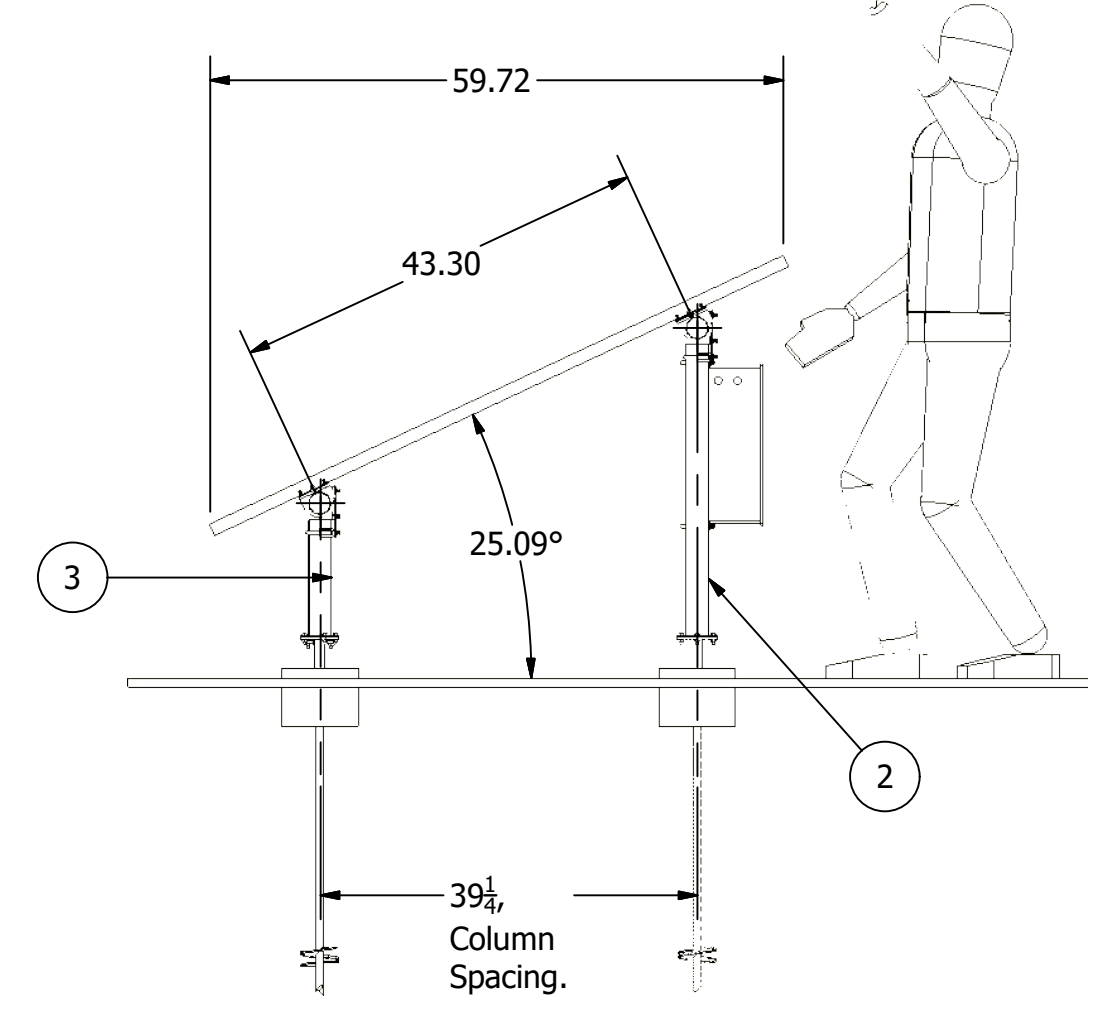
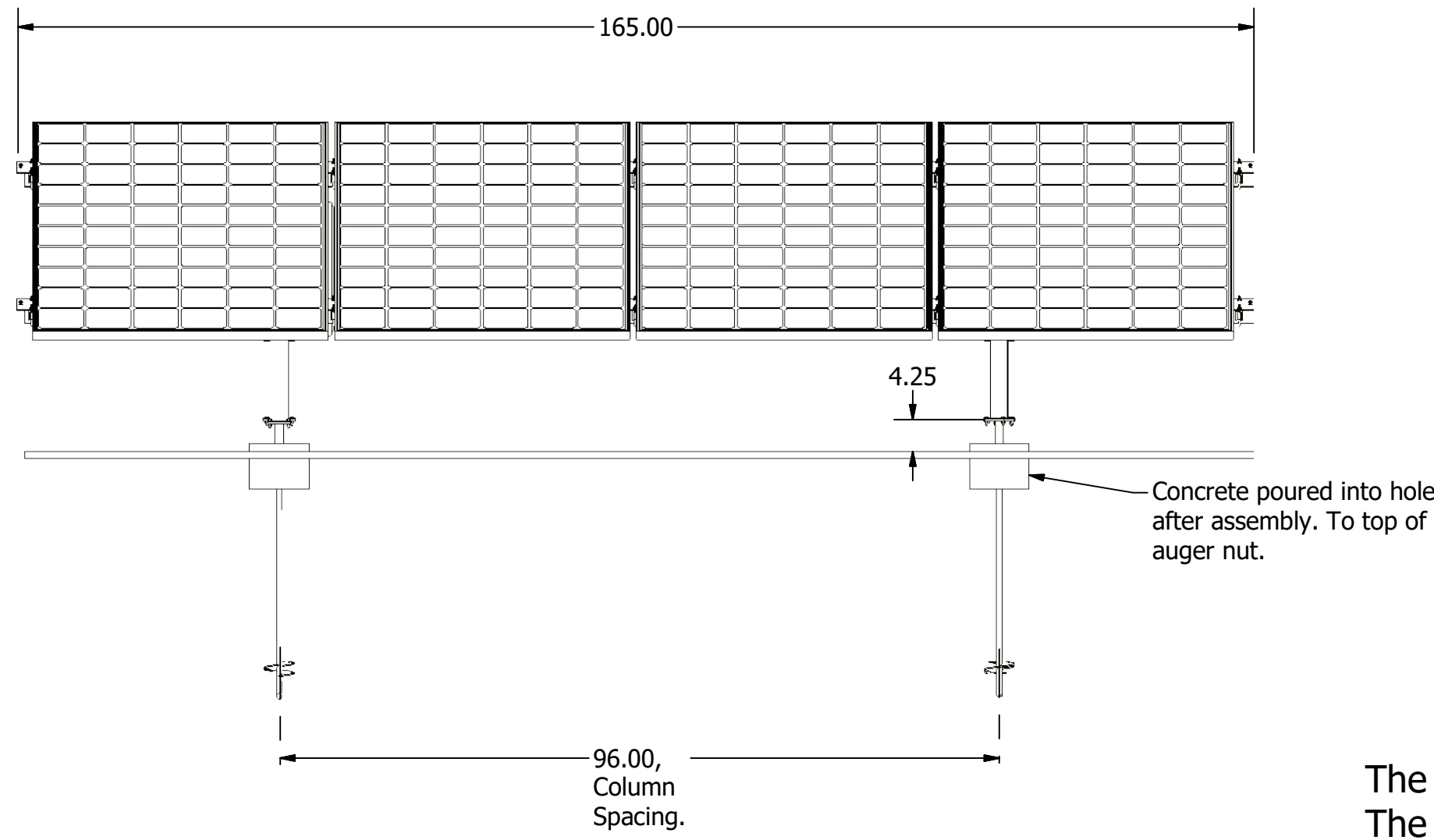
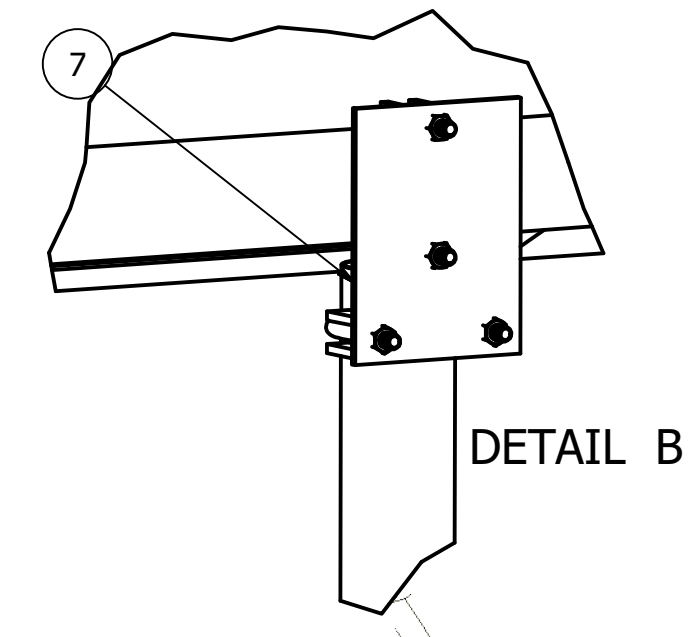
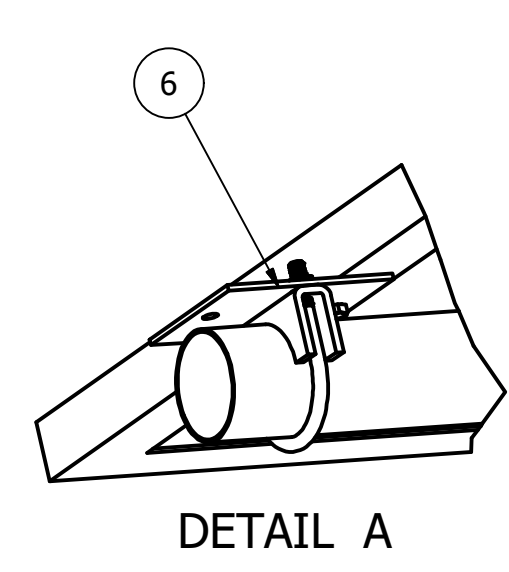


In Detail A, the connection between the panels and the fence posts is shown. The array can be extended laterally. In order to join sections of fence post tube, 2" EMT fits snugly inside the fence post tube. If a different panel is used, the front-to-back post spacing will change. The control box has components for an off grid system, with a pure sine wave inverter.



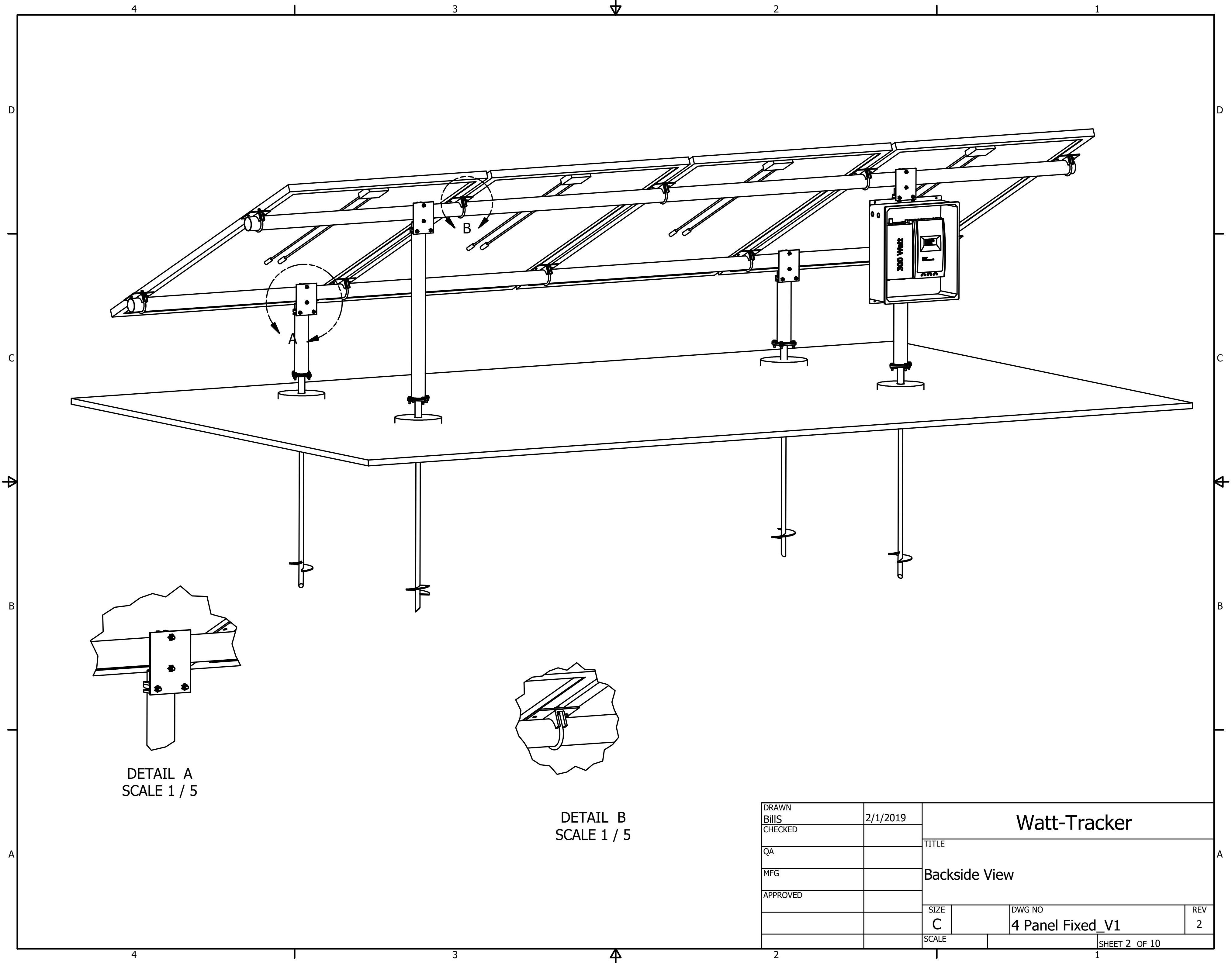
The column spacing depends upon the the location of the mounting holes on the panel. The math is the following: Column spacing = Panel Hole spacing x Cosine(panel angle). In this example, Column Spacing = 43.3" x Cosine(25) = 39.24"

The posts and horizontal beams are galvanized fence posts, measuring 2 3/8" diameter. They are the least expensive source of pipe. If 2 sections need to be spliced, 2" EMT fits snugly inside. Use 4 1/4-20 bolts and nuts to secure.

PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION	ESTIMATED
1	4	SolarWorld_SW285	250 Watt	
2	2	RearColumn	See Page 7	
3	2	FrontColumn	See Page 7	
4	18	3042T910_CLAMPING U-BOLT	McMasterr-Carr	\$2.14
5	2	2EMT_Horizontal_A	Fence posts, 2 3/8" OD, 164" long	\$1.95/ foot
6	10	PanelMountingPlate_EMT	Mount, Panel to Horizontal Pipe	\$14.00
7	4	PostMountingPlate_EMV1	Mount, Column to Horizontal Pipe	\$14.00
8	1	EPEVER_Tracer_4220A	24 volt MPPT Charge Controller & MT50	\$146.00
9	1	Reliable_Electric_300 Watt	Inverter-300 Watt,600 Watt peak,24 volts	\$65.00
10	32	ANSI B18.2.2 - 1/4 - 20	Hex Nuts (Inch Series) Hex Nut	
11	16	ANSI/ASME B18.2.1 - 1/4-20 UNC - 0.625	Hex Bolt - UNC (Regular Thread - Inch)	
12	16	ANSI/ASME B18.2.1 - 1/4-20 UNC - 1	Hex Bolt - UNC (Regular Thread - Inch)	

DRAWN	2/1/2019	<b>Watt-Tracker</b>		
BILLS CHECKED				
QA		TITLE		
MFG		4 panel ground mount array		
APPROVED		SIZE	DWG NO	REV
		C	4 Panel Fixed_V1	2
		SCALE	SHEET 1 OF 10	

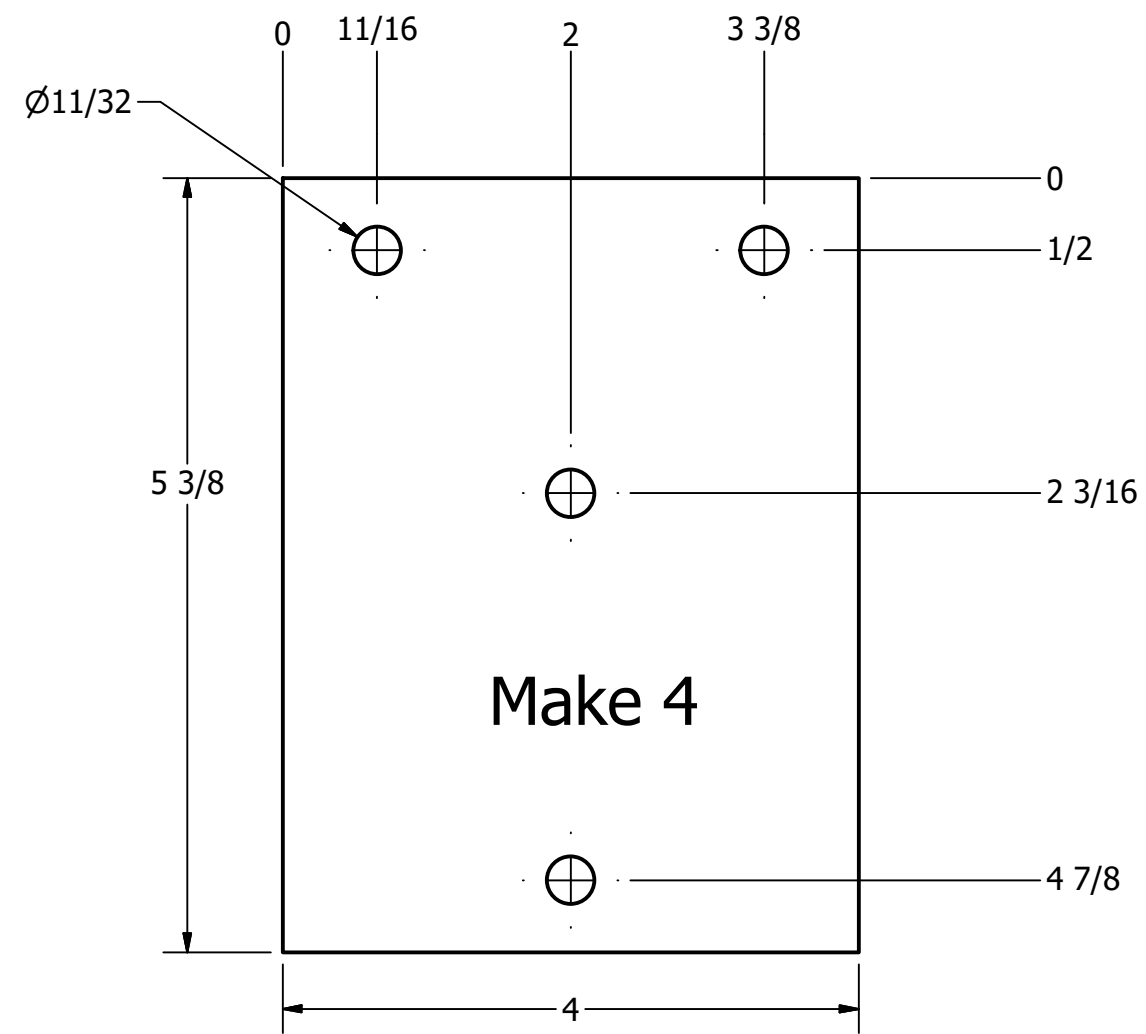


DETAIL A  
SCALE 1 / 5

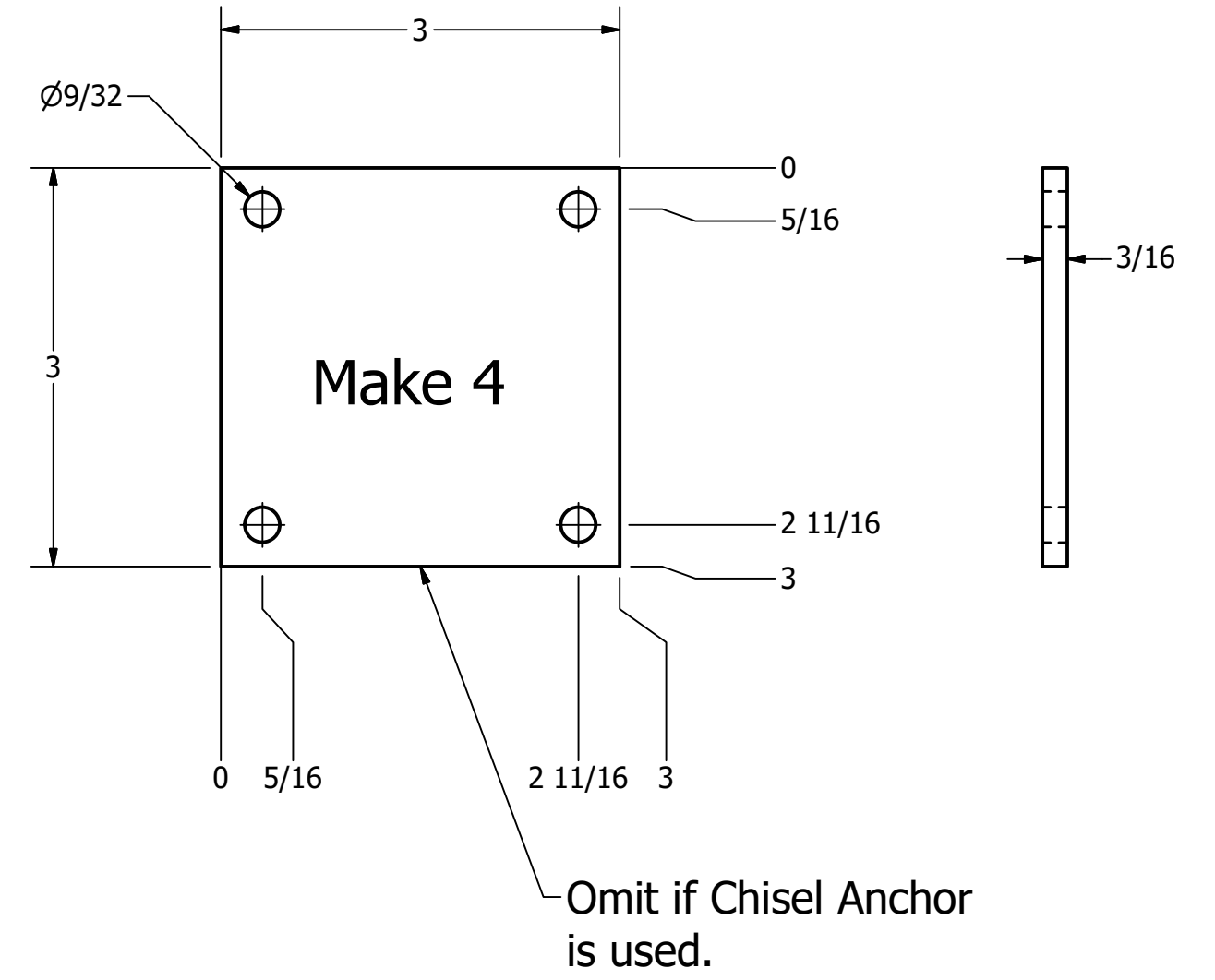
DETAIL B  
SCALE 1 / 5

DRAWN		Watt-Tracker		
BiLLS	2/1/2019	TITLE		
CHECKED		Backside View		
QA		SIZE	DWG NO	REV
MFG		C	4 Panel Fixed_V1	2
APPROVED		SCALE	SHEET 2 OF 10	

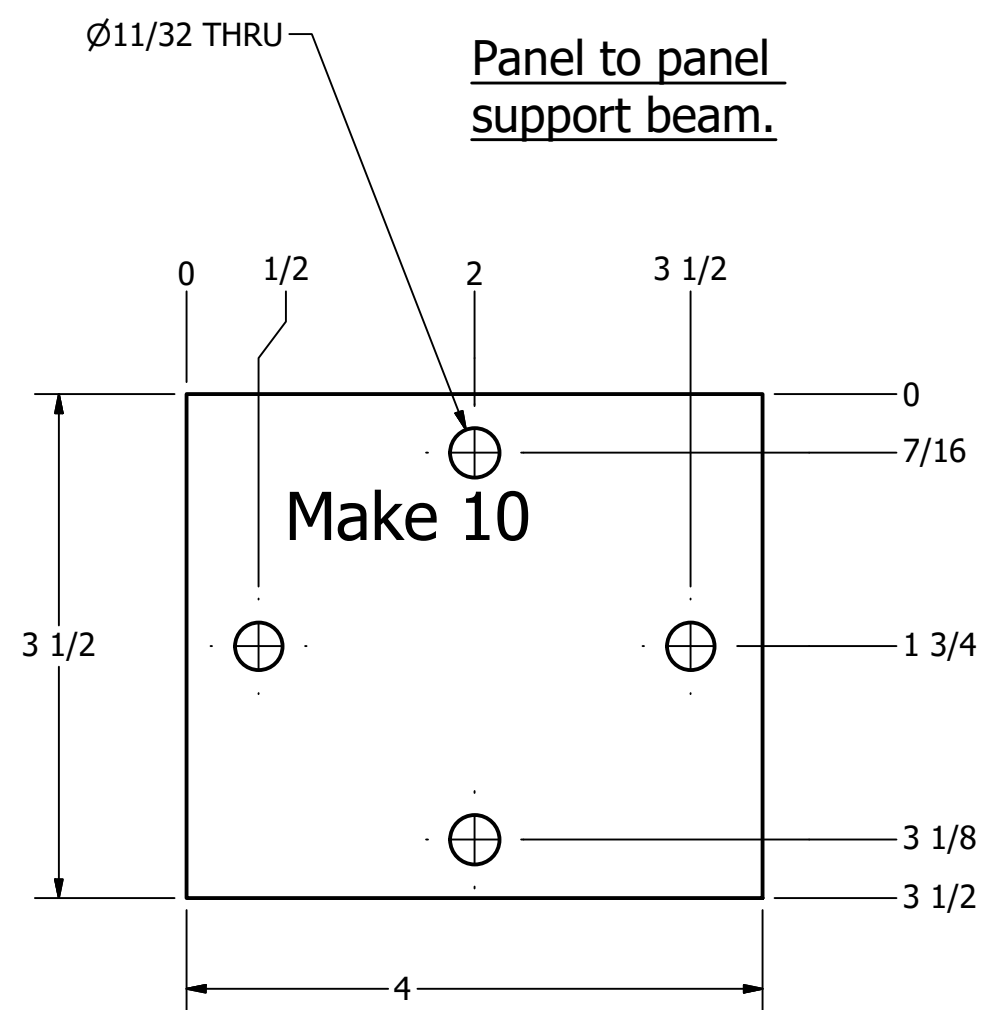
Column top to panel support pipe.



For Auger.

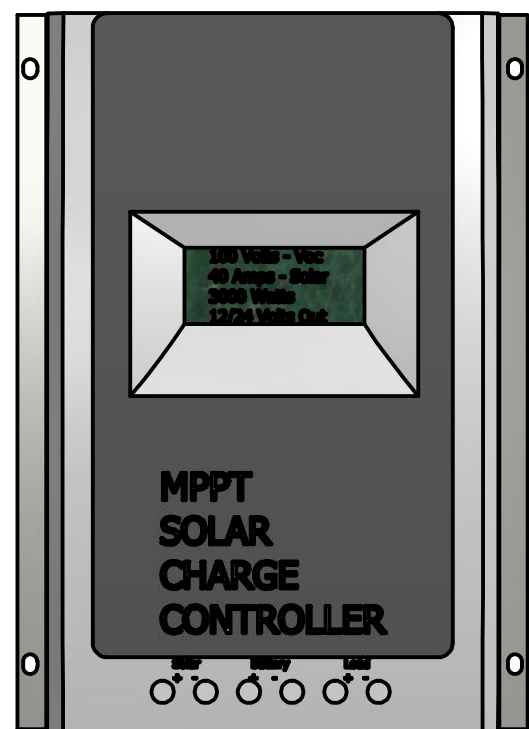


Panel to panel support beam.

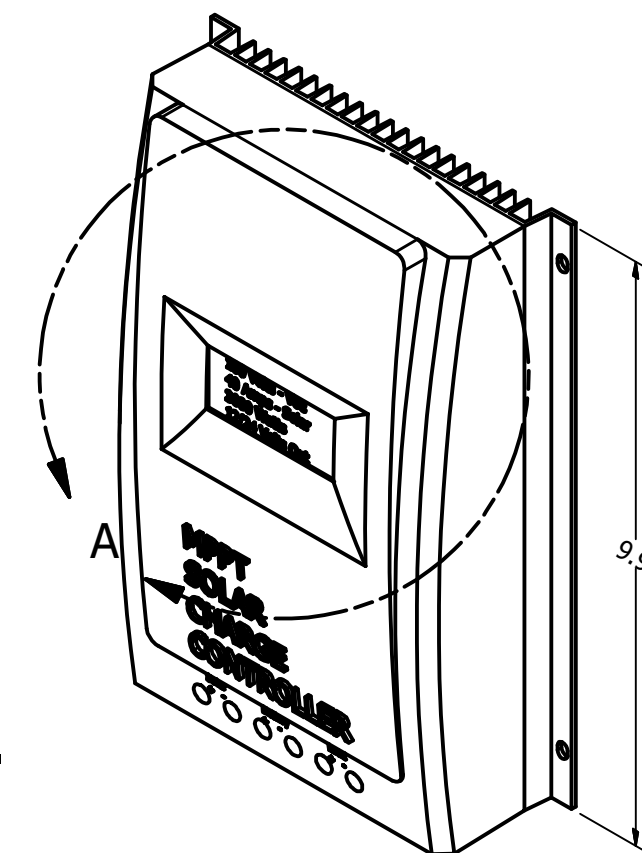
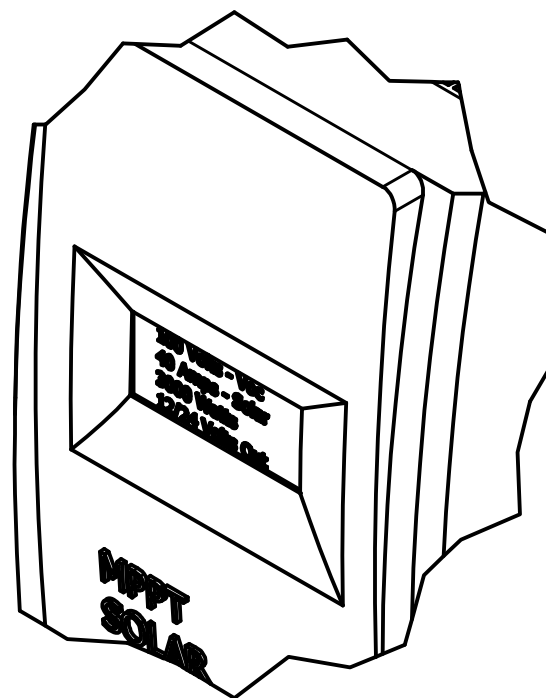


DRAWN	2/1/2019	Watt-Tracker		
BILLS				
CHECKED		TITLE		
QA		Machined Parts for ground mount		
MFG		SIZE	DWG NO	REV
APPROVED		C	4 Panel Fixed_V1	2
		SCALE	SHEET 3 OF 10	

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	EPEVER_Tracer_4210A	24 volt MPPT Charge Controller & MT50

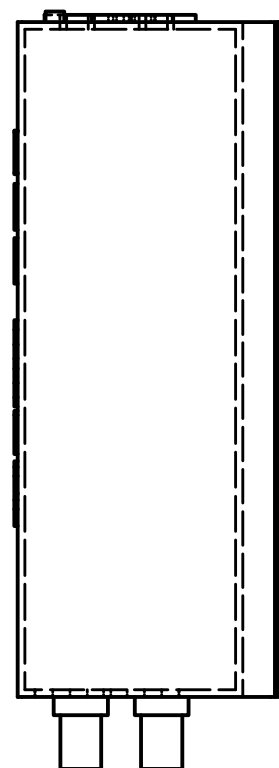
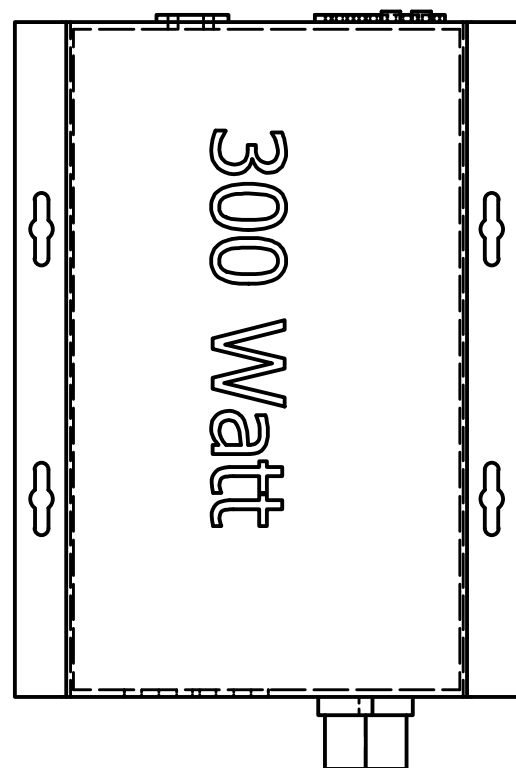


DETAIL A

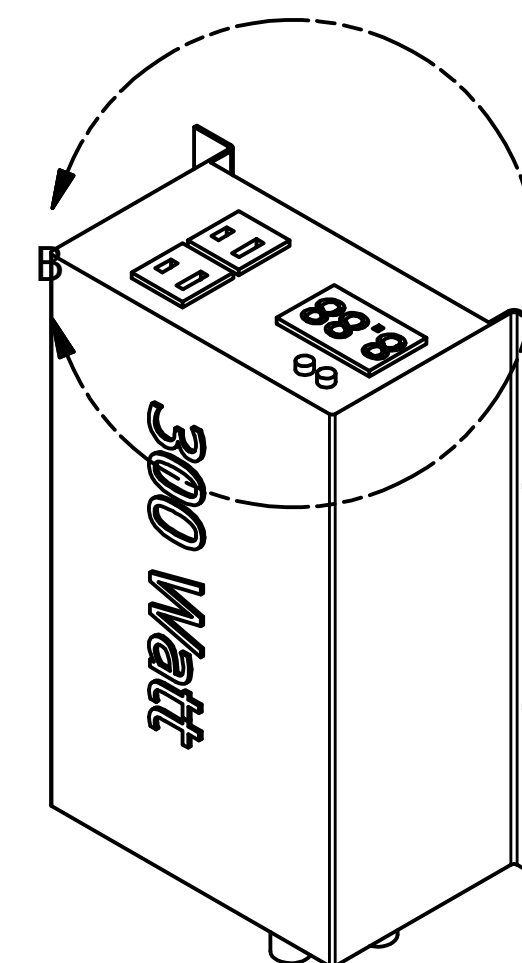
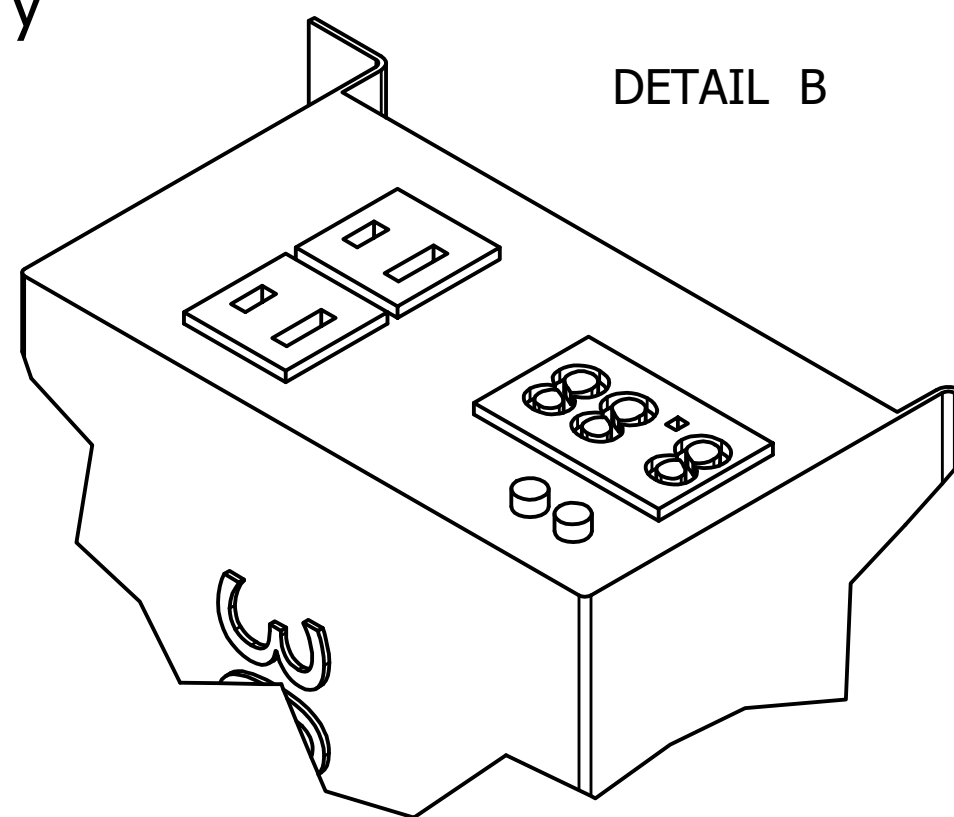


This above unit can receive 1000 watts of solar. By adding 3000 watts, it will start regulating, and charging the battery earlier and later in the day. The different versions can receive from 10 to 40 amps solar. This unit is for 40 amps. The unit will self detect whether the battery voltage is 12 or 24 volts. There is also a setting for lithium batteries.

The unit below can provide 300-600 watts of power at 120 Vac with a 24 volt battery pack. It has a low voltage cut-off if the battery voltage gets too low.

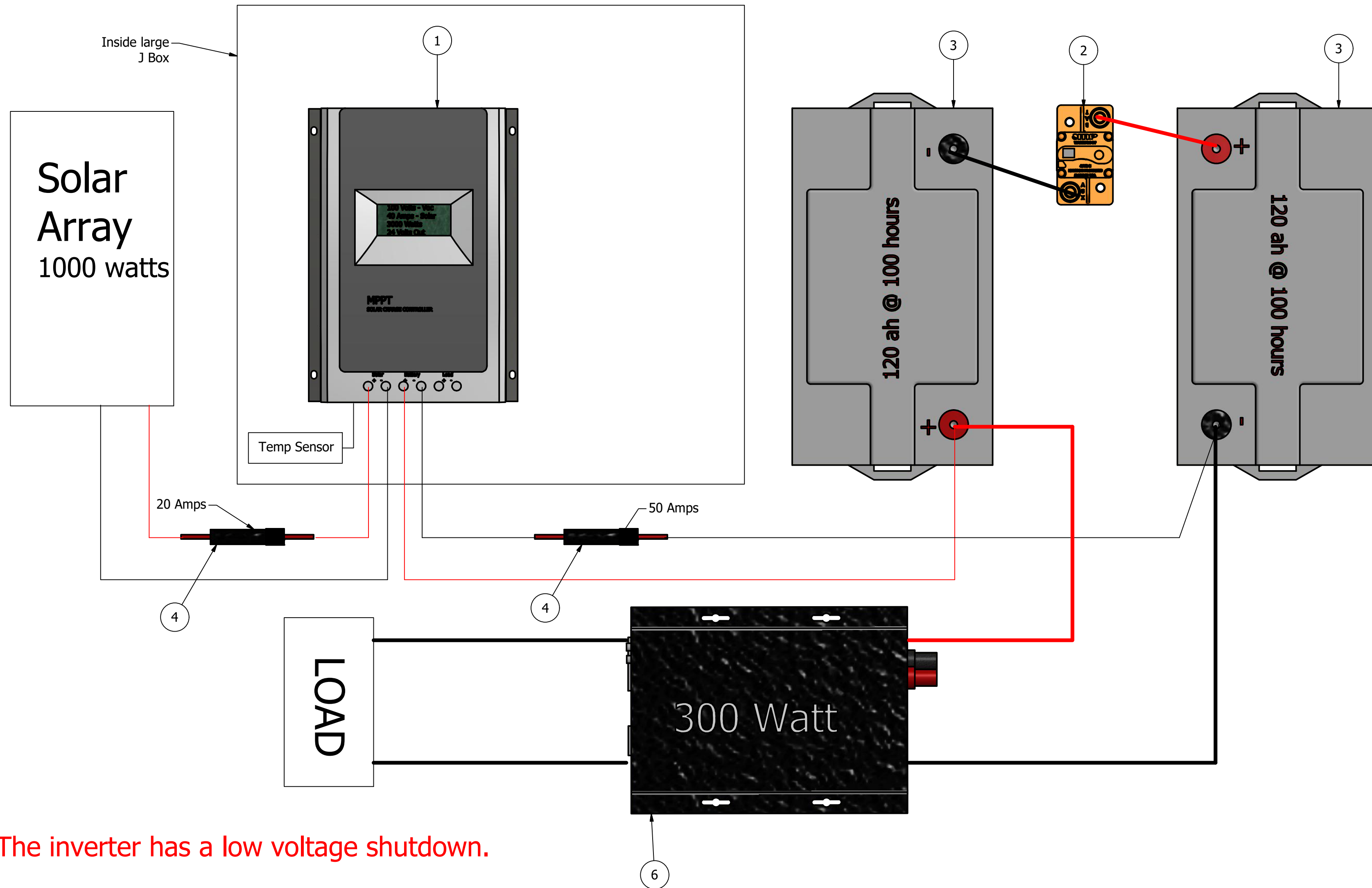


DETAIL B



DRAWN	2/1/2019	Watt-Tracker		
BILLS CHECKED				
QA		Charge Controller. For Off grid system		
MFG		SIZE	DWG NO	REV
APPROVED		C	4 Panel Fixed_V1	2
		SCALE	SHEET 4 OF 10	

Operation: Solar power (1000 watts, <100 volts /10 amps) is regulated to max 47 amps @ 24 volts to charge the batteries. The batteries provide 24 volt power to a 300 watt pure sine wave inverter. The battery amps are fused with a 175 amp breaker. The panel configuration is 2s2p. This means that there is a parallel set of 2 panels in series. The series panel connection makes 2 x Voc or 80 volts. The parallel connection makes the amps 2 x Isc or about 16 amps.



The inverter has a low voltage shutdown.

PARTS LIST				
ITEM	QTY	PART NUMBER	DESCRIPTION	ESTIMATED COST
1	1	EPEVER_Tracer_4220A	24 volt MPPT Charge Controller & MT50	\$109
2	1	CircuitBreaker_175-S2-120-2	Re-settable breaker from Mechanical Products	\$49
3	2	Pharos_120ah	Deep Cycle Solar Battery	\$25.00
4	2	InlineFuseHolder	Ace electronics, Houston	
5	1	Fuse_AGC	2 @ 40 amp & 2 @ 20 amp	
6	1	Reliable Electric_300 Watt	Inverter-300 Watt,600 Watt peak,24 volts	\$65.00

DRAWN	2/1/2019	Watt-Tracker		
BiLLS				
CHECKED		TITLE		
QA		Electrical schematic, off grid system		
MFG		SIZE	DWG NO	REV
APPROVED		C	4 Panel Fixed_V1	2
		SCALE	SHEET 5 OF 10	



The layout includes running 2 conductors in PVC from the array to the j Box, inside the shed.  
The wire size should be AWG 10.

Assembly is as follows: Tools are (1 ea) sockets and (4 ea) open end wrenches (1/2").

1. Place the column sets (long and short column) 92 inches apart.
2. Each horizontal bar will have 11 pipe clamps attached. Place the horizontal pipes on top of the columns as noted, tighten the pipe clamps.  
The horizontal pipe with the junction box goes on top, with the box facing the rear of the array.
3. Attach the panels with the panel wires on the top, from one side to the other. You may have to tweek the location as you build from left to right.  
Each panel gets 4 bolts and nuts.
4. Connect the MC4 connectors, joining the left 2 panels and the right 2 panels. Red tape denotes the 2 wires to be connected.  
If an MC4 connector is fully engaged, use the red tool in the small J Box to sepatate. Dont loose this tool. The remaining 2 wires go to the junction box located at mid span.  
The connectors are polarized. The voltage should be 70 volts.
5. Check voltage on the Anderson connector leaving the small junction box. Should be approx 2 times the Voc value of a panel. Or 70 volts again. The difference is that the amps are doubled to 16 amps. This is twice the short circuit amps (Isc-8.5 amps) listed on the panel label).
6. The next step is to mount the large junction box on one of the rear columns. Use 2 pipe clamps. Place the batteries on the wooden 2 x 6's.
7. **Connect the Anderson connector between the batteries the charge controller first.** Connect the solar panel wires next. Read the display next to the Charge controller.  
It should show power in.....
8. Connect the heavy gauge wire between the batteries and inverter.

**Fusing and wire gauge selection:** This is based on an 1140 watt array (4 panels at 285 watt each), and a 2500 watt inverter and a 24 volt battery.

The array is configured as 2S2P. This means panels 1,2 and panels 3,4 are in series and panels 1,2 are in parallel with panels 3,4.

The label on the back of a panel shows an Isc of 9.84 amps and a Voc of 39.7 volts. The voltage of 2 panels in series is  $2 \times 39.7 = 79.4$  volts.

The current thru 2 panels in series is 9.84 amps. But the parallel set of 2 panels contributes another 9.84 amps.

In summary, the 2 wires from the array shows a voltage of 79.4 volts and a current of 19.68 amps.

**Panel Fusing:** Each 2 panel circuit is fused at 10 amps in the small junction box. It should be 15 amps because there may be a day in which the conditions are optimal.

The NEC recommends using a 25 % safety margin, so the current is  $9.84 \times 1.25 = 12.3$  amps. In terms of wire size, the NEC recommends a safety margin of 25%.

So the design current is  $9.84 \times 1.25 \times 2 = 24.6$  amps. I have an additional fuse in the large J box of 30 amps.

**Panel Wire Size:** I am using # 12 which is good for 15 amps.

The panel power goes to the MPPT charge controller. The charge controller regulates the panel voltage to battery voltage plus some.

The current to the battery is estimated by dividing the panel wattage by the battery voltage -  $1140 / 24 = 47.5$  amp.

I have placed a 50 amp fuse in that path. Hook to the middle 2 lugs on the charge controller. Observe polarity.

**Charge controller to battery wire size:** Copper conductor has a voltage drop based on the ohms per foot of the wire. I am using #10 AWG wire.

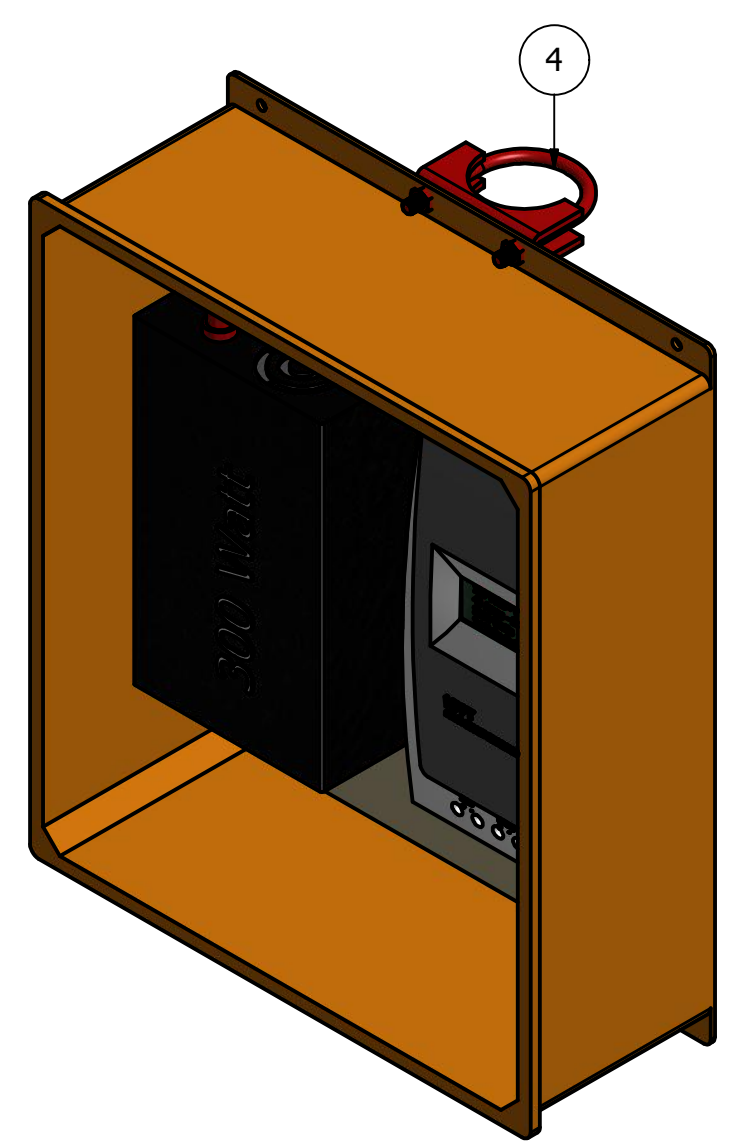
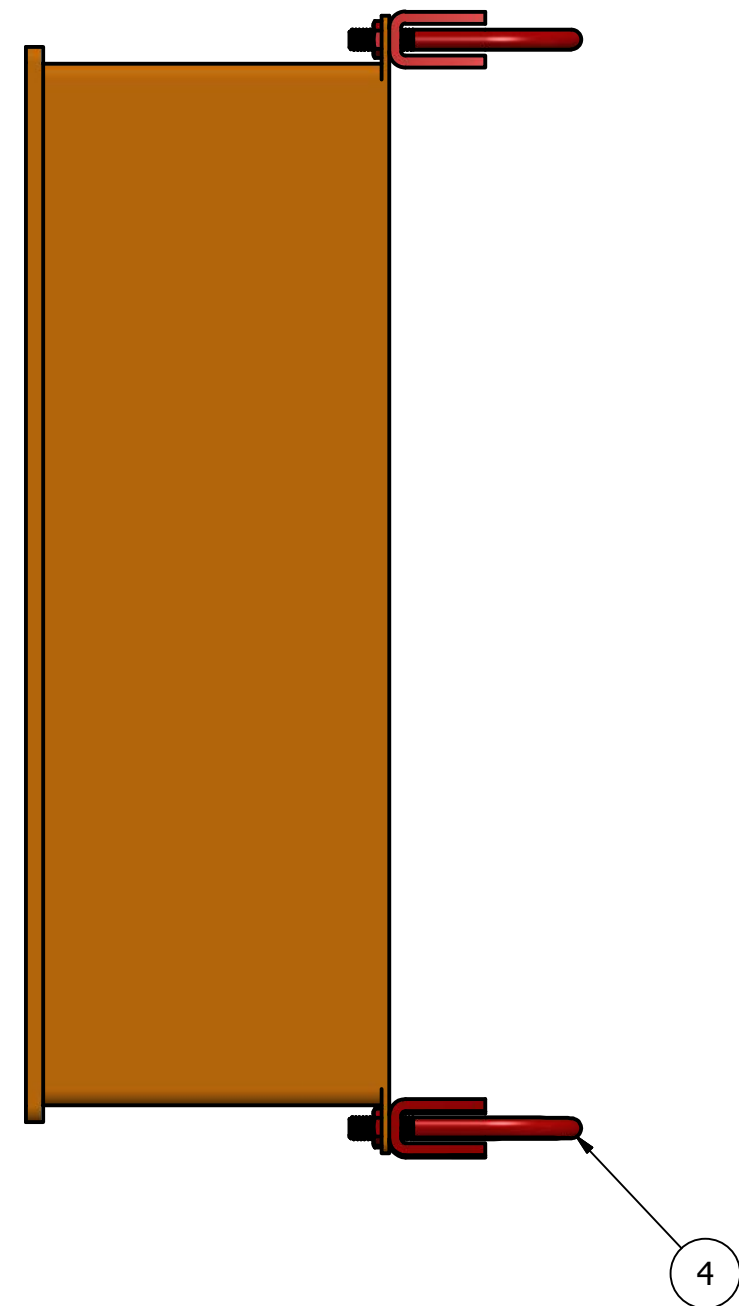
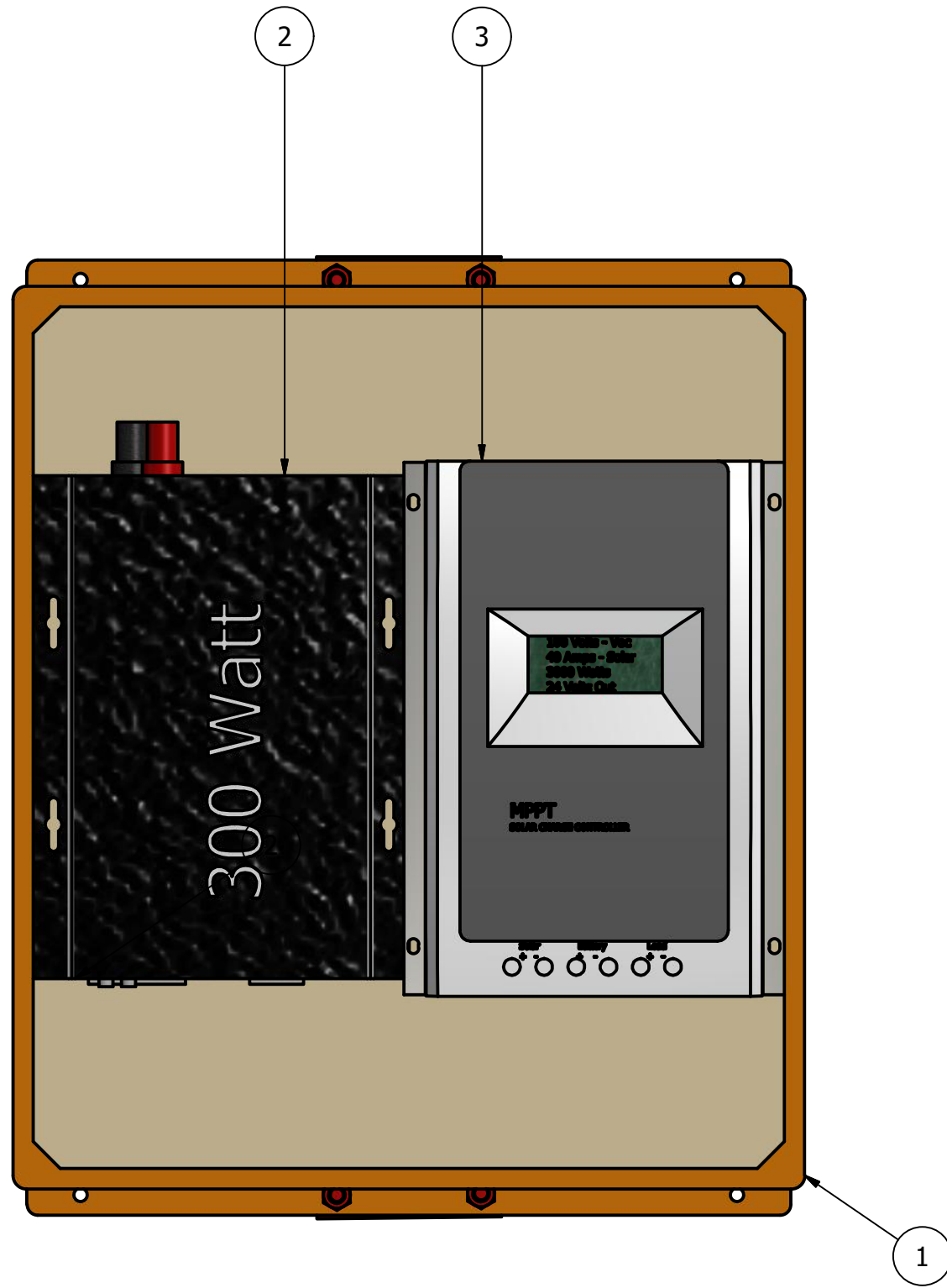
There is a 1% voltage drop. 1% of 24 volts is 0.24 volts. Wire is sized for no more than 1-2% voltage drop.

**Inverter:** It is 2500 watts, but can surge to 5000 watts. The amps between the battery and inverter is  $5000 \text{ watts} / 24 \text{ volts} = 208$ .

A smart phone application for dc wire sizing indicates that the wire should be 2 AWG. One could use smaller wire because the 207 amps can only be for a short time. #6 would be adequate. It has a dia of 0.16".

**The system can be upgraded to 3000 watts, as the charge controller can take 40 amperes.**

DRAWN	2/1/2019	Watt-Tracker		
BIILS				
CHECKED		TITLE		
QA				
MFG				
APPROVED				
		SIZE	DWG NO	REV
		C	4 Panel Fixed_V1	2
		SCALE	SHEET 6 OF 10	

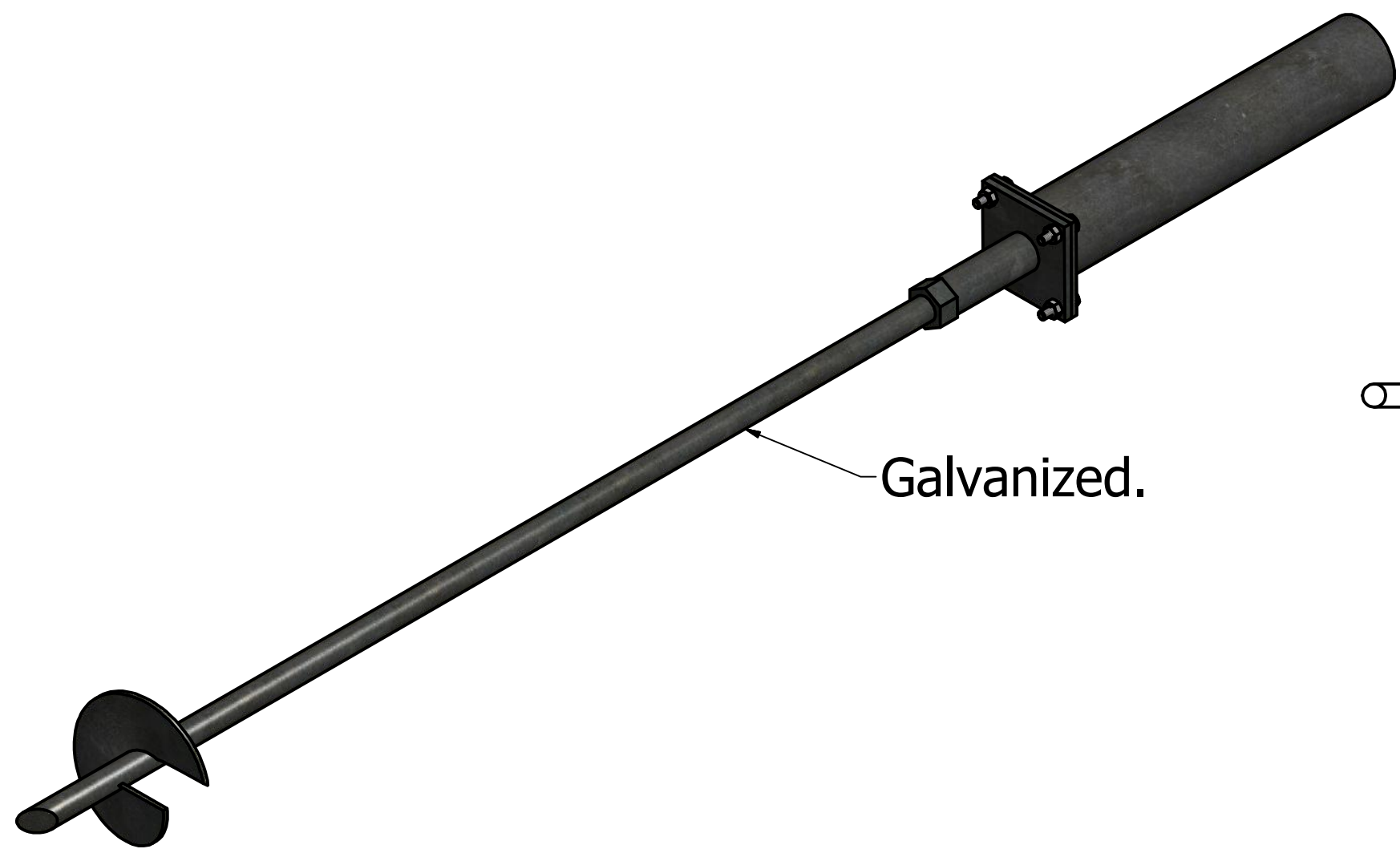
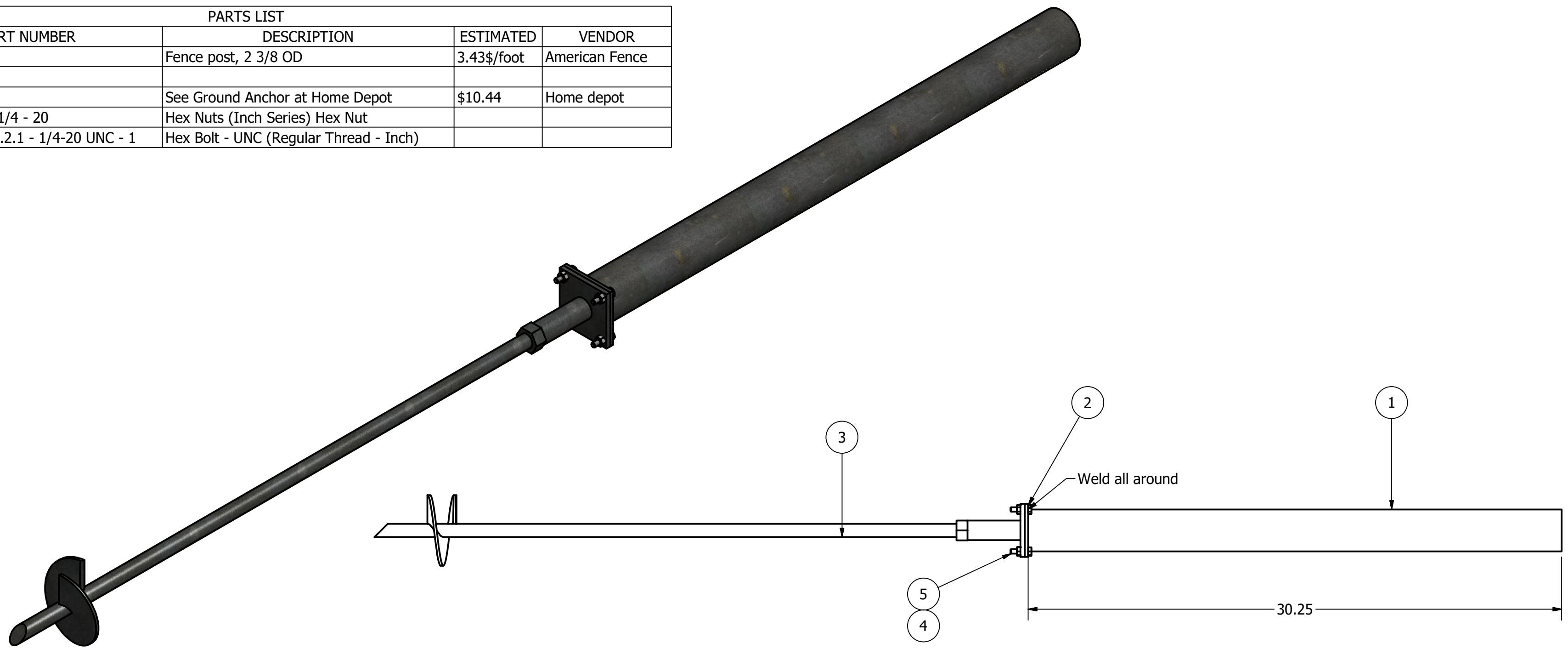


PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION	ESTIMATED COST	VENDOR
1	1	JBox_Vynckier_VJ_1514W	Surplus - altech Metals	34\$	Altech Metals-surplus
2	1	Reliable Electric_300 Watt	Inverter-300 Watt,600 Watt peak,24 volts	\$65.00	eBay
3	1	EPEVER_Tracer_4220A	24 volt MPPT Charge Controller & MT50	\$109	eBay
4	2	3042T910_CLAMPING U-BOLT	McMaster Carr	\$2.15	McMasterr-Carr

DRAWN	2/1/2019	<b>Watt-Tracker</b>		
BiLLS				
CHECKED		TITLE		
QA		Charge Controller, Off grid system		
MFG		SIZE	DWG NO	REV
APPROVED		C	4 Panel Fixed_V1	2
		SCALE	SHEET 7 OF 10	

PARTS LIST					
ITEM	QTY	PART NUMBER	DESCRIPTION	ESTIMATED	VENDOR
1	1	Long_Column	Fence post, 2 3/8 OD	3.43\$/foot	American Fence
2	1	BoltPlate			
3	1	ScrewAnchor	See Ground Anchor at Home Depot	\$10.44	Home depot
4	4	ANSI B18.2.2 - 1/4 - 20	Hex Nuts (Inch Series) Hex Nut		
5	4	ANSI/ASME B18.2.1 - 1/4-20 UNC - 1	Hex Bolt - UNC (Regular Thread - Inch)		



PARTS LIST					
ITEM	QTY	PART NUMBER	DESCRIPTION	ESTIMATED	VENDOR
1	1	Short_Column	Fence post, 2 3/8" OD	\$3.43/foot	American Fence
2	1	BoltPlate			MFG
3	1	ScrewAnchor	See Ground Anchor at Home Depot		
4	4	ANSI B18.2.2 - 1/4 - 20	Hex Nuts (Inch Series) Hex Nut		
5	4	ANSI/ASME B18.2.1 - 1/4-20 UNC - 1	Hex Bolt - UNC (Regular Thread - Inch)		

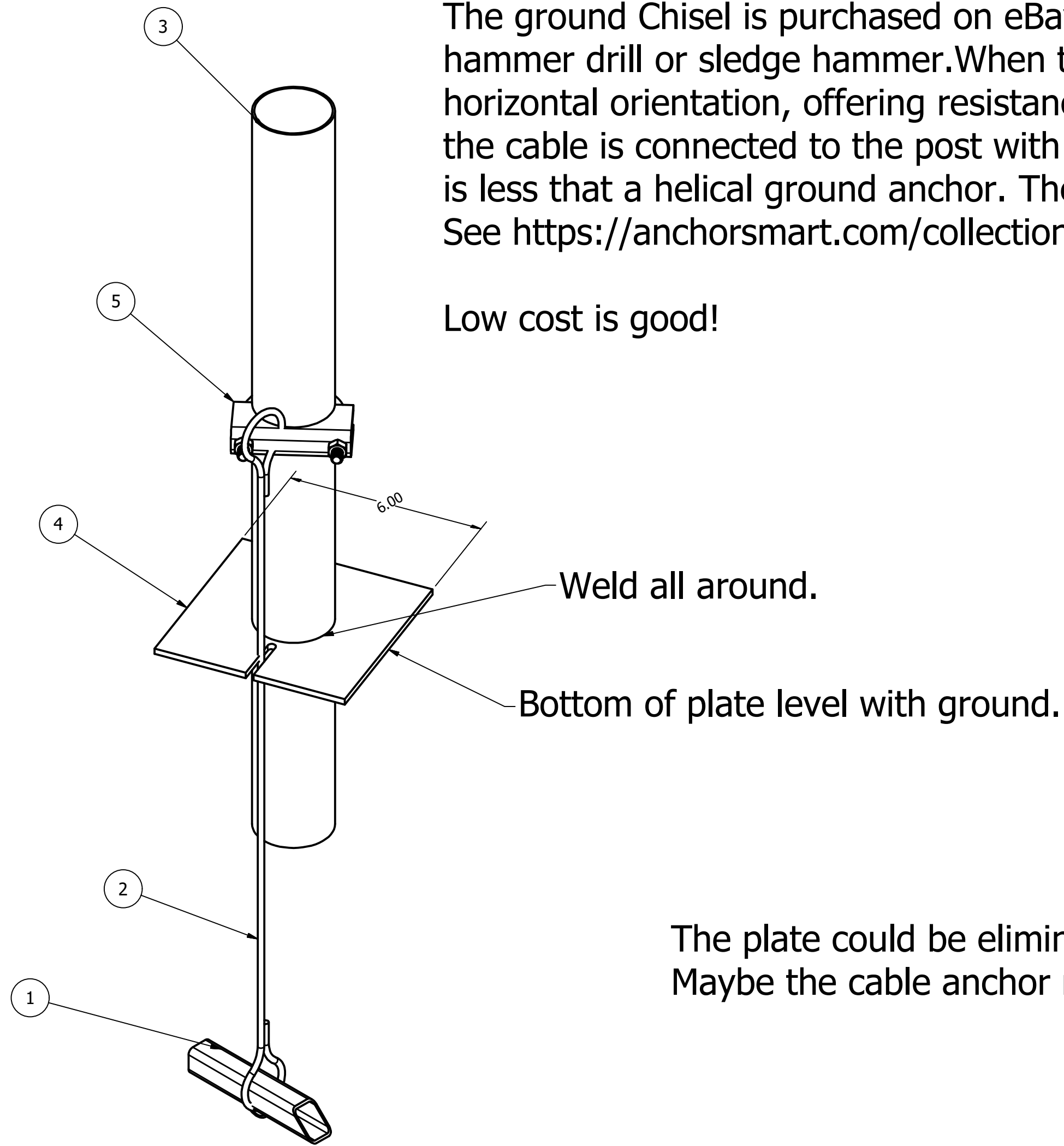
DRAWN	2/1/2019
Biils	
CHECKED	
QA	
MFG	
APPROVED	

<b>Watt-Tracker</b>			
TITLE			
Legs, See page 9 for alternate anchor			
SIZE	DWG NO	REV	
C	4 Panel Fixed_V1	2	
SCALE	SHEET 8 OF 10		



This depicts an alternate method of anchoring the 4 panel array to the ground. The posts are embedded into the ground by 6-12". Embedded to the depth of the 6" plate. The ground Chisel is purchased on eBay, or fabricated. It is driven into the ground with a hammer drill or sledge hammer. When the galvanized cable is pulled, the Chisel re-aligns to a horizontal orientation, offering resistance to being pulled out of the ground. The loose end of the cable is connected to the post with a pipe clamp. I show this alternative, because the cost is less that a helical ground anchor. The cable is 36" long. See <https://anchorsmart.com/collections/steel-anchors> for the holding power of a chisel anchor.

Low cost is good!

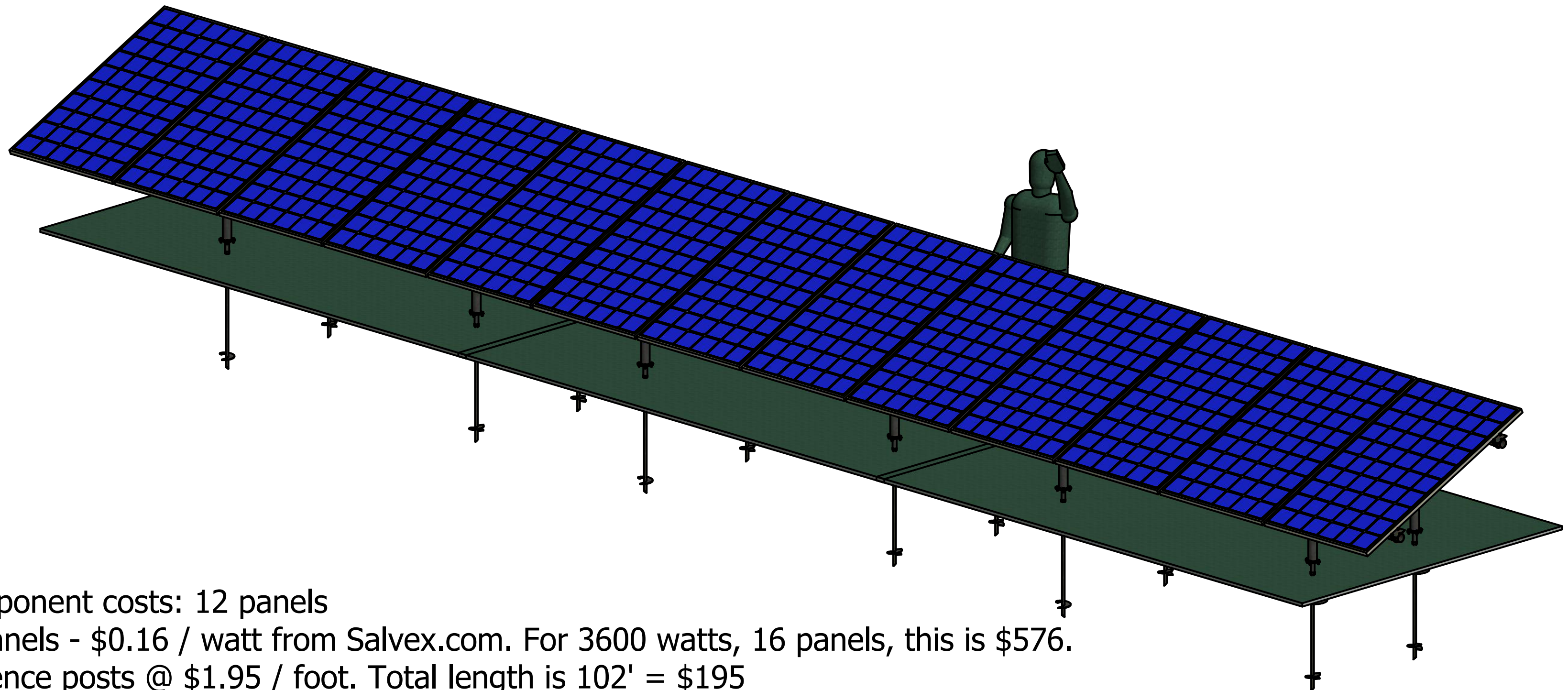


The plate could be eliminated, and concrete placed around the column. Maybe the cable anchor not imbedded in the concrete.

DRAWN	2/1/2019	Watt-Tracker		
BILLS				
CHECKED		TITLE		
QA		Alternate Anchor		
MFG		SIZE	DWG NO	REV
APPROVED		C	4 Panel Fixed_V1	2
		SCALE	SHEET 9 OF 10	

PARTS LIST				
ITEM	QTY	PART NUMBER	DESCRIPTION	ESTIMATED COST
1	1	Chisel Anchor	See <a href="https://anchorsmart.com">https://anchorsmart.com</a> or Duckbill Earth Anchors by Foresight Products.	\$5 each = eBay-> Chisel Anchor
2	1	Cable_Galvanized		Included in Chisel Anchor
3	1	FencePost_2		
4	1	Ground Plate		
5	1	3042T910_CLAMPING U-BOLT	McMaster Carr	

The question arises is "What is the cost of this ground mount"? I have tried to offer an alternative that is low cost. I am using a 3000 watt grid tied inverter from eBay. So the array should be in 3 sections. The fence posts can be joined / spliced with 2" EMT x 12" long



Component costs: 12 panels

1. Panels - \$0.16 / watt from Salvex.com. For 3600 watts, 16 panels, this is \$576.
2. Fence posts @ \$1.95 / foot. Total length is 102' = \$195
3. Inverter - SMA - eBay - 3 kWatts - 669 \$
4. Ground anchors based on Home Depot cost - \$12 x 10 = \$120

According to PV Watts, a 3600 watt array saves 564\$/ year.  
 The cost for the major components, listed above is \$0.43 per watt so far.  
 $0.43 \times 3600 = 1548\$$ . **Payoff is 1548\$ / 564\$ or 2.7 years.**  
**The ROI is reciprocal of this or 36%.** Take that Capital One!  
 It could be installed 16 man hours.

This does not include the installation cost.

DRAWN	2/1/2019	Watt-Tracker		
BILLS CHECKED				
QA		TITLE		
MFG		Construction Notes and Estimated cost		
APPROVED		SIZE	DWG NO	REV
		C	4 Panel Fixed_V1	2
		SCALE	SHEET 10 OF 10	