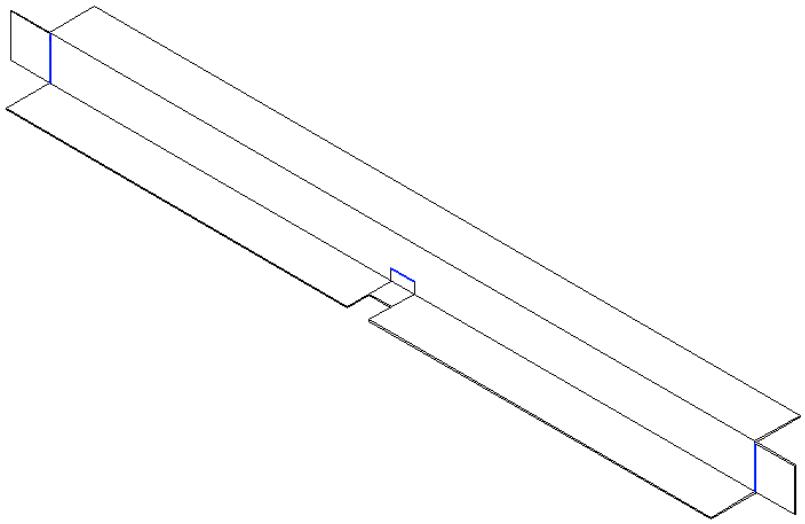


Figure 4.24; Ridge Z-Closure Bend, BLUE indicates bend lines

Step 6: Bend the end tabs back 90°. In Figure 1.24, the tabs are bent toward you.

Step 7: Bend the ½_inch (1.27_cm) center strip up 90° to make a hole for the Solar Panel wires.

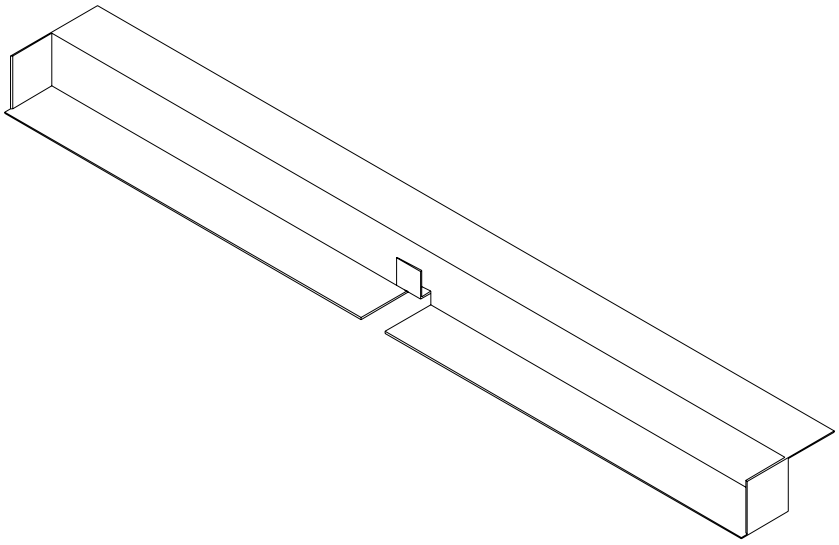


Figure4.25; Finished Ridge Z-Closure

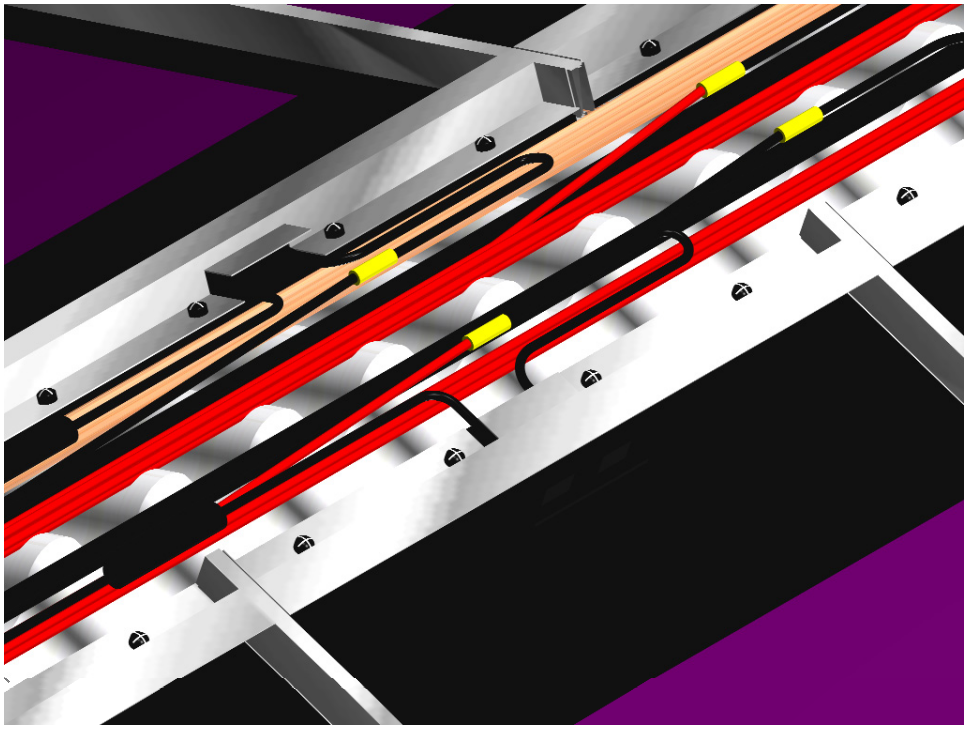


Figure 4.26; Ridge Z-Closure Install

Step 8: Screw four Mod Truss Screws into the Ridge Z-Closure.

a.) The Solar Panel wires need to go through the ½_inch (1.27_cm) center strip.

b.) The Ridge Z-Closure needs to be lined up with the top edge of the Solar Panel with tape sealant between the Solar Panel and Ridge Z-Closure.

c.) The Ridge Z-Closure is screwed to the top furring strip.

Step 9: Repeat Steps 1-8 for the rest of the Panels.

B. Install the Custom Z-Closure along the rakes of both sides of the new roof. The Custom Z-Closures are 1x1.75x1_inch (2.54x4.45x2.54_cm) "Z" that are 12_foot (3.66_m) long.

Step 1: Measure the distance from the bottom of the new roofing panels to the peak of the roof. This measurement should be about 10'-2.75" (311.78_cm).

Step 2: Cut ONE Custom Z-Closure to the measurement in Step 1 or just under!

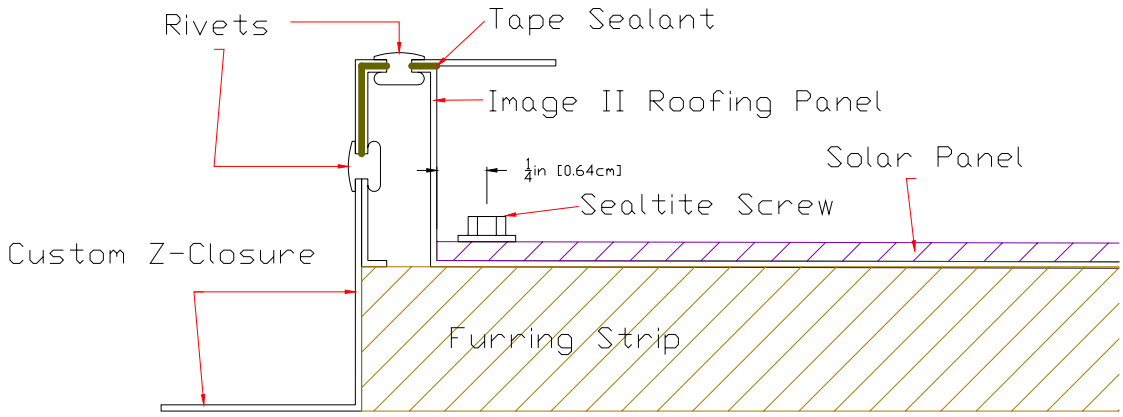


Figure 4.27; Female Leg of Roofing Panel to Custom Z-Closure Rivets

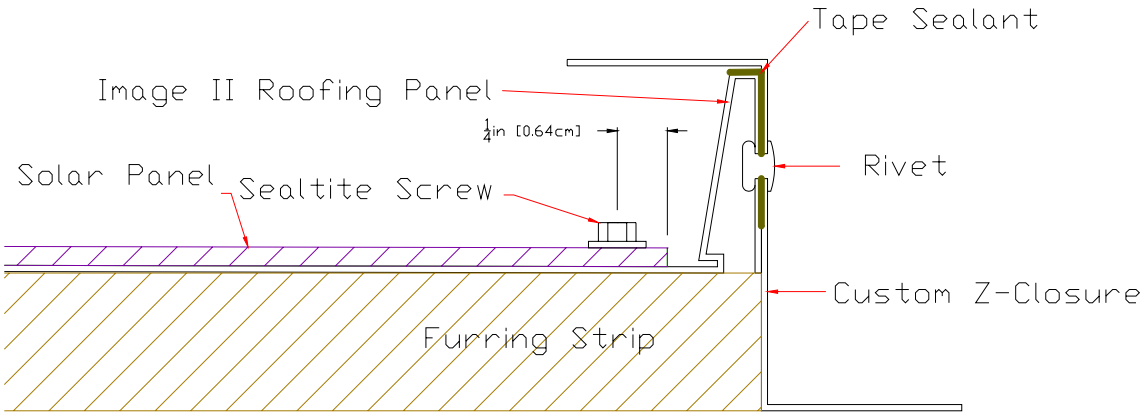


Figure 4.28; Male Leg of Roofing Panel to Custom Z-Closure Rivets

Step 3: Apply Tape Sealant along the Top Edge of the Roofing Panel. See Figures 4.27 & 4.28 on Page 4-30.

Step 4: Align the Custom Z-Closure along the rake of the roof with the bottom edge flush with the bottom edge of the Roofing Panel. Make sure that the top edge of the Custom Z-Closure does not extend beyond the peak of the roof.

Step 5: Attach the Custom Z-Closure to the rake of the roof with rivets every 12_inches (30.48_cm). Do not install any rivets in the Custom Z-Closure within 24_inches (60.96_cm) of the peak. The Custom Z-Closure that will be installed on the other side of the roof will overlap the peak by 24_inches (60.96_cm).

WARNING: You need to drill holds through Custom Z-Closure and the first layer of the Roofing Panel. See Figures 4.27 & 4.28 on Page 4-30. Drilling all the way through the Roofing Panel will create a hole for water.

a.) Drill a 1/8" hole about 2_inches (5.88_cm) from the bottom end of the Roofing Panel through the side of the Custom Z-Closure and through ONE layer of the Roofing Panel.

b.) Secure the Custom Z-Closure to the Roofing Panel with a rivet through the hole.

c.) Repeat a & b.) every 12_inches (30.48_cm), stopping within 24_inches (60.96_cm) of the peak

NOTE: In Figure 4.27, there is a rivet in to top of the Custom Z-Closure through the Female Leg of the Roofing Panel. The manufacture has told me that rivets can be installed in top of both the Female and Male Legs. I question whether a rivet could go through the Male Leg without problems!

d.) Install rivets through the top of the Custom Z-Closure into the top of the Female Leg of the Roofing Panel. The Holes need to be drilled about 3/16_inch (0.48_cm) from the edge of the Custom Z-Closure. Also, offset the top rivets from the rivets in the side.

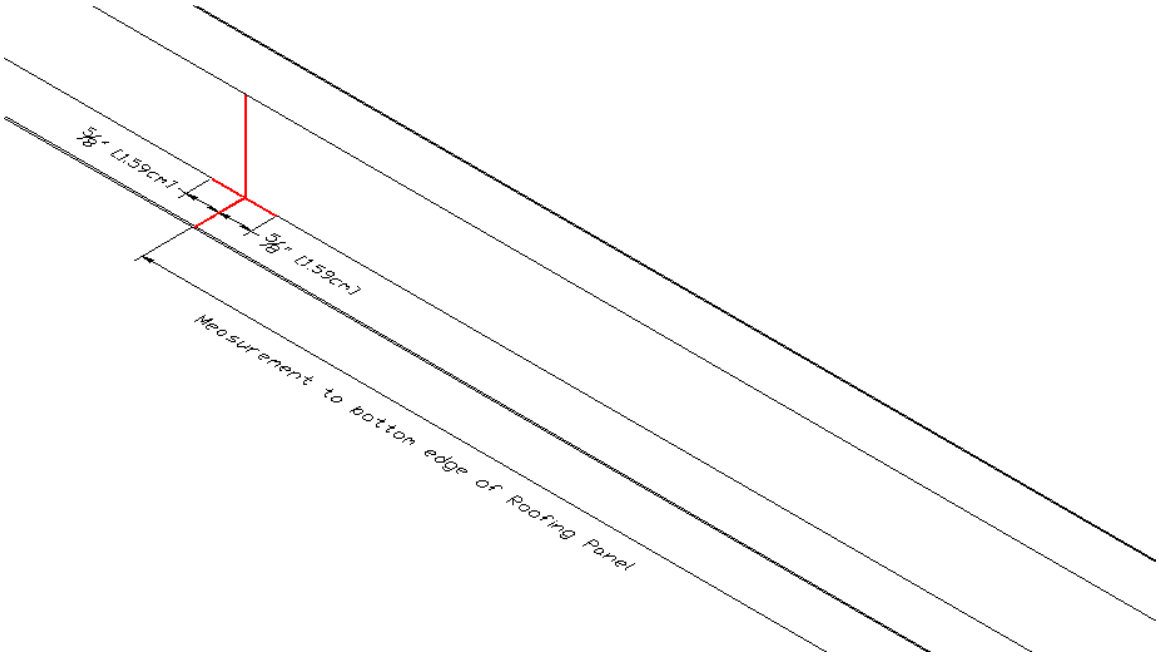


Figure 4.29; Custom Z-Closure Peak Cut, Red indicates cut

Step 6: Measure the Peak Cut distance for the Custom Z-Closure on the opposite side of the roof from the Custom Z-Closure just installed.

NOTE: The measurement will be the distance from the bottom end of the Roofing Panel to the apparent intersection at the peak. On the bottom of the roof, place the tape measure on the top of the Female Leg and measure the distance to the apparent peak (the imaginary point where the Roofing Panels from both sides of the roof would meet if they were extended). This distance should be about 123-3/8_inches (313.37_cm).

Step 7: Orient the Custom Z-Closure to be installed for cutting. While facing the end of the building looking at the peak, if the Custom Z-Closure just installed is on the Left, measure the Peak Cut distance from the Right (all Figures have this orientation). If the last installed is on the Right, measure from the Left.

Step 8: Cut the Custom Z-Closure through the bottom and middle sections of the "Z". Do not cut the top section this will be the peak; see Figure 4.29 on Page 4-32.

Step 9: Cut 5/8_inches (1.59_cm) from the last cut between the bottom and middle sections, both directions; see Figure 4.29 on Page 4-32.

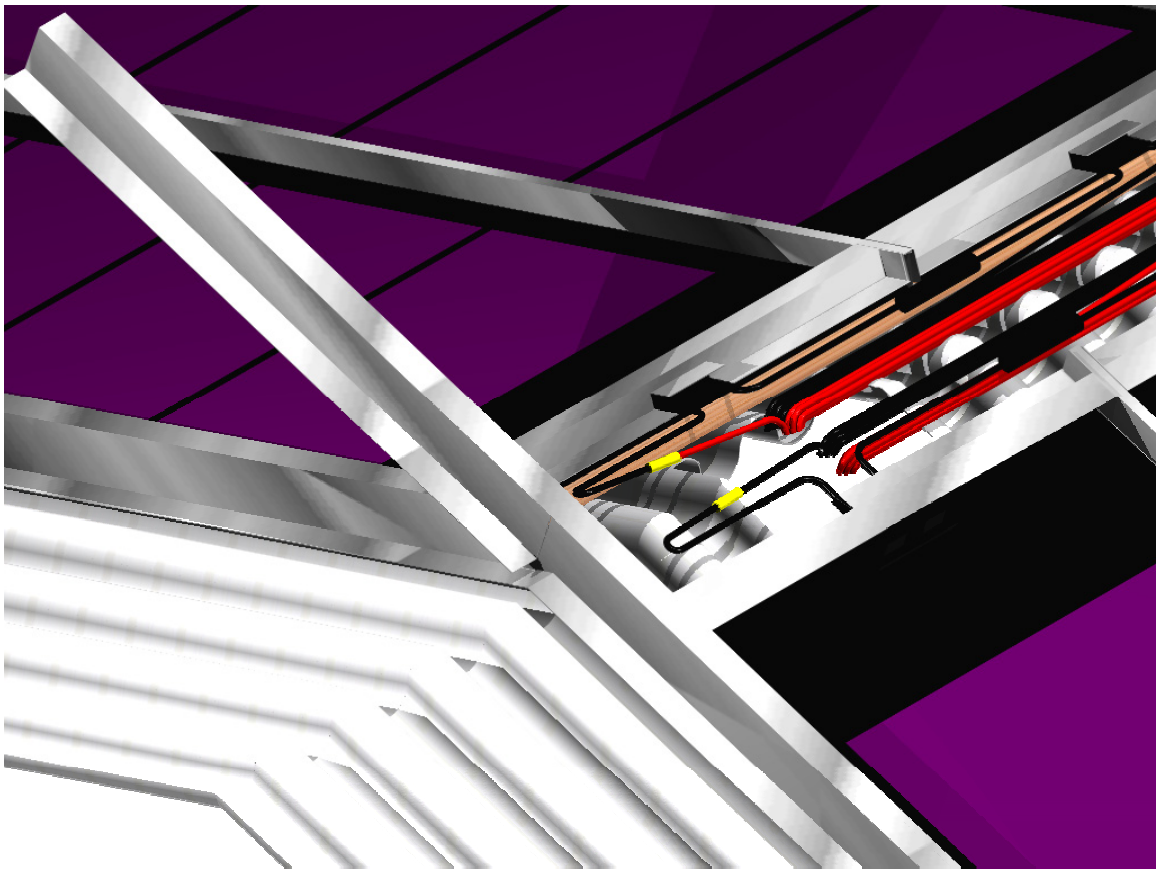


Figure 4.30; Installing the Second Custom Z-Closure, Tab Bend

Step 10: Attach the Custom Z-Closure to the rake of the roof with rivets every 12_inches (30.48_cm). Same as Step 5 on Page 4-31 with the exception of installing rivets the entire length of the Roofing Panel.

Step 11: Bend the tab down on the bottom side of the “Z”, second installed closure onto the first installed closure.

Figure 4.31; Custom Z-Closure, Peak Bend

Step 12: Bend the second installed Custom Z-Closure onto the first installed closure creating a peak at the top of "Z".

Step 13: Install three rivets in the bent section of the second closure. These rivets will go through both Custom Z-Closures and ONE layer of the Roofing Panel; see Figures 4.27 & 4.28 of Page 4-30.

Step 14: Install a rivet in the middle (1.75_inch) section of the second closure at the peak about 1_inch (2.54_cm) from the top. This rivet will go through two layers of the second closure.

Step 15: Bend the second bottom tab down and, if there is enough room between the old roof and the bottom of the Custom Z-Closure, install a rivet through the tab.

NOTE: This entire peak section should be caulked with tube sealant.

Step 16: Repeat Steps 1-15 for the other rake.

C. Install the Ridge Cap to the new roof. The Ridge caps are 10'-2" (3.1_m) long. First install Tape Sealant along the top of the Ridge Z-Closure and peak of the Custom Z-Closure and then attach the Ridge cap to the ridge with rivets.

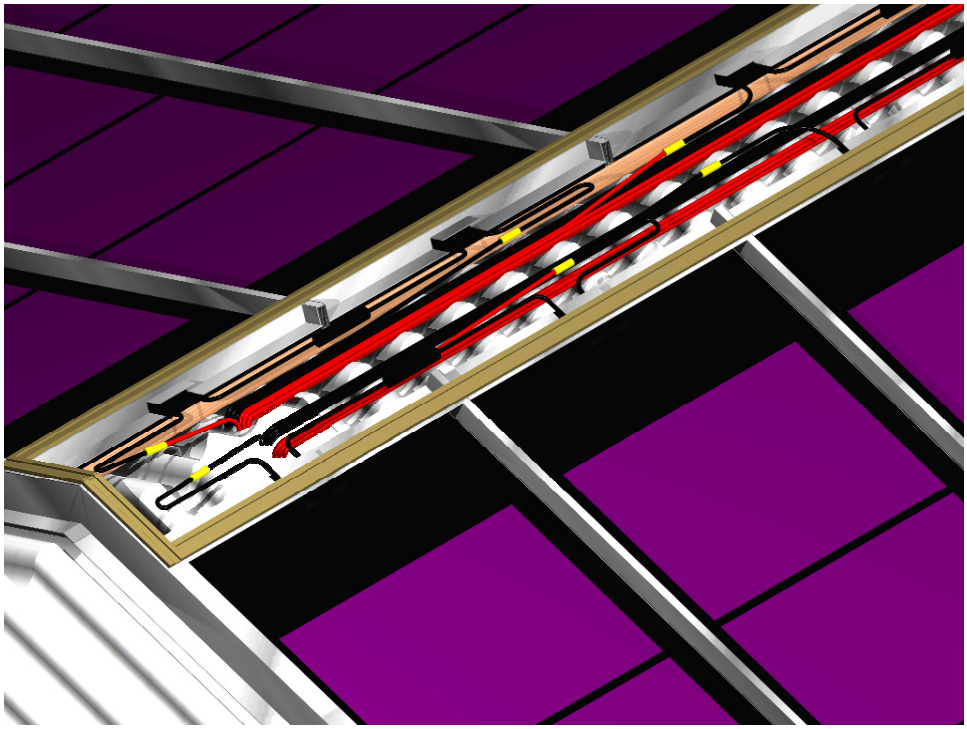


Figure 4.32; Ridge Cap Tape Sealant

Step 1: Apply Tape Sealant on top of the Custom Z-Closures at the peak, at both ends (rakes). Use about 11_inches (27.94_cm) of tape centered at the peak.

Step 2: Apply Tape Sealant from one end of the new roof to the other on top of the Ridge Z-Closures, both sides.

Step 3: Place the Ridge Cap on the peak so that it is flush at the rake and centered on the peak.

Step 4: Attach the end (rake) of the Ridge Cap with four rivets, the Ridge Cap to the Custom Z-Closure.

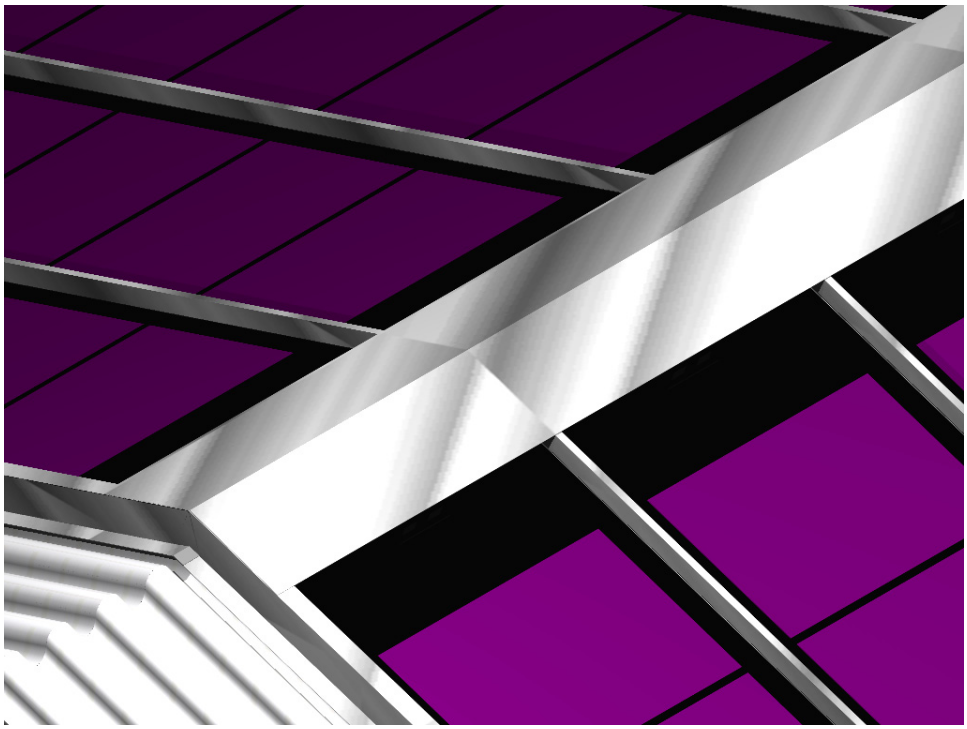


Figure 4.33; Ridge Cap

Step 5: Attach the edge of the Ridge Cap with three rivets in each Ridge Z-Closure. Install a rivet within 2_inches (5.88_cm) of both ends of the Ridge Z-Closure and one rivet in the center.

Location	# Cap Sections	Length of Ridge Cap	
		Feet/Inch	Meters
Gisenyi	3	21' 4-3/8"	6.51
Mutura	3	21' 4-3/8"	6.51
Nyabishongo	2	13' 4-3/8"	4.07
Rushashi	2	18' 8-3/8"	5.7
Rutsiro	3	21' 4-3/8"	6.51

Table 4.34; Ridge Cap Length

Step 6: Apply a bead of Tube sealant on top of the Ridge Cap just installed about 1_inch (2.54_cm) from the end where the next cap will be placed.

Step 7: Overlap the two Ridge Cap sections by 2_inches (5.88_cm) with the bead of Tube Sealant between the sections.

Step 8: Attach the two sections together with four rivets.

Step 9: Attach the Ridge Cap to the Ridge Z-Closures as in Step 5.

NOTE: For the last section of Ridge Cap, install the factory cut edge towards rake. Then attach the Ridge Cap to the Custom Z-Closure with four rivets.

Step 10 Seal any hole with Tube Sealant, look closely at,

1. The holes in the Ridge Z-Closures where the Solar Panel wires go into the peak.
2. Between the Ridge Cap and the Female Legs of the Roofing Panels.
3. The both rakes at the peak.

C. Turn ON the Solar Disconnect to allow the batteries to charge. The Solar Disconnect could actually be turned ON after the Solar Panel wiring is completed; see Figure 3.2 on Page 3-5.

5 ELECTRICAL WIRING; DESIGN CONSIDERATIONS

INTRODUCTION:

This section describes the design considerations for the electrical wiring to give some insight in why the materials supplied were selected.

POWER DISTRIBUTION:

A. There are six circuits in the Main Lug. Both legs have been tied together with a jumper wire. The Inverter has one 110_VAC output at 3000_Watts.

CIRCUITS

1. Power for Buildings to the Left
2. Power for Building to the Right
3. Computer Plug.
4. Computer Plug.
5. Computer Plug.
6. Power for the Lights/Plugs for Power Building.

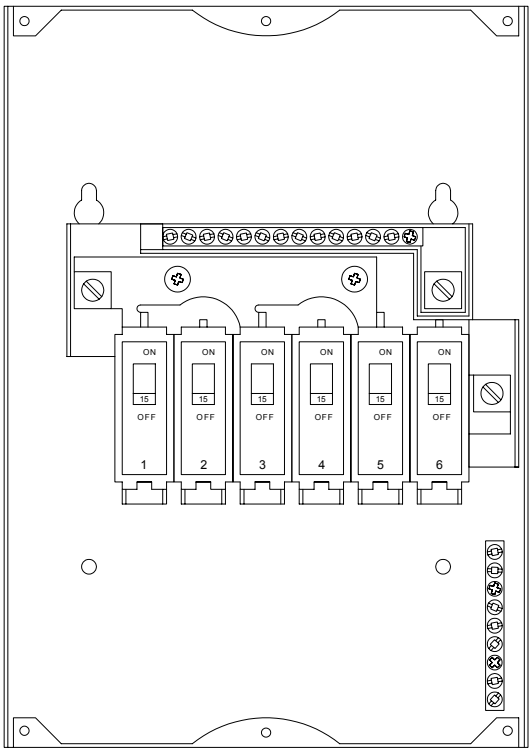


Figure 5.1; Main Lug

B. Figures 5.2 to 5.6 show the building layouts for the five sites. The furthest distance from the Control Module to the last building is in Mutura; see Figure 5.3 on this page. This distance is estimated at 470_feet. Therefore, 10-2UF outdoor wire was selected.

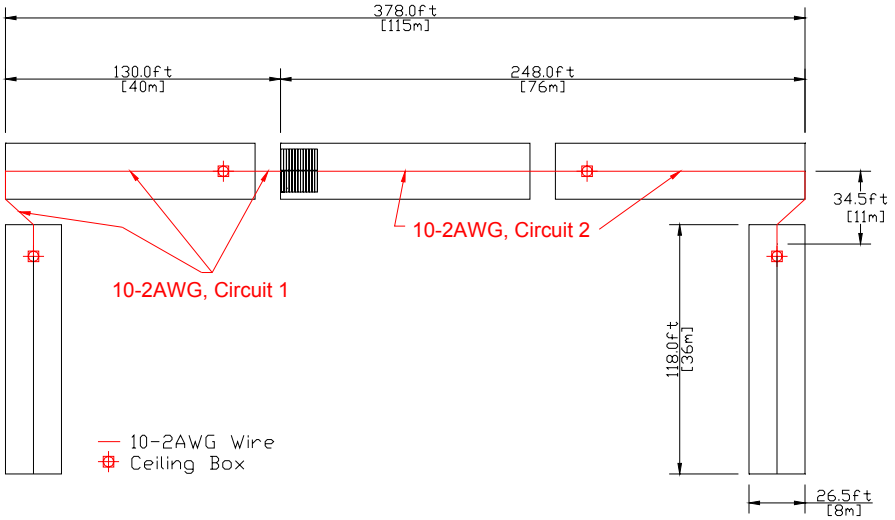


Figure 5.2; Gisenyi Building Layout

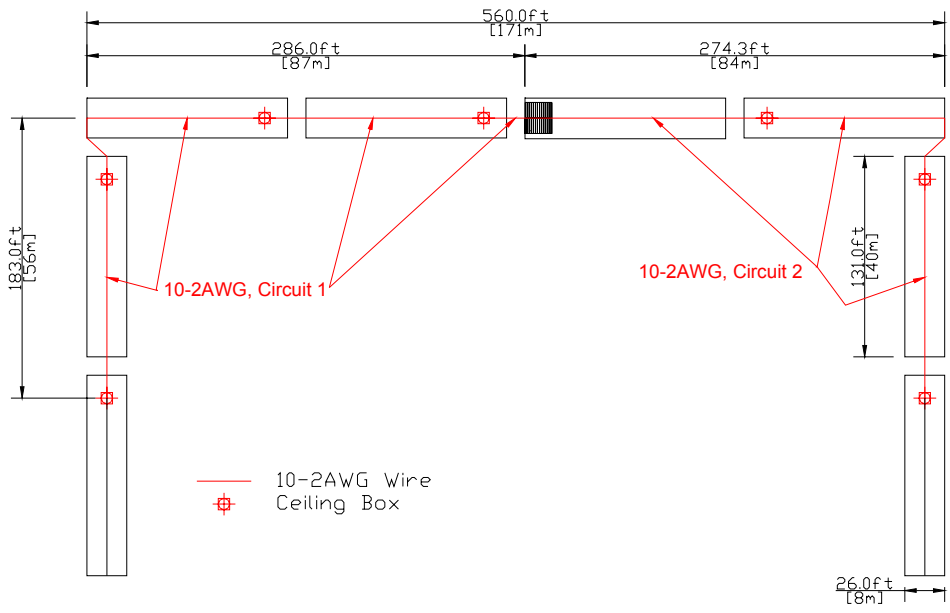


Figure 5.3; Mutura Building Layout

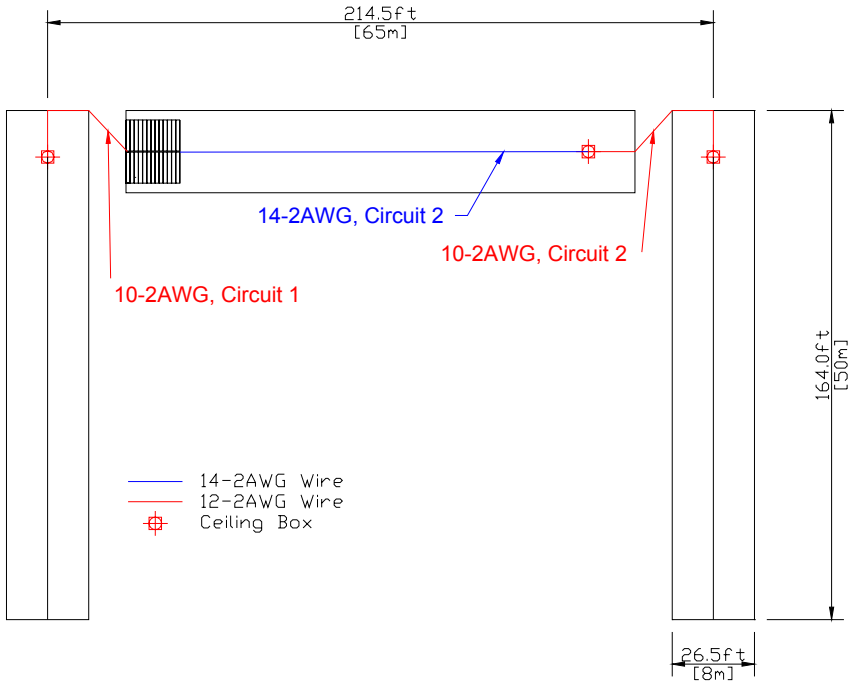


Figure 5.4; Nyabishongo Building Layout

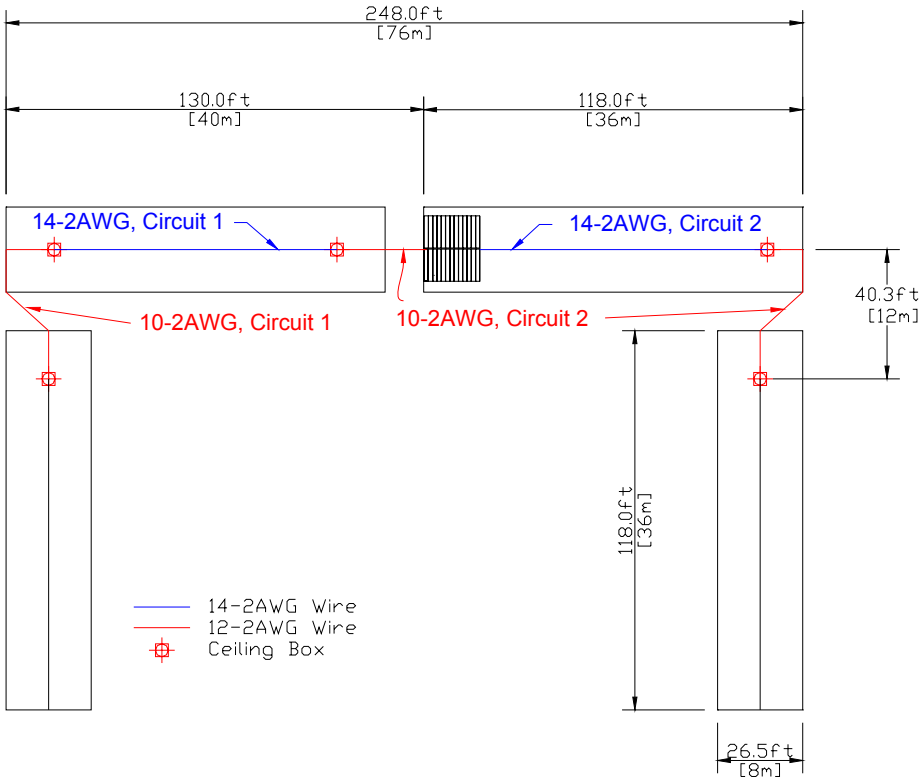


Figure 5.5; Rushashi Building Layout

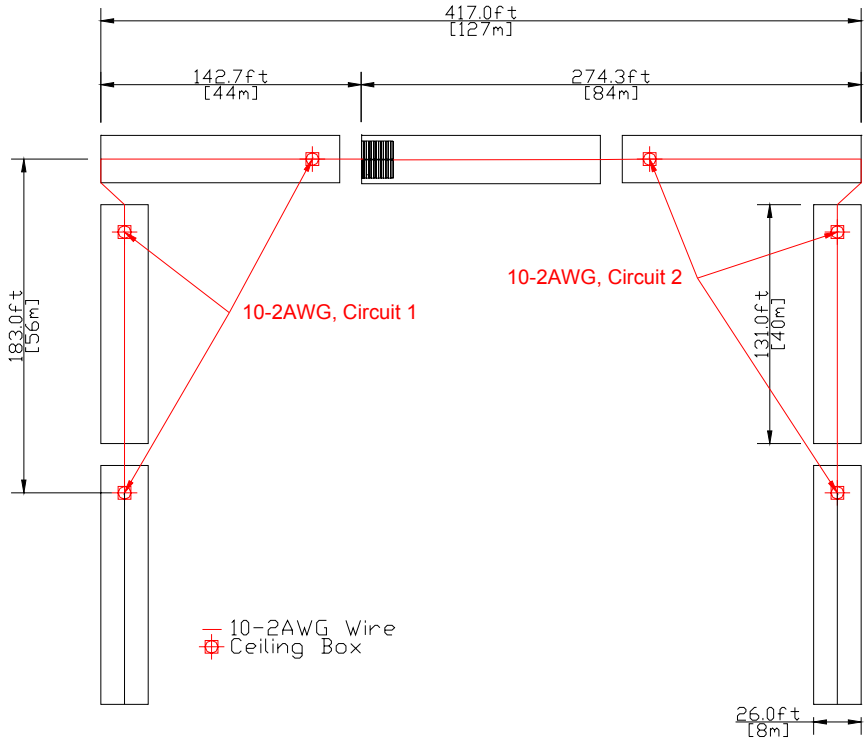


Figure 5.6; Rutsiro Building Layout

B. The 14-2 wire, 14-3 wire, ½" conduit, and conduit components were selected to run power from a Ceiling Box in each of the buildings (of circuit one & two) to each of the lights with 14-2. Then run 14-3 to the each light switch with a Plug below each switch. This will give a plug in each of the offices, classrooms and clinics with minimal wire/conduit.

	Lights					Plugs				
Location	Office	Classrooms	Clinic	Computers	Total	Office	Classrooms	Clinic	Computers	Total
Gisenyi	2	12	0	1	**15**	2	12	0	3	**17**
Mutura	2	16	2	1	**21**	2	16	2	3	**23**
Nyabishongo	2	6	2	1	**11**	2	6	2	2	**12**
Rushashi	2	8	2	1	**13**	2	8	2	3	**15**
Rutsiro	2	14	2	1	**19**	2	14	2	3	**21**
				Total	**79**				**Total**	**88**

Table 5.7; Number of Lights and Plugs

In the building with the Control Module, power can come from circuit six. Run 14-2 from circuit six to the lights and then 14-3 to the light switch with a plug just below the switch in each Office, Classroom, or Clinic. Again, this will give a plug in each office, classroom and clinic with minimal wire/conduit. There is a plug on the Control Module already connected to circuit six.

For the Computer Room, circuits 3-5 can supply three dedicated circuits for the computers. An extra plug for below the light in the computer room was not included. Plugging multiple computers into the lighting circuit could cause problems.

C. Possible Problems,

- The building layout was done with the assumption that the buildings are 15_feet apart. From the pictures of the buildings, they look much greater than 15-feet (closer to 60)!

- Six extra Ceiling boxes would give the option of running powering through the second to the last buildings at Gisenyi, Rushashi, and/or Rutsiro with 14-2 (or 14-3). That is the second to the last building for both circuit one and circuit two, two buildings at each location. This would free up some 10-2UF.

- Still thinking!