

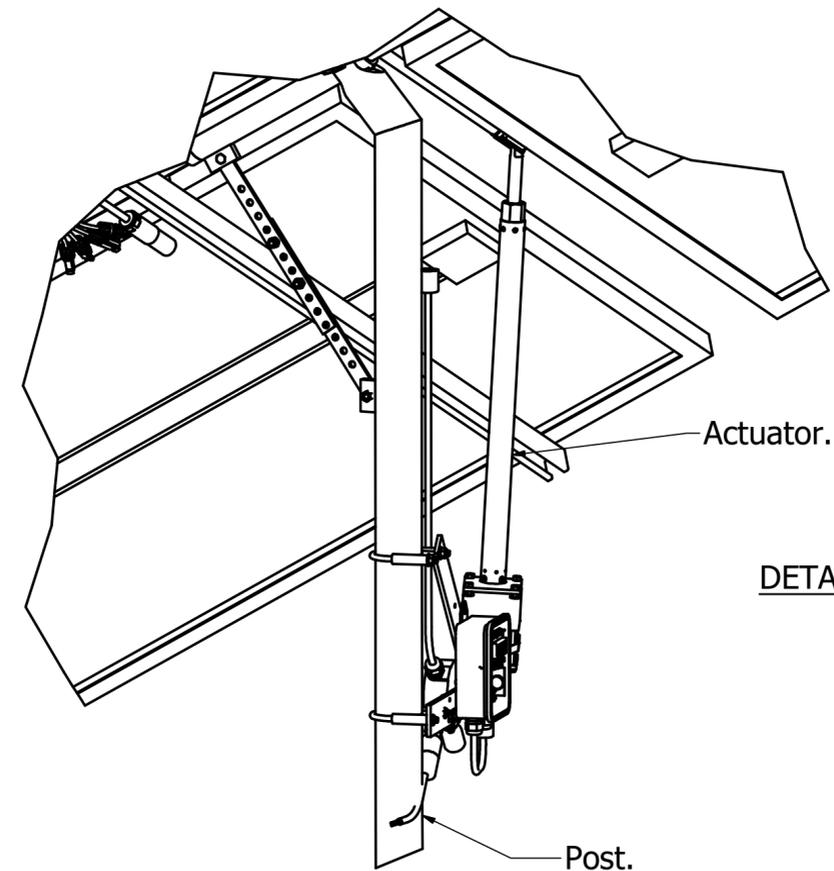
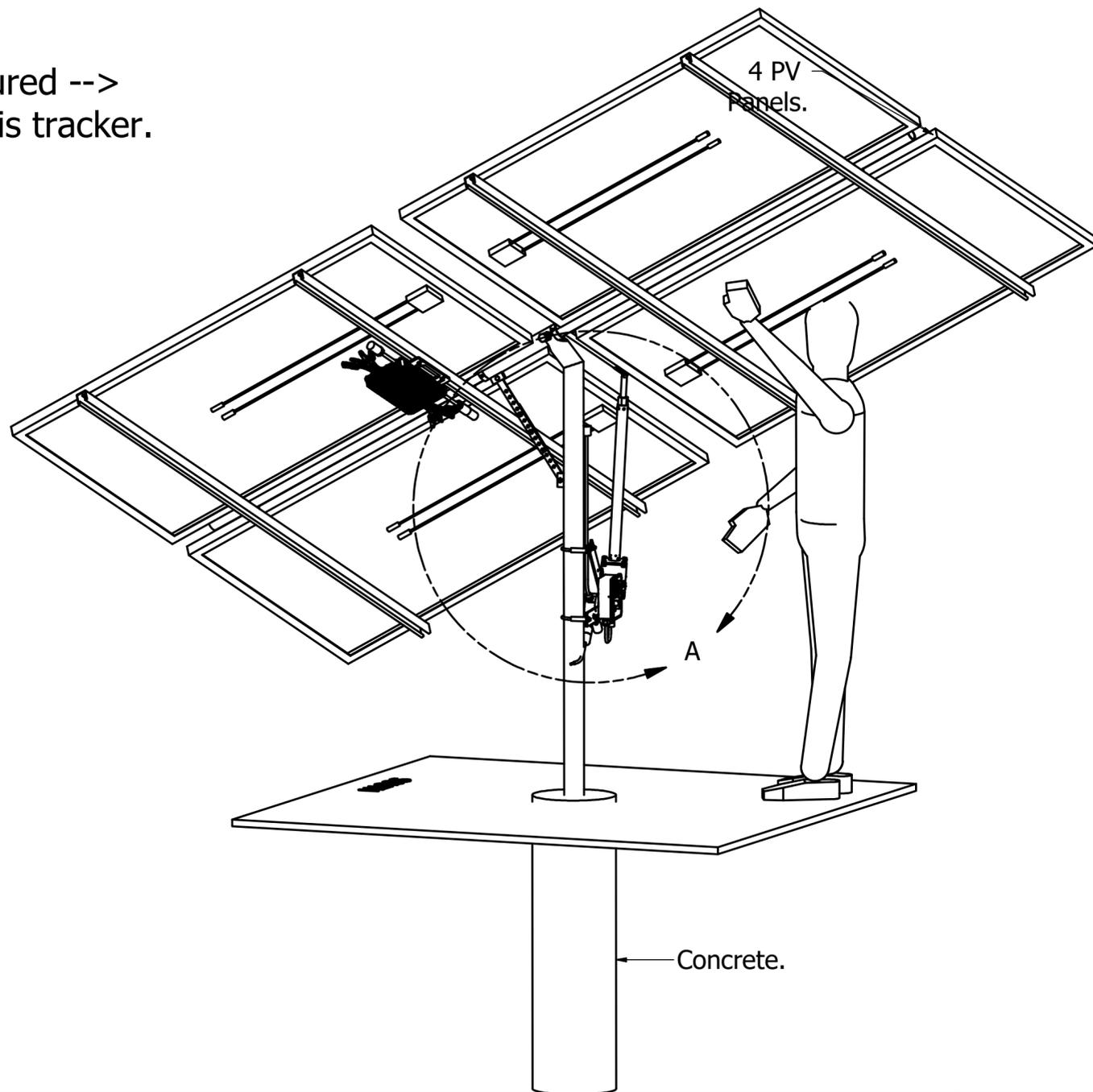
2 Axis Solar Tracker - one axis motorized, the other is manually adjusted, seasonally.

One difference between a single axis tracker and a dual axis tracker, is that the height of the dual axis array is higher due to the need for more ground clearance.

This drawing shows multiple mechanical designs for mounting up to 1200 watts of solar panels on a solar tracker. A couple of designs are shown, depending upon the maker's machining skills.

The controller is an Arduino Uno, programmed to cause movement, east to west, rain or shine. Parking in the evening. The DC voltage from the panels, feed into a 4 in 1 Micro inverter, which provides 4 amps at 220 volts.

Pictured -->
2 axis tracker.



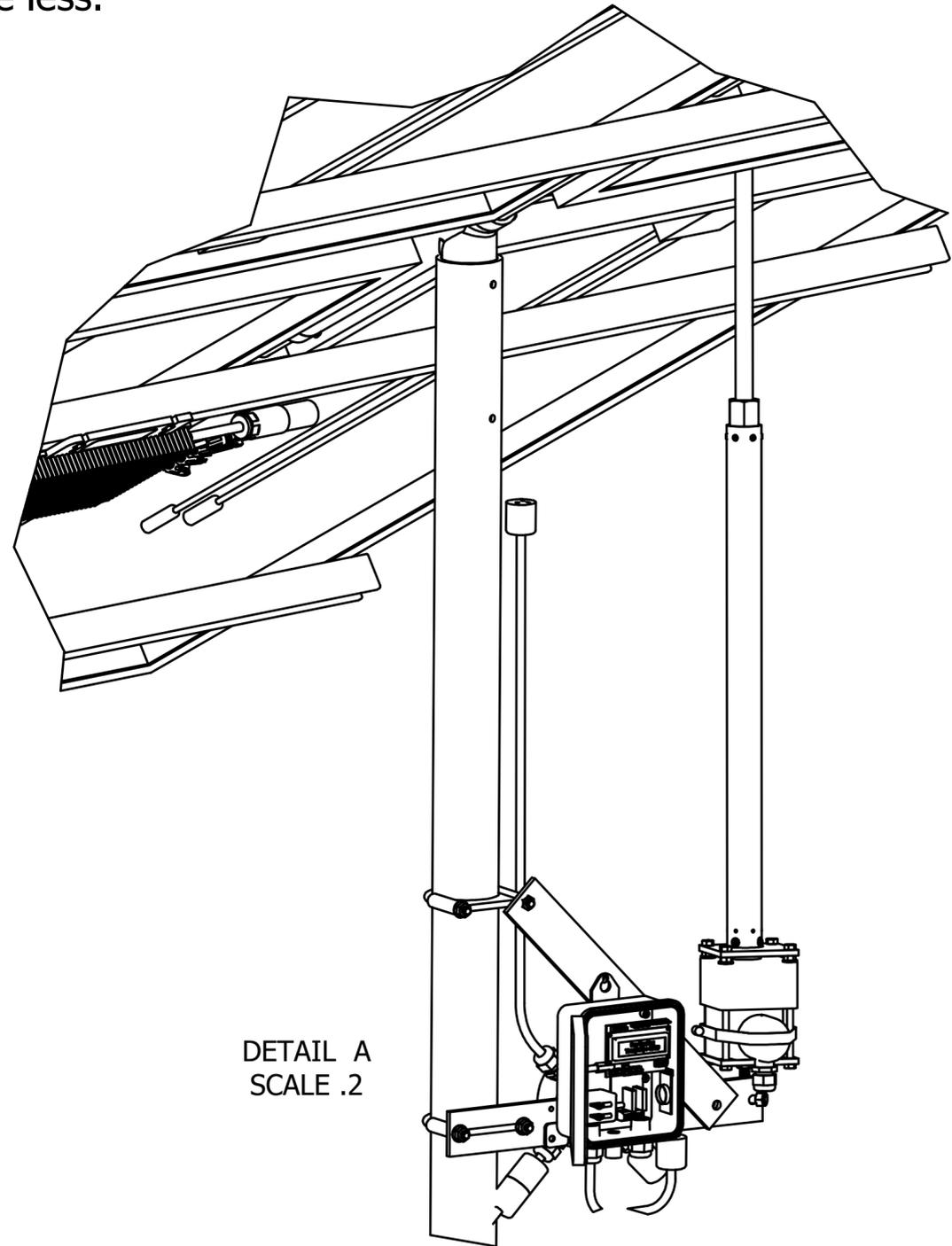
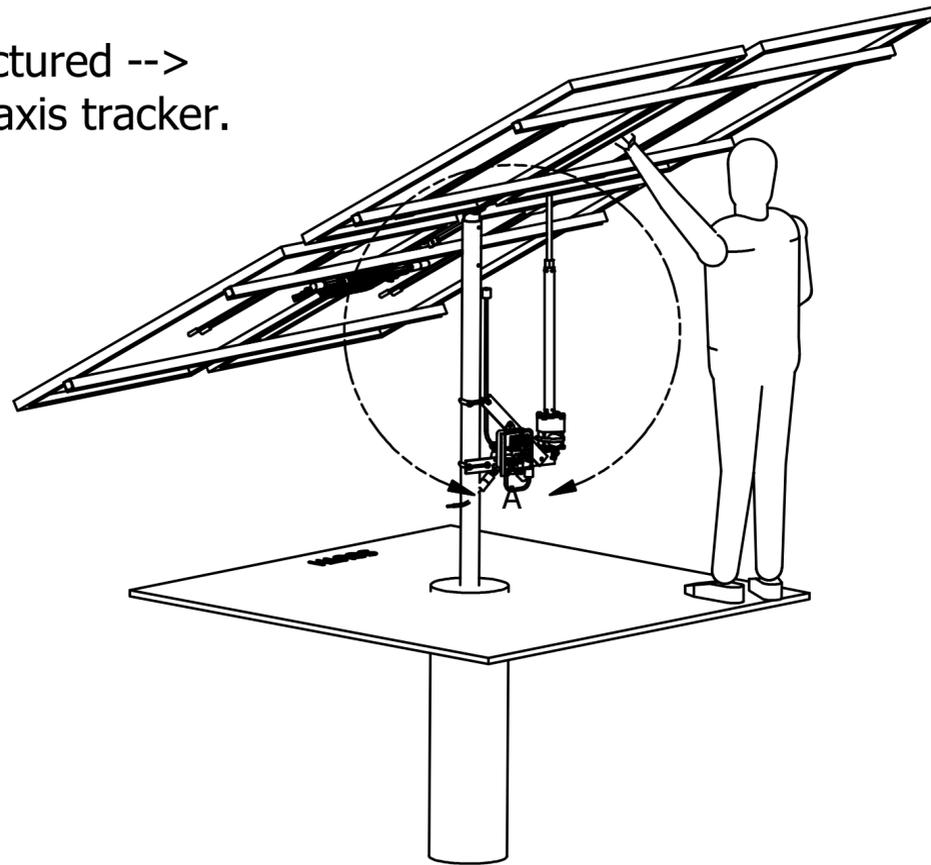
Solar panels can be purchased for \$0.22 per watt thru Salvex.com.
1200 watts (4 panels) cost \$264.
The 4 in 1 Inverter from NEF Power costs \$180.
The UNO, Real Time Clock and Solid State Relay, wall wart < \$50.

DRAWN	1/14/2019	Watt-Tracker, LLC		
BILLS		TITLE		
CHECKED		Overall View - 2 X Tracker		
QA		SIZE	DWG NO	REV
MFG		C	2X_V3_Simple	
APPROVED		SCALE	SHEET 1 OF 15	

1 Axis Solar Tracker - 1 Axis is motorized

This design is lower to the ground, hence wind loading would be less.
Fabrication is simpler. Still supports 1200 watts.

Pictured -->
1 axis tracker.



DETAIL A
SCALE .2

DRAWN	1/14/2019	Watt-Tracker, LLC		
BILLS		TITLE		
CHECKED		Single Axis Tracker		
QA		SIZE	DWG NO	REV
MFG		C	2X_V3_Simple	
APPROVED		SCALE	SHEET 2 OF 15	

There are some decisions that need to be made.

1. The mechanical design approach depends upon the welding and machining skills of the builder. Plans are included for just welding, drilling holes and cutting steel to length. Different plans include machining on a mill.
2. A building permit is sometimes required, and all permitting jurisdictions are different. The City of Houston requires that a professional engineer sign off for hurricane wind speeds. And a master electrician for the electric part. Harris county requires nothing. In some cases a permit is required by a Home Owners Association (HOA). A 2 axis tracker is taller, and subject to higher wind loads. For this reason, a single axis tracker may be preferable, as it is not as tall.

Description, 2 Axis tracker: 2 nd axis manually adjusted with a linkage.

1. The user should be qualified to work with 120 volt / 240 volt systems. The user should follow all code provisions mandated by the building code.
2. This single axis tracker can carry 1200 Watts of panels with microinverters. As such, the power connects to a 220 volt, 15 amp breaker in the breaker panel. The location of the breaker should be on the opposite end of the breaker panel as the 220 volt service feed. Each array will generate 4 amps at 220 volts. If there are more than 2 arrays, the breaker and wire size should be selected accordingly.
3. The array faces south. Designed for the latitude of Houston, 29'. For higher latitudes, bottom panels will be closer to the ground, the column embedded depth may need to be decreased.
4. Building codes in Houston require a lockable disconnect between the array and the breaker box, to protect a power company linemen in a power outage. Never mind that the inverter, by specification, does not put power on the line in the absence of a grid signal. Never mind that many other states do not require a lockable disconnect. Progress is slow! One of the hardest tasks in the installation is running the power back to the breaker box. In Houston, it is a buried PVC pipe, in a 18" deep trench.
5. A similar 3-D CAD model is viewable at http://www.watt-tracker.com/SingleAxis_1000W.html
6. The designer's e mail is william.swann2@gmail.com. For a 3-D model, viewable with AutoDesk Design Review, request it from the designer. The designer may make changes not shown in this set of plans. Also, please report errors / suggestions to the designer. Thanks.

Construction Notes:

1. Unistrut length: The bars to which the panels are connected, can be any rust resistant material. I used Unistrut. Substitutions can be galvanized stop sign posts or 1.5"/1.75" square tubing. Holes may have to be drilled dependent upon the panel mounting hole locations. Cut the unistrut to where there are 2 slots on either side of midspan. The overall length is dependent upon the size of the panels.
2. The post should be galvanized. In certain locations, with direct burial of galvanized steel, a coating called CorroCote may be required.
3. Column Embedment: For wind loading, the column is imbedded in the ground by 3'. Where building codes require wind resistance to hurricane windspeeds, a column brace may be needed.
4. Changes to these construction notes may occur. The drawings are tightly integrated, and that a simple change may have unforeseen consequences. For example, the installer may use 300 watt panels instead of 250 watt panels. It is obvious that the bars to which the panels mount have to be longer, but it may be less obvious that the panels may hit the ground when rotated 40 degrees from the horizontal. The fix, is to make the column longer / higher.
5. Actuator: The drawings include a design for a 110 volt actuator, or a 12 volt actuator from WindyNation.
6. A ground rod needs to be installed, as well as weeb washers, to connect the solar panel aluminum frame, electrically, to the ground rod.

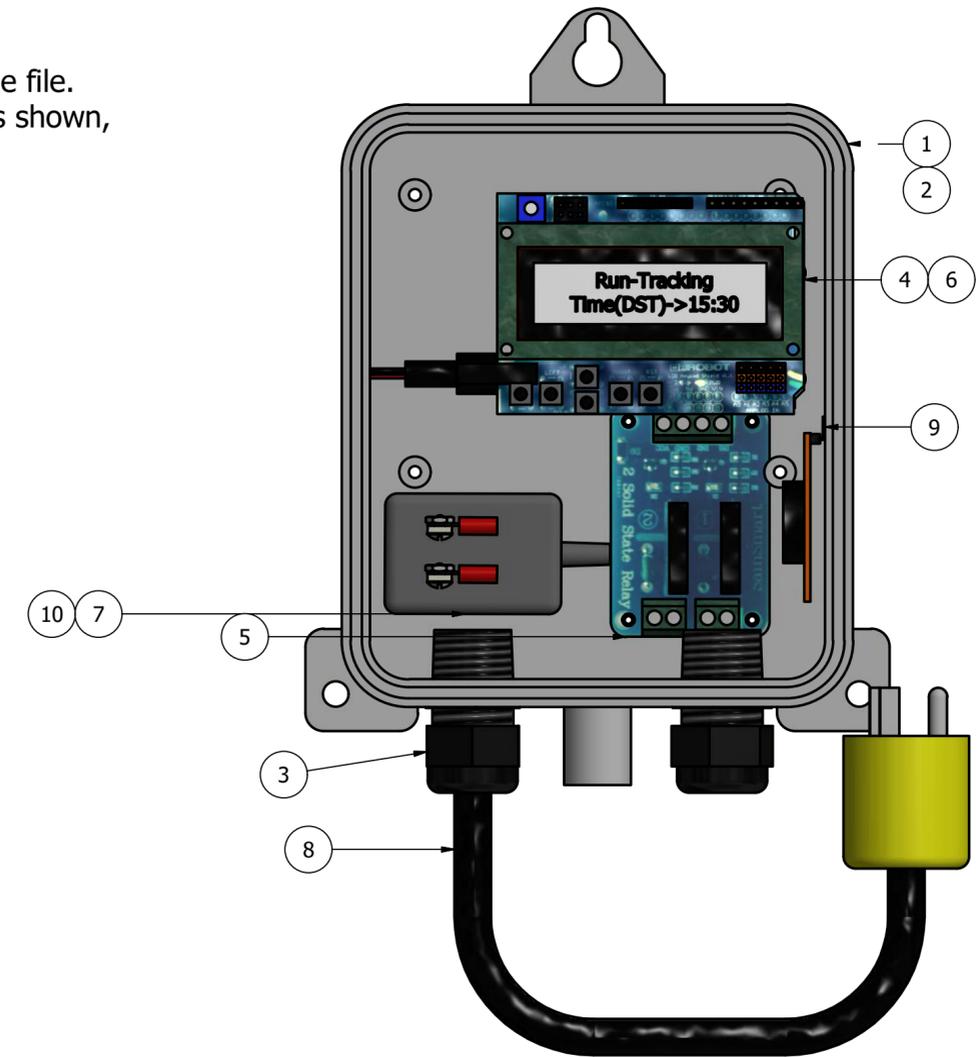
I lead a free solar workshop at TxRxLabs, on the last Friday of each month at 2 - 4 PM. 205 Roberts Street.

DRAWN	1/14/2019	Watt-Tracker,LLC		
BILLS		TITLE		
CHECKED		Construction Notes		
QA		SIZE	DWG NO	REV
MFG		C	2X_V3_Simple	
APPROVED		SCALE	SHEET 3 OF 15	

Program Description:

1. By single axis tracking, the energy harvest in Houston is increased by 23%. Two axis tracking increases the harvest by 30%. What is done with the power produced can be providing 220 Vac power to the user/grid, or DC power thru a charge controller to a battery / inverter system. The latter has been done for a Hydroponics setup.
2. This tracker program causes the array to tilt rain or shine. It rotates +/- 40 degrees from horizontal, and returns to a horizontal position in the night hours. Since the rotation is just 40 degrees, there is a 1.5 hour dwell on either ends of rotation, morning and evening. The day is split up into 24 moves, each 15 minutes. The pseudo moves are simply turning on an actuator for 50 seconds. The actuator movement is non linear with respect to rotation angle, but that is OK because being close to facing the sun is close enough. A turnbuckle is used to compensate for the height of the sun at noon. In Houston, it ranges from 83 degrees above the horizon in the summer to 37 degrees above the horizon the the winter.
3. Say the sun is 30 degrees above the horizon, and the array is 30 degrees from being flat. The error angle is 30 degrees. $(90 - 30 - 30)$ The actual projected area is $\cos(30) = 0.86$. So the tracker is getting 86% of the available energy. Is tracking worth it? All the solar farms have at least 1 axis tracking.
4. The buttons on the LCD shield are UP=Run, DOWN=Stop, RIGHT = Set Time. A drawback in the program that when a power outage occurs, the position of the array has to be reset. This is done by dis-connecting the actuator rod from the array with a quick release pin, and rotating the actuator rod to the correct position. A program improvement would be to incorporate an angle sensor / accelerometer, making the motion closed loop.
5. Knowing when to move the array is provided by a real time clock printed circuit board, with a lithium button cell providing power when the grid is absent.
6. I recommend using 4 in 1 microinverters. (APsystems, NEF....)

The C program is written thru a GUI called Flowcode, and is available either installed on an Aduino UNO or as a Flowcode file. Contact the author - Bill Swann at william.swann2@gmail.com, or 832-338-3080. I do recommend using the components shown, as the code uses them.



PARTS LIST

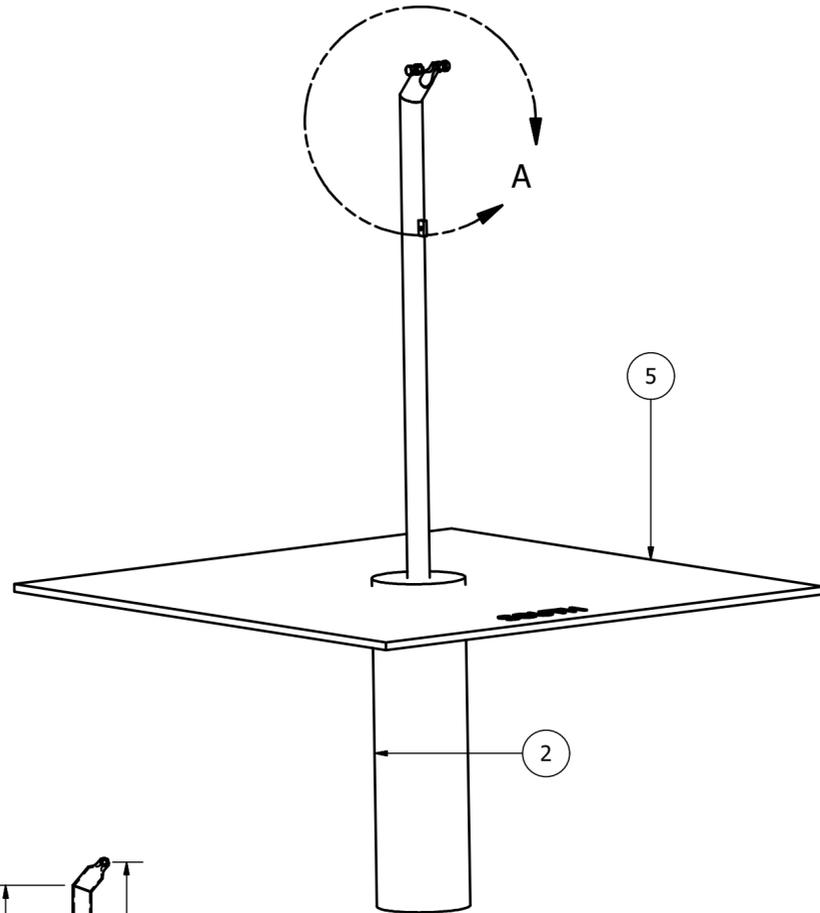
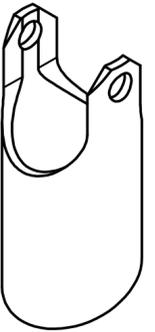
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	MicrocontrollerBox	
2	1	BoxLid	
3	2	Heyco_p5NPT	Compact Liquid Tight Chord Grip,Heyco_1/2" NPT
4	1	DFRobot_LCD_Keypad_Shield	LCD and 5 button keypad
5	1	SS_Relay	SainSmart
6	1	UNO	Arduino UNO R3
7	1	120 vac to 12 v dv Supply	12 Volt wall wart, 500 mAmps, small size
8	1	PlugAndChord_110V	Plug And Chord_110V
9	1	RTC	Real Time Clock, eBay-DS3231 chip.
10	1	Shrink Tube	3/8", over wall wart lugs
11	1	Motor Lead	3 conductor x 18" long
12	3	ANSI B18.6.3 - No. 4 - 40 - 1/8	Cross Recessed Binding Head Machine Screw - Type IA
13	3	91075A236_18-8 SS MALE-FEM THRD HEX STANDOFF	

DRAWN	1/14/2019	Watt-Tracker,LLC	
BILLS CHECKED		TITLE	
QA		Program description	
MFG		SIZE	DWG NO
APPROVED		C	2X_V3_Simple
		SCALE	REV
			SHEET 4 OF 15

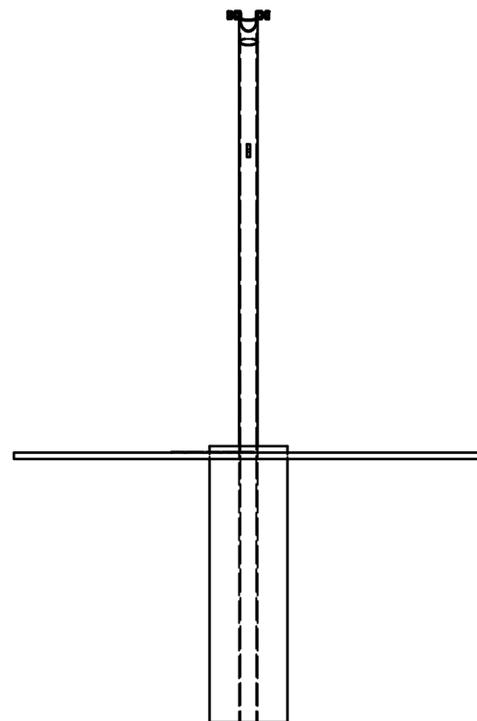
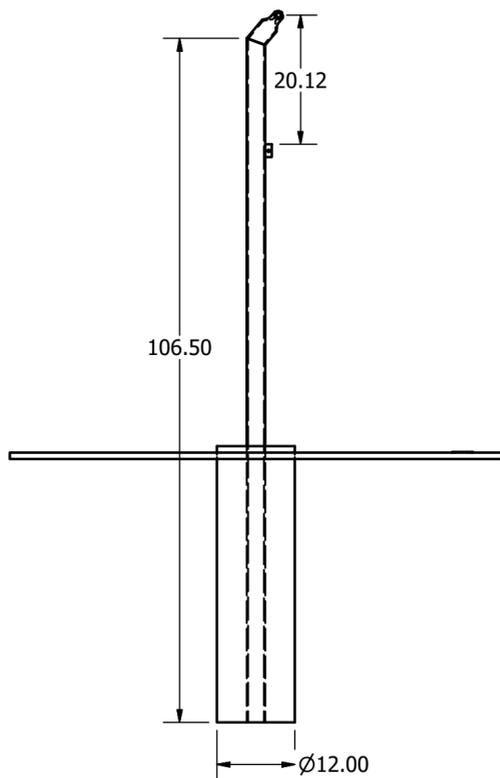
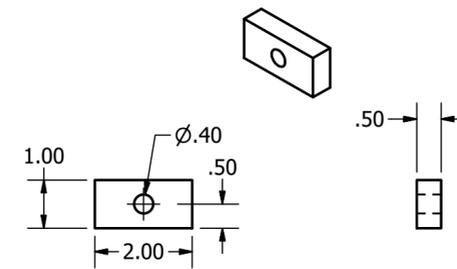
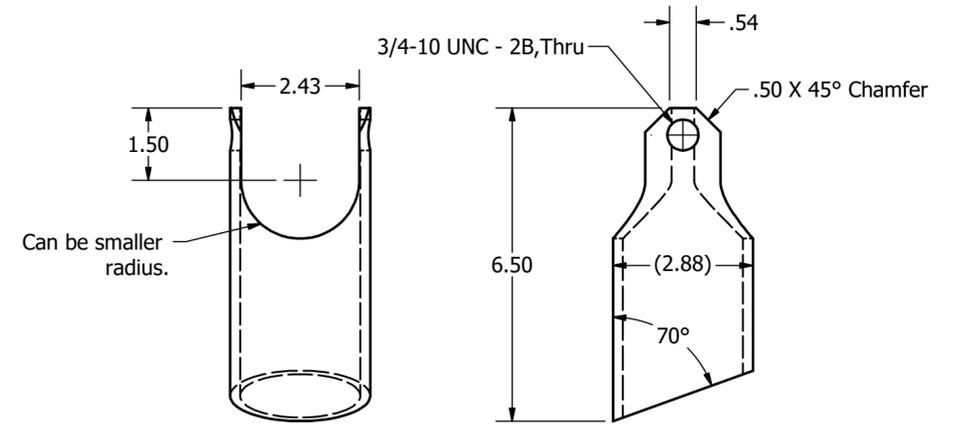
Details of support post for a 2 axis tracker.
 Use this if the maker has access to a milling machine.
 The details of the pipe that is used with this are on page 7.
 There is an alternate method on page 6.

Construction Details:

1. Screw the bolt onto the top piece, with nut. Weld nut to column top, 2 places.
2. If wind loading is an issue, an angled brace can be added between the column and ground.



DETAIL A
 SCALE 0.12 : 1

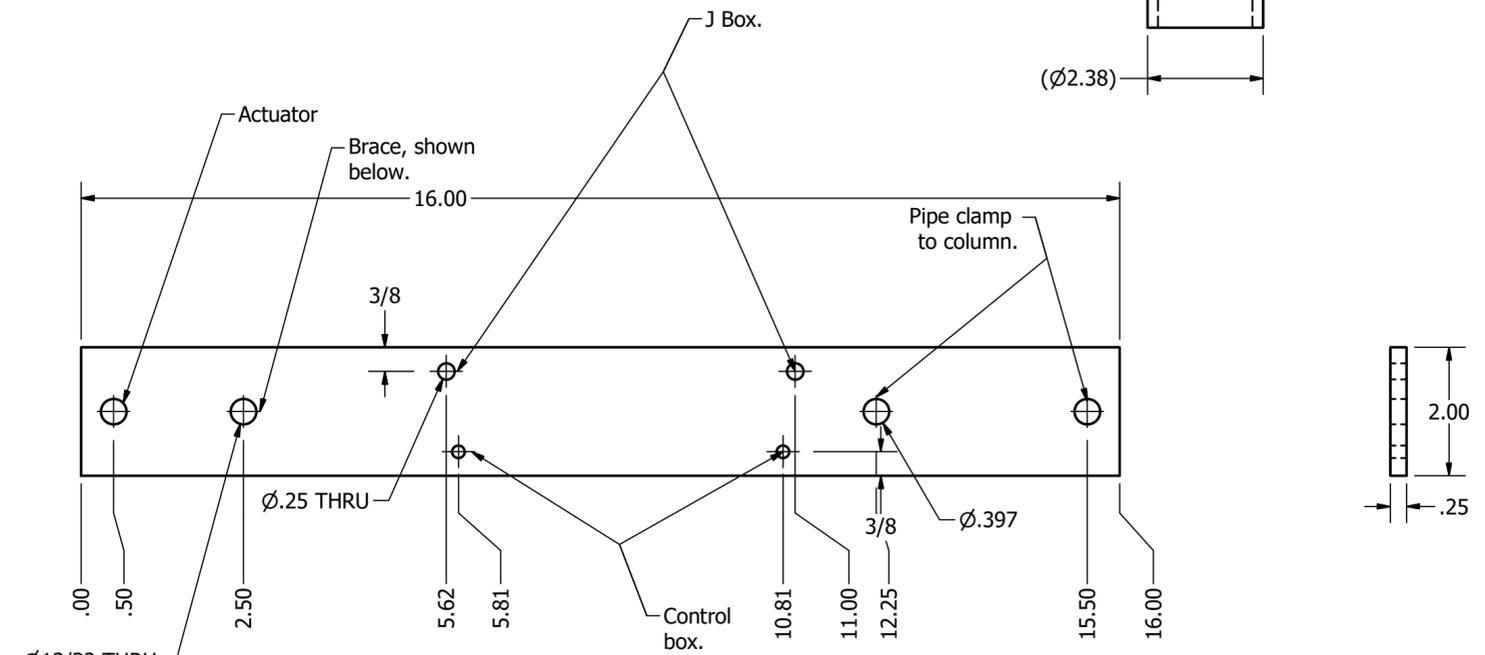
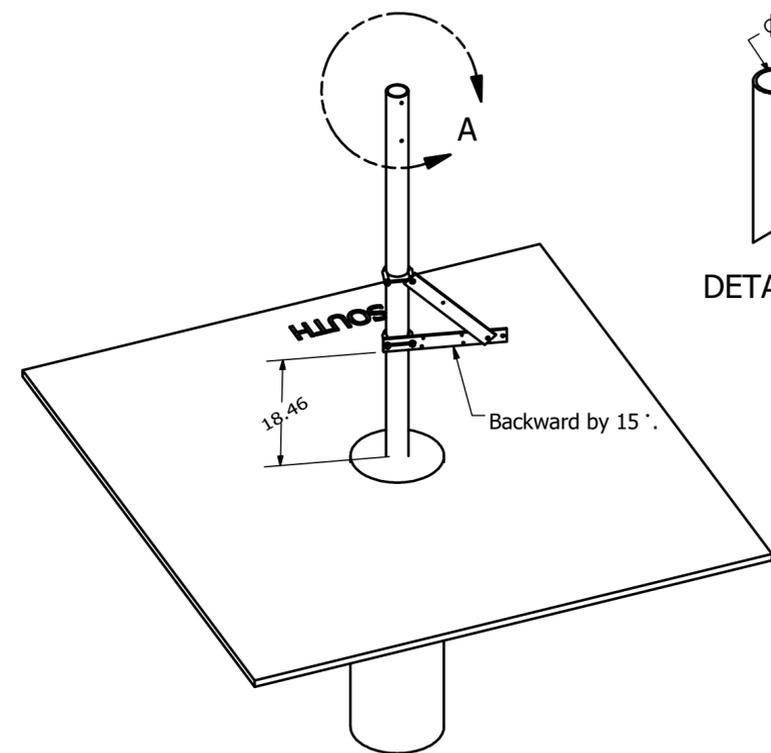
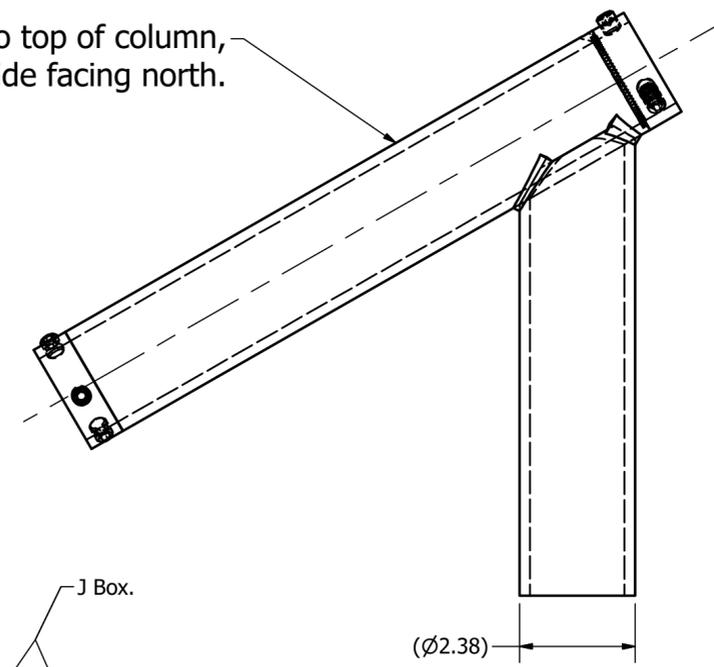
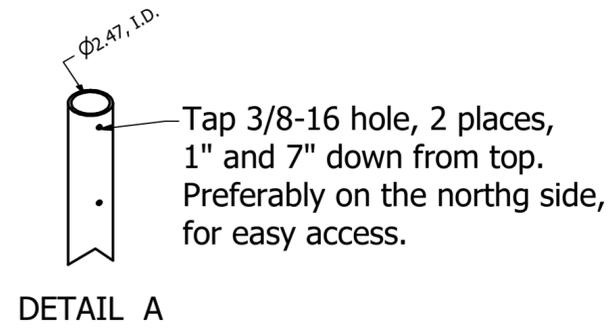


PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Tab_Turnbuckle	Flatbar, 0.5" x 1" x 2"
2	1	Concrete	
3	2	ANSI/ASME B18.2.1 - 3/4-10 UNC - 1.5	Hex Bolt - UNC (Regular Thread - Inch)
4	2	ANSI B18.2.2 - 3/4 - 10	Hex Nuts (Inch Series) Hex Nut
5	1	Ground	
6	6.500 in	ANSI/AISC Rolled Steel - 2 1/2-6.5	Pipe Standard Weight
7	106.500 in	ANSI/AISC Rolled Steel - 2 1/2-100.5	Pipe Standard Weight

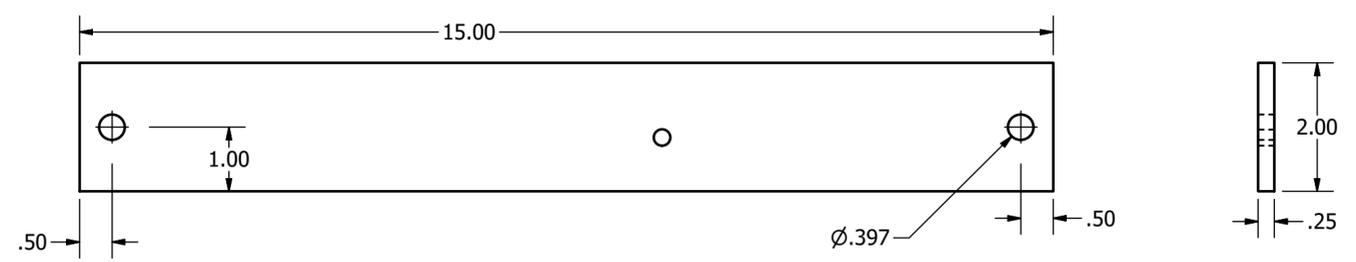
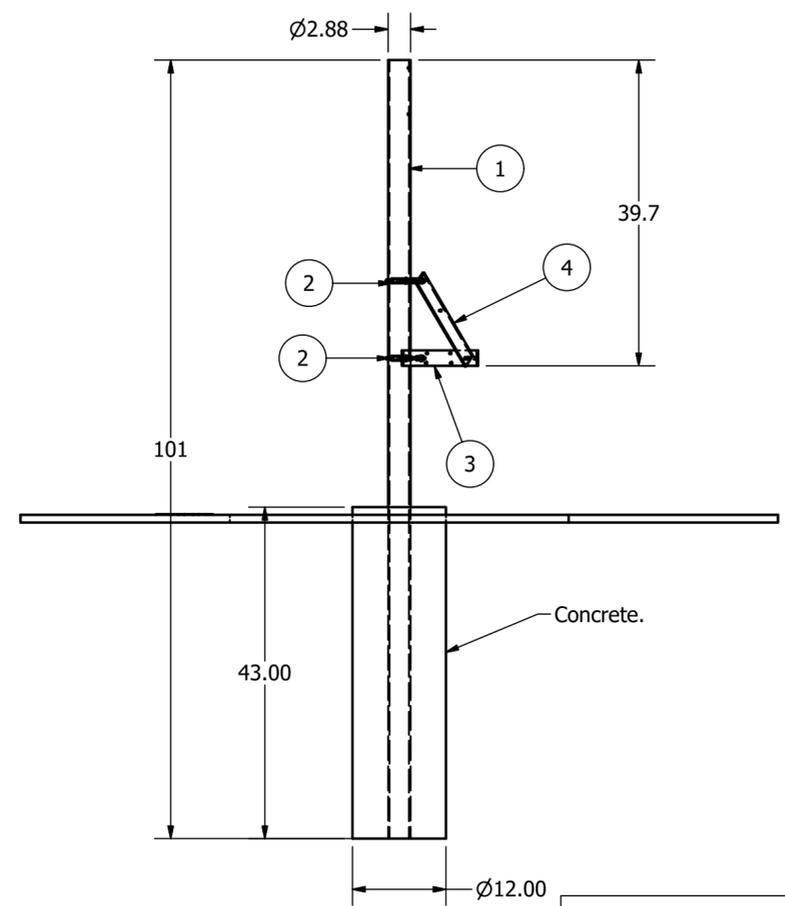
DRAWN	1/14/2019	Watt-Tracker, LLC	
BILLS		TITLE	
CHECKED		Details of support post for a 2 axis tracker.	
QA		SIZE	DWG NO
MFG		C	2X_V3_Simple
APPROVED		SCALE	REV

Details of support post for a 1 axis tracker.
Use this if the maker has access to a milling machine.

This assembly inserts into top of column,
with high side facing north.



Bracket and brace for holding
Actuator and Control Box.

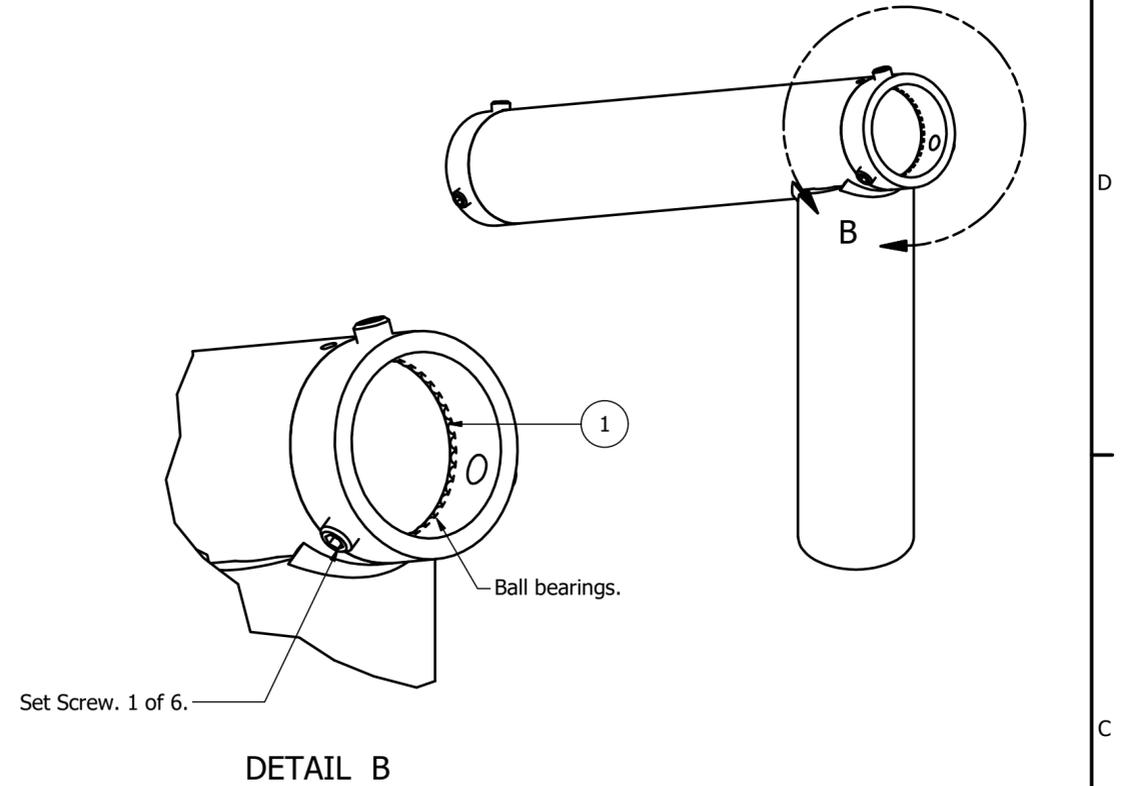
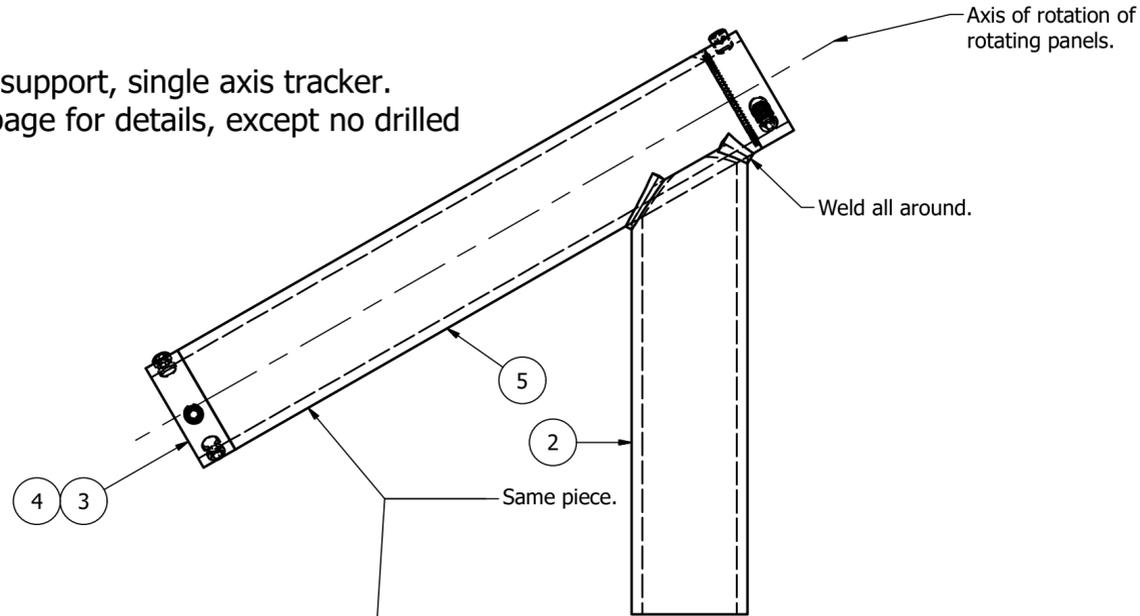


PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	101.000 in	ANSI/AISC Rolled Steel - 2 1/2-101	Pipe Standard Weight
2	2	3042T340	Clamping U Bolt, McMaster-Carr,Zink Plated
3	1	Bar_LowerActuatorMount_Simple	
4	1	Brace_LowerActuatorMount_Simple	

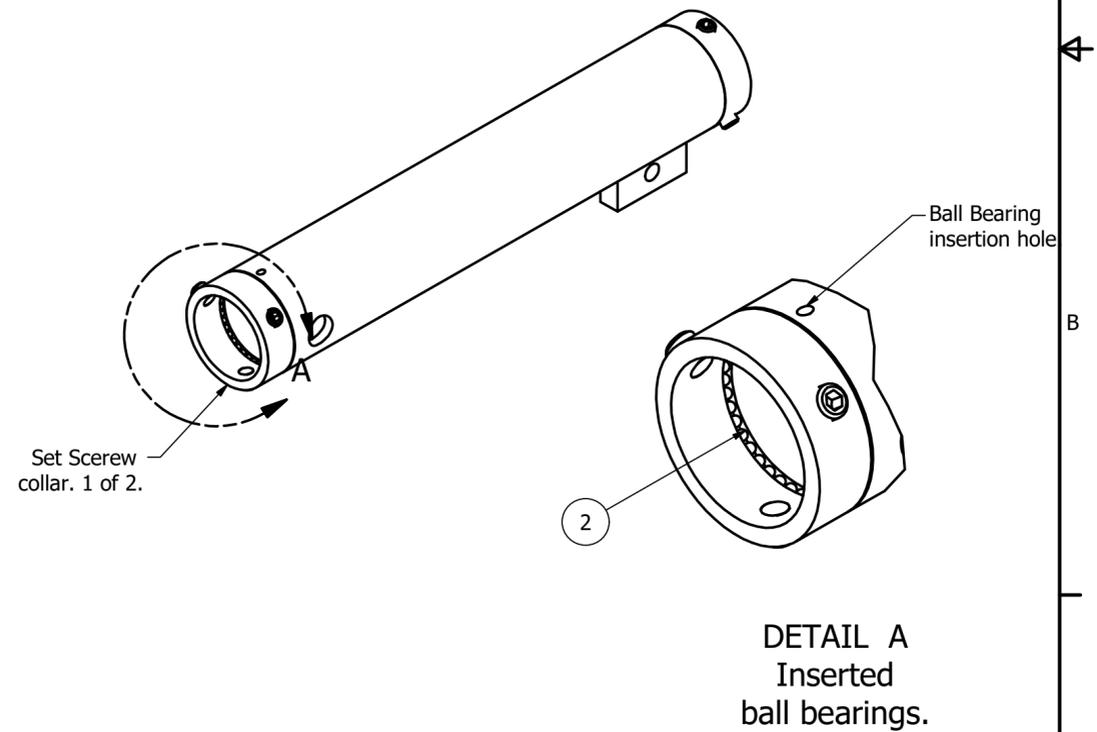
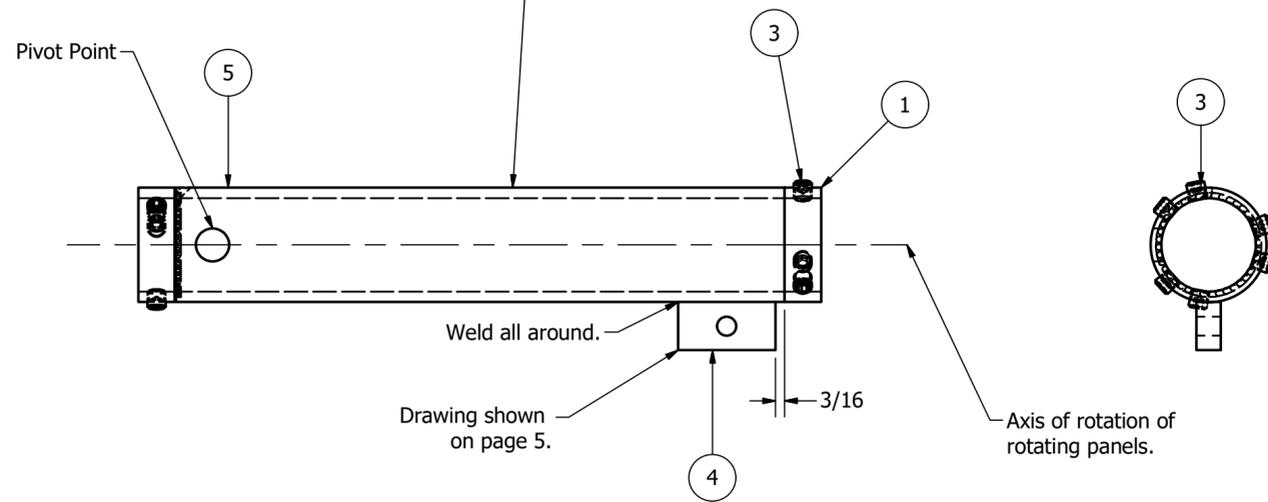
DRAWN	1/14/2019	Watt-Tracker,LLC	
BILLS		TITLE	
CHECKED		Single Axis Tracker and Actuator mount parts	
QA		SIZE	DWG NO
MFG		C	2X_V3_Simple
APPROVED		SCALE	REV
			SHEET 6 OF 15

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	40	McM9529K36	McMaster-Carr,Hardened Stainless Steel Ball, 9/64"
2	10.000 in	ANSI/AISC Rolled Steel - 2-10	Pipe Extra Strong
3	1.500 in	ASME B36.10M Pipe 2 - Schedule 80 - .75	Welded and Seamless Wrought Steel Pipe
4	6	ANSI B18.3 - 3/8-16 UNC x 0.44	Hexagon Socket Set Screw - Oval Point
5	12.500 in	ANSI/AISC Rolled Steel - 2-12.5	Pipe Extra Strong
6	1	Tab_Turnbuckle	Flatbar,0.5" x 1" x 2"

Main spar support, single axis tracker.
See next page for details, except no drilled hole.



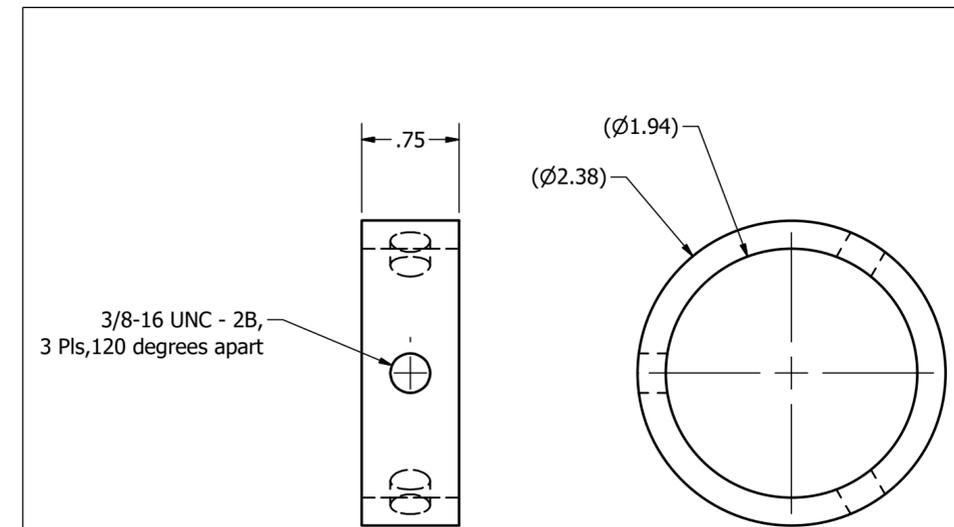
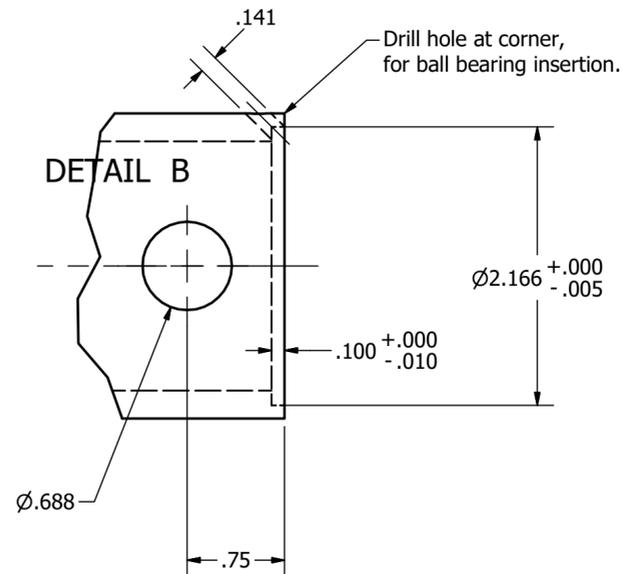
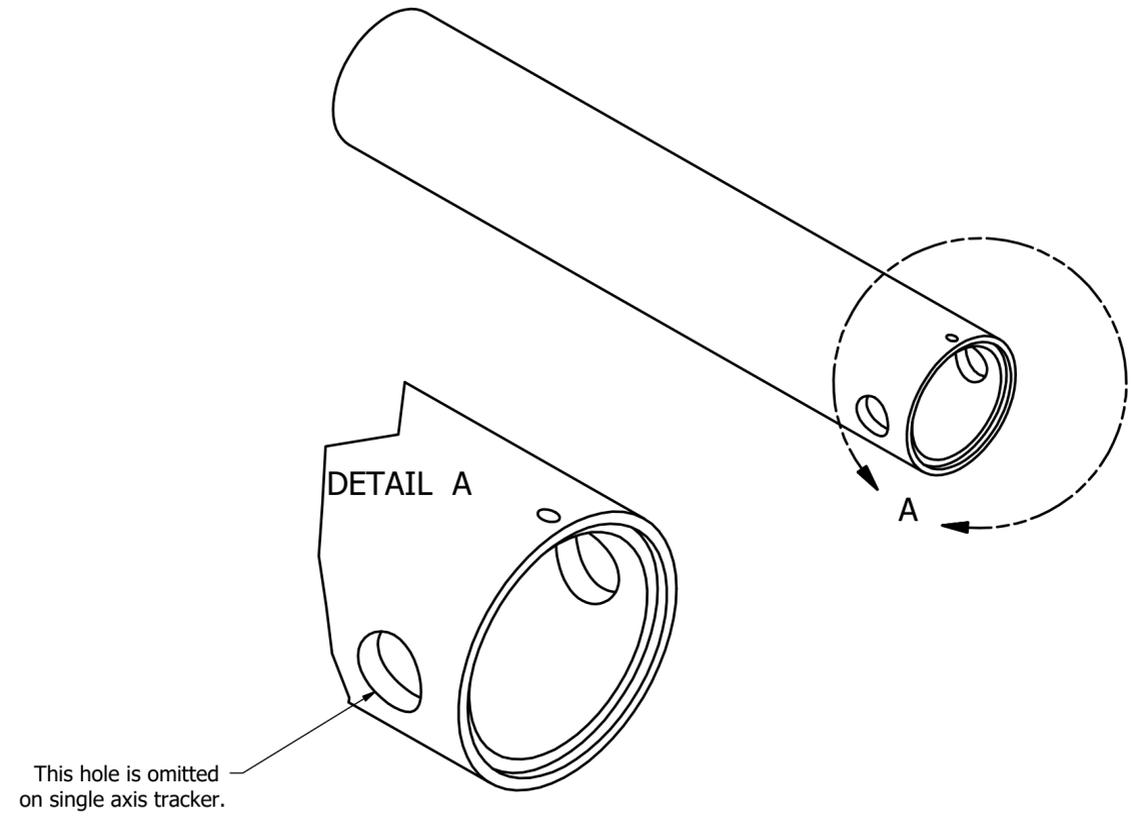
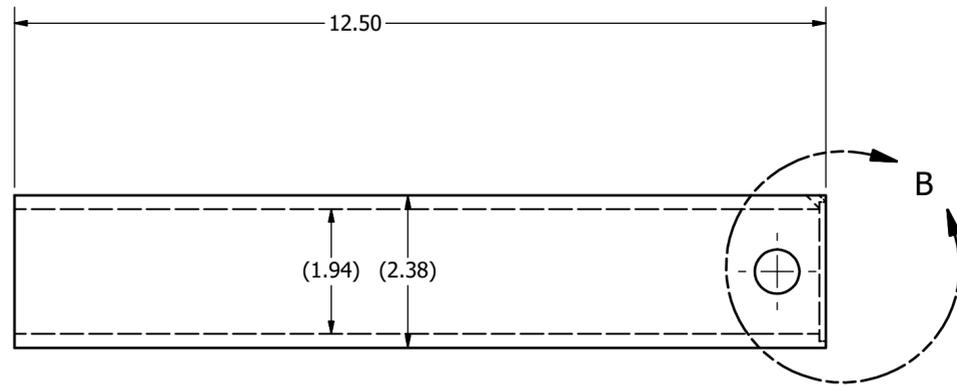
Main spar support, 2 axis tracker.
See next page for details.



PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1.500 in	ASME B36.10M Pipe 2 - Schedule 80 - .75	Welded and Seamless Wrought Steel Pipe
2	40	McM9529K11	Bearing Ball,1/8" Dia, McMasterr-Carr
3	6	ANSI B18.3 - 3/8-16 UNC x 0.38	Hexagon Socket Set Screw - Flat Point
4	1	Tab_Turnbuckle	Flatbar,0.5" x 1" x 2"
5	12.500 in	ANSI/AISC Rolled Steel - 2-12.5	Pipe Extra Strong

DRAWN	1/14/2019	Watt-Tracker,LLC	
BILLS		TITLE	
CHECKED		Main Spar Support, On column top., 1X or 2X	
QA		SIZE	DWG NO
MFG		C	2X_V3_Simple
APPROVED		SCALE	REV
			SHEET 7 OF 15

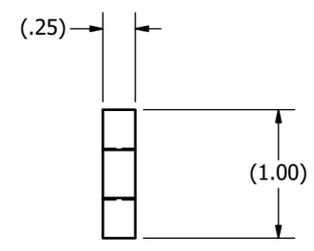
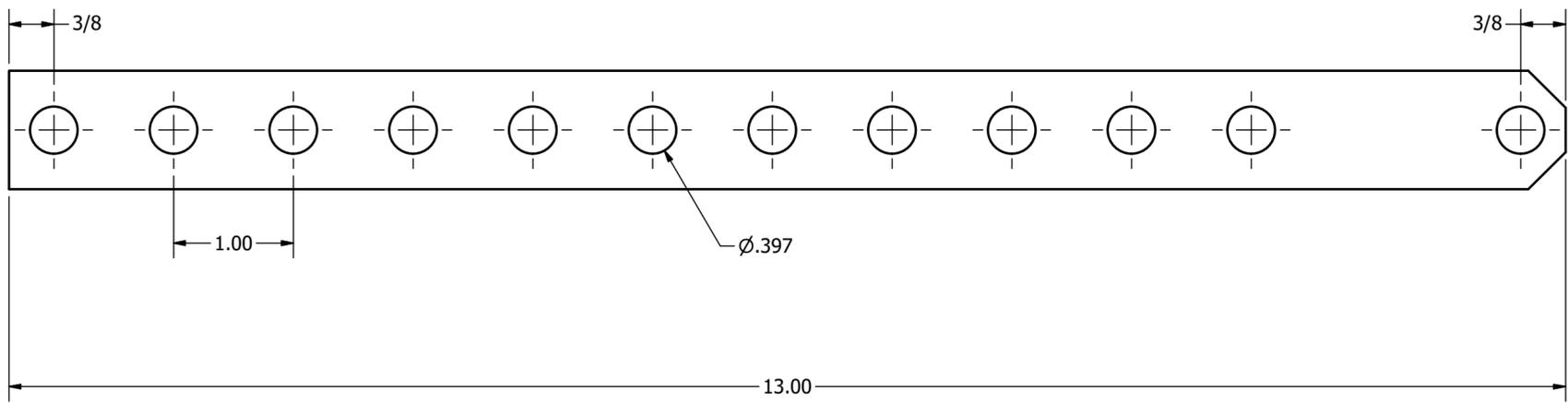
2 items are detailed here: Collar and main spar support.
 This piece is used on the 1 axis or 2 axis tracker.



Make 2

DRAWN	1/14/2019	Watt-Tracker, LLC		
BiLLS		TITLE		
CHECKED		Main Spar Support Drawing		
QA		SIZE	DWG NO	REV
MFG		C	2X_V3_Simple	
APPROVED		SCALE	SHEET 8 OF 15	

Make 2



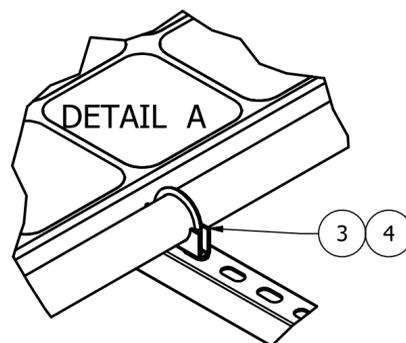
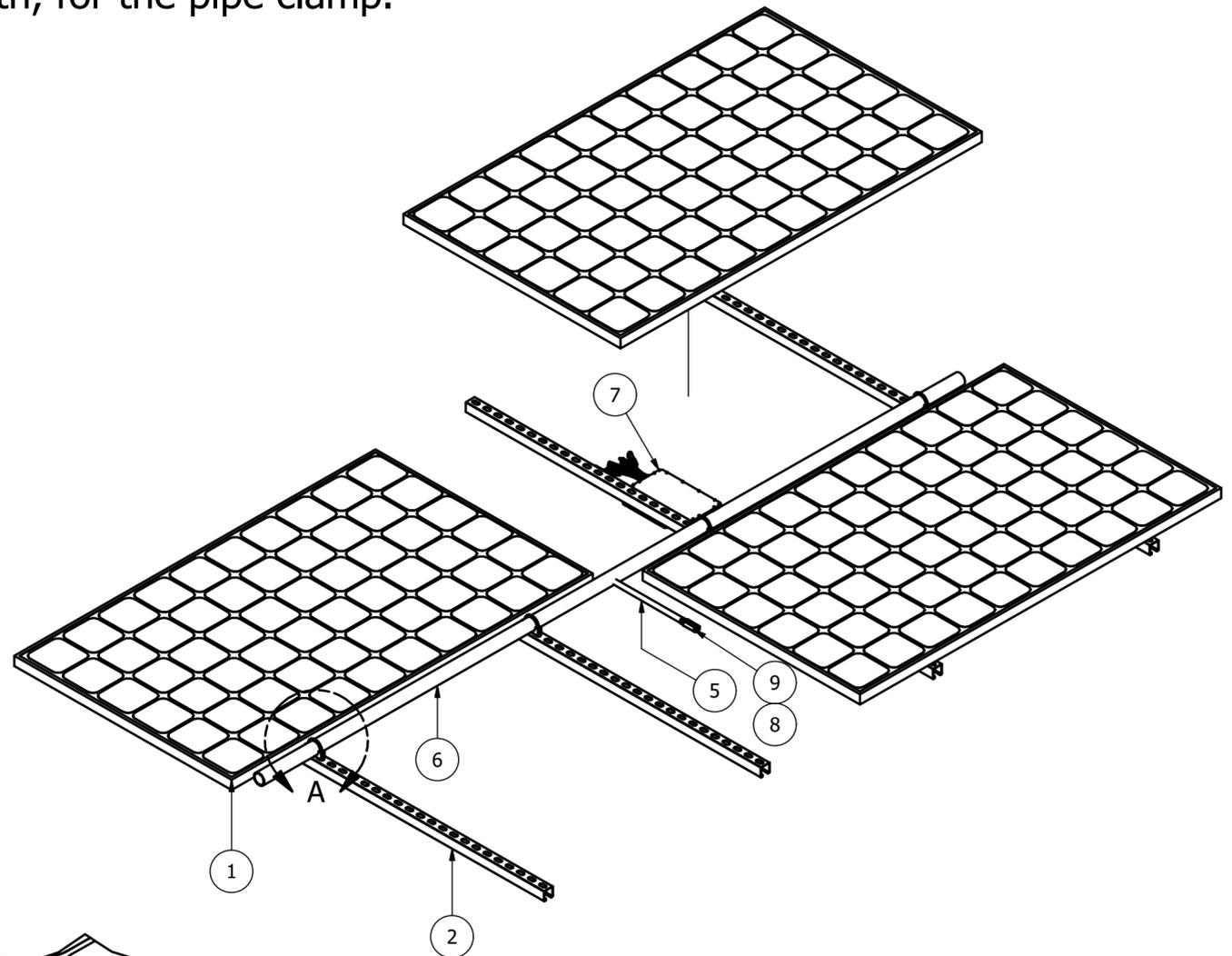
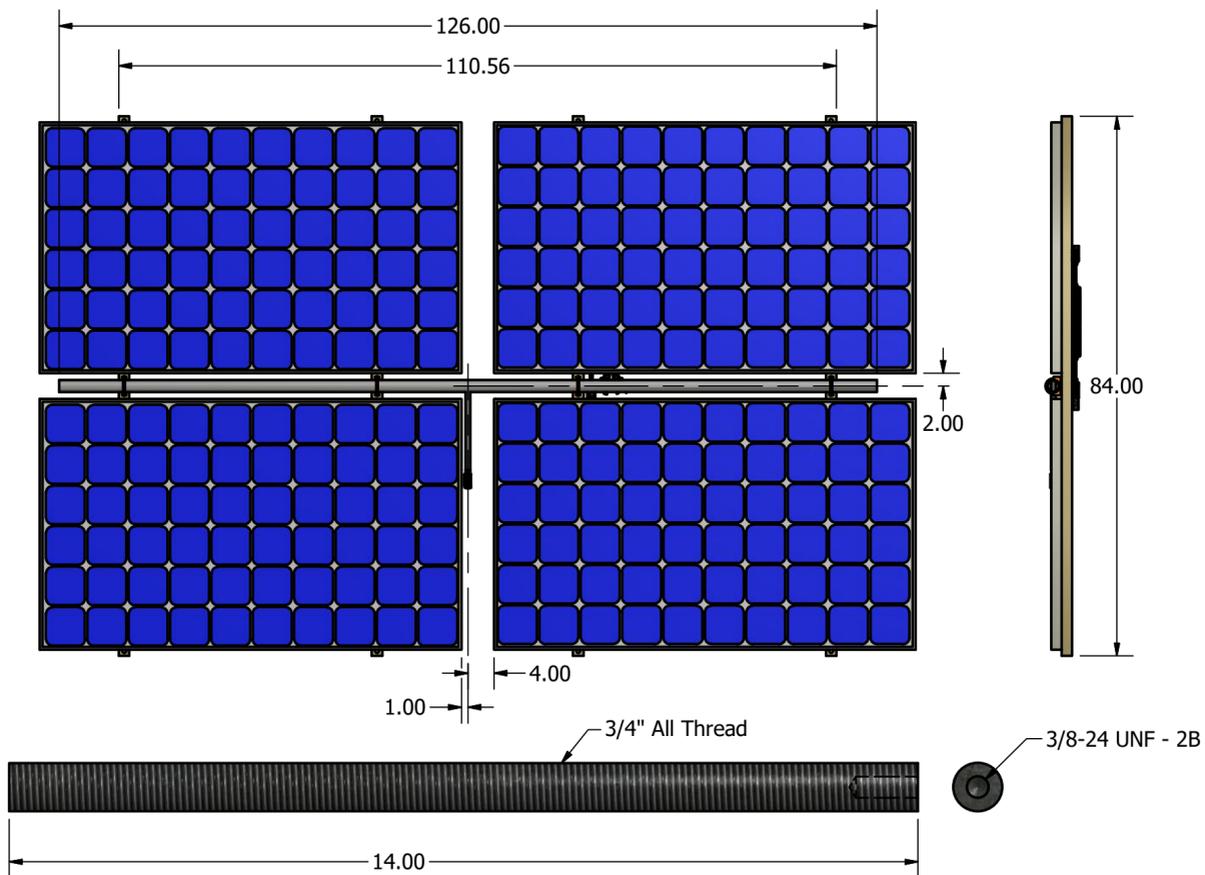
DRAWN	1/14/2019	Watt-Tracker,LLC		
BILLS		TITLE		
CHECKED		Linkage		
QA		SIZE	DWG NO	REV
MFG		C	2X_V3_Simple	
APPROVED		SCALE	SHEET 9 OF 15	

What you see:

1. 4 panels connected to Unistrut with hex bolts, large washers and nuts.
2. Unistrut connected to a main spar with pipe clamps and large washers.
3. The main spar is tapped midway (1"-NC) and the torque arm threaded thru and tacked to the main spar.

Construction notes:

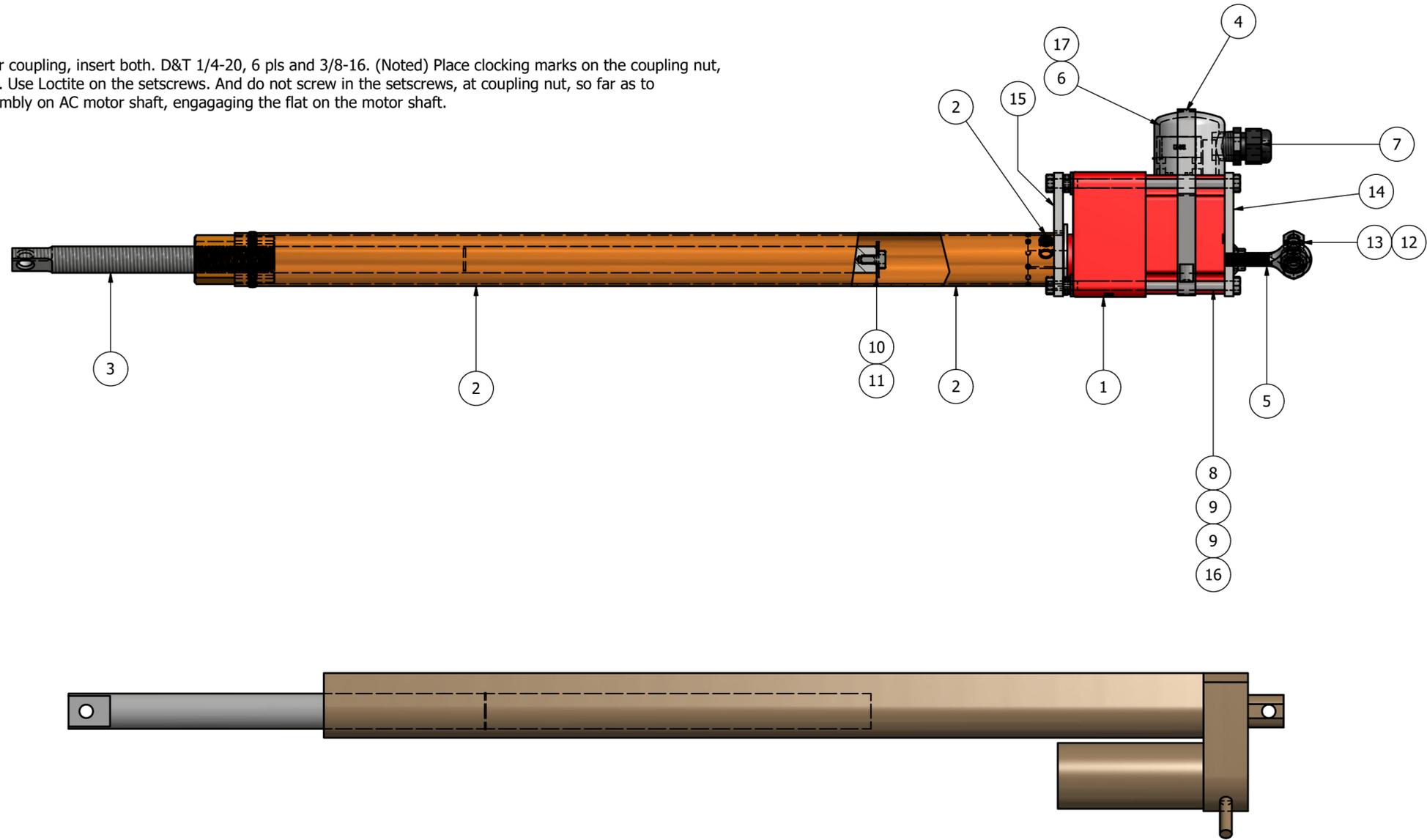
1. The main spar length is 1/2 of a pipe length - 21', but can be shorter.
2. Panels have mounting slots inboard of the panel end. These should be used. And the main spar can be shortened to be flush with the outboard edge of the Unistrut.
3. The Unistrut length is dependent upon the small dimension of the panel. It is 84 with panels shown. When cutting the Unistrut, have a slot on either side of the midpoint of the unistrut length, for the pipe clamp.



PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	4	Trina_TSM250	250 Watt
2	4	A-1200-HalfSlot	Framing Strut Square A-1200-HalfSlot
3	4	3042T860	Clamping U Bolt
4	8	ANSI B18.22.1 - 3/8 - wide - Type A	Plain Washer (Inch)Type A and B
5	1	TorqueBar_V3	3/4" -NC All Thread, Steel bar x 12" long
6	126.000 in	ANSI_AISC - 1 1_2-107(2)	Pipe Standard Weight
7	1	NEF_MI_1200	NEFPOWER.COM
8	1	Stud	All Thread,3/8-24
9	1	2447K180	Clevis Rod End

DRAWN	1/14/2019	Watt-Tracker,LLC	
BILLS		TITLE	
CHECKED		Array	
QA		SIZE	DWG NO
MFG		C	2X_V3_Simple
APPROVED		SCALE	REV
		SHEET 10 OF 15	

After turning coupling nut and motor coupling, insert both. D&T 1/4-20, 6 pls and 3/8-16. (Noted) Place clocking marks on the coupling nut, as it may have to be dis-assembled. Use Loctite on the setscrews. And do not screw in the setscrews, at coupling nut, so far as to contact the lead screw. Position assembly on AC motor shaft, engaging the flat on the motor shaft.



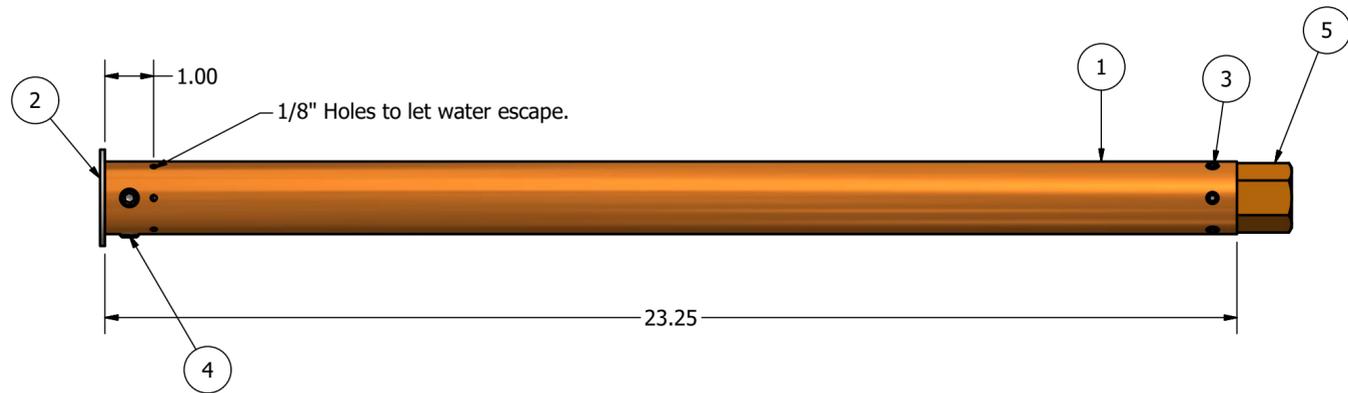
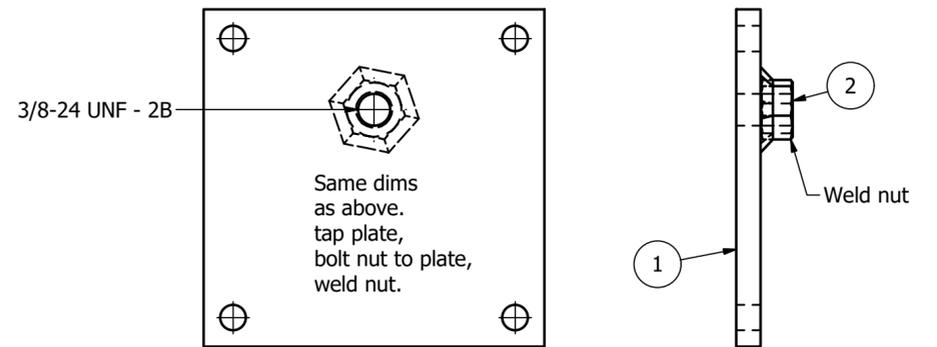
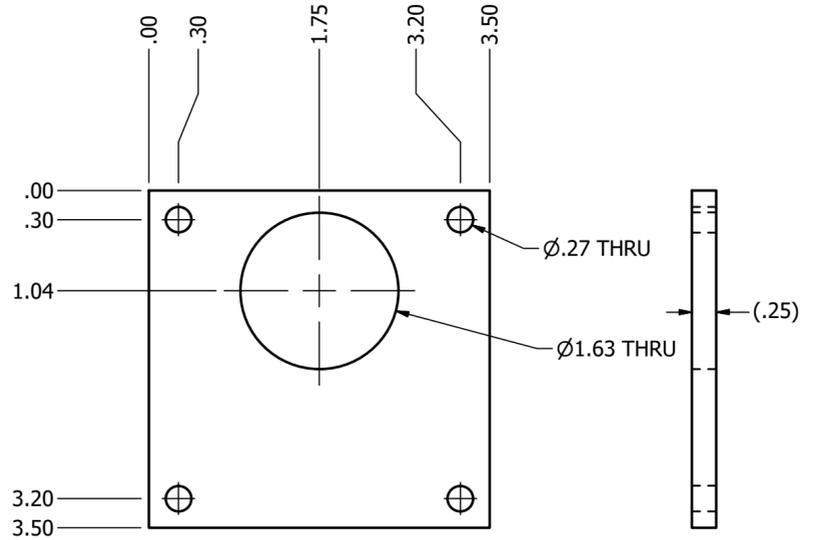
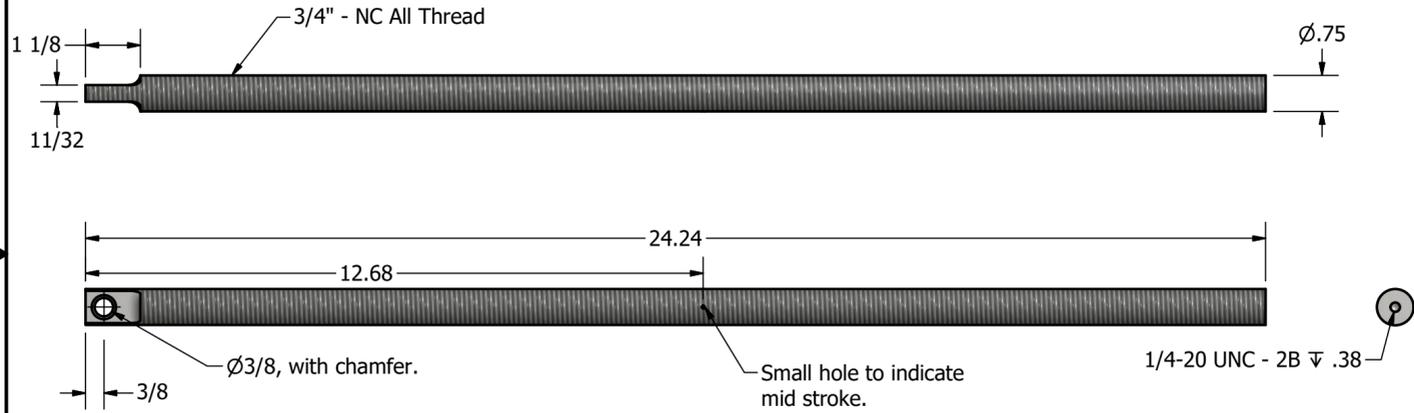
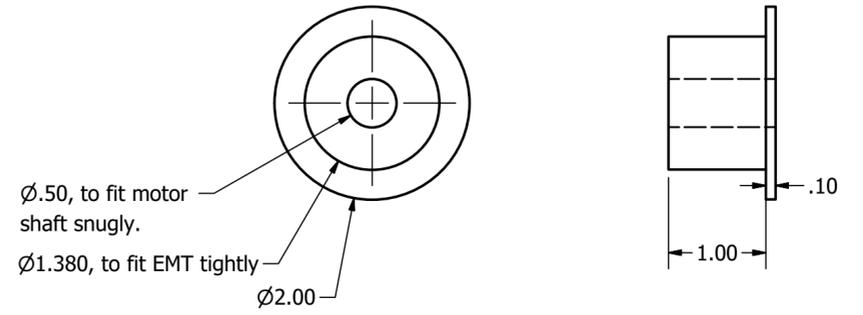
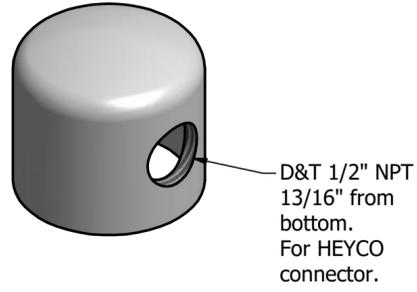
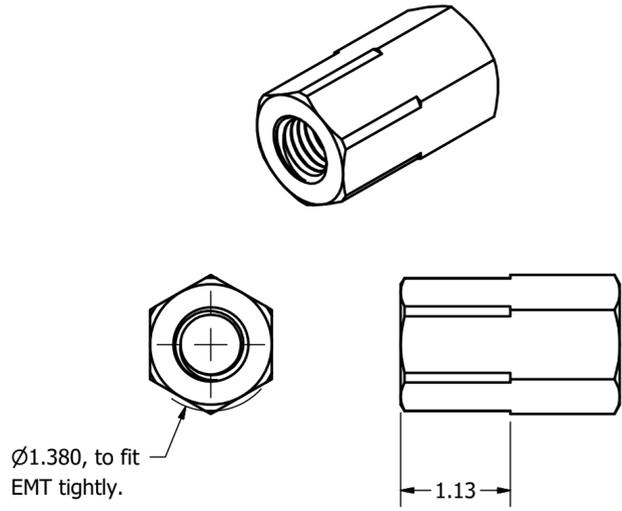
12 volt - DC -actuator from Windy Nation,16 " stroke. Code is different and it uses dc relay. The actuator has limit switches, and if there is a power outage, the array position will be incorrect just for 48 hours, at most. Prevent water intrusion on the rod end, as I have had one fail because of this.

PARTS LIST

ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	SMK550A_5GN9KA	Oriental Motor,Synchronous gearhead/Ebay \$25
2	1	EMT_Rotating_Stronger	EMT Tube with Coupling Nut and Bushing
3	1	Allthread_p75	All Thread, 5/8-NC,Plated
4	1	HoseClamp	5", from Home Depot
5	1	60645K14	Rod End Clevis, McMaster-Carr
6	1	Cap_PVC_1p25	Cap_PVC, 1-1/4" PVC Pipe
7	1	HEYCO_connector	1/2 NPT Pipe Threads, with grommet
8	4	ANSI/ASME B18.2.1 - 1/4-20 UNC - 5	Hex Bolt - UNC (Regular Thread - Inch)
9	8	ANSI B18.2.2 - 1/4 - 20	Hex Nuts (Inch Series) Hex Nut
10	1	ANSI B18.22.1 - 1/4 - wide - Type B	Plain Washer (Inch)Type A and B
11	1	ANSI/ASME B18.2.1 - 1/4-20 UNC - 0.5	Hex Bolt - UNC (Regular Thread - Inch)
12	1	ANSI/ASME B18.2.1 - 3/8-16 UNC - 1.25	Hex Bolt - UNC (Regular Thread - Inch)
13	1	ANSI B18.2.2 - 3/8 - 16	Hex Nuts (Inch Series) Hex Nut
14	1	Mtg_Plate	Mounting Plate for motor
15	1	MotorMtgPlate_Outboard	Mounting plate,Vexta Motor
16	4	ANSI B18.22.1 - 1/4 - narrow - Type A	Plain Washer (Inch)Type A and B
17	1	RC_Bundle	10 watt resistor/400 ohms ,0.6 mF Cap(250 Volt), in series

DRAWN	1/14/2019	Watt-Tracker,LLC	
BiLLS		TITLE	
CHECKED		Actuator	
QA		SIZE	DWG NO
MFG		C	2X_V3_Simple
APPROVED		SCALE	REV
			SHEET 11 OF 15

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	Cap_PVC_1p25	Cap_PVC, 1-1/4" PVC Pipe



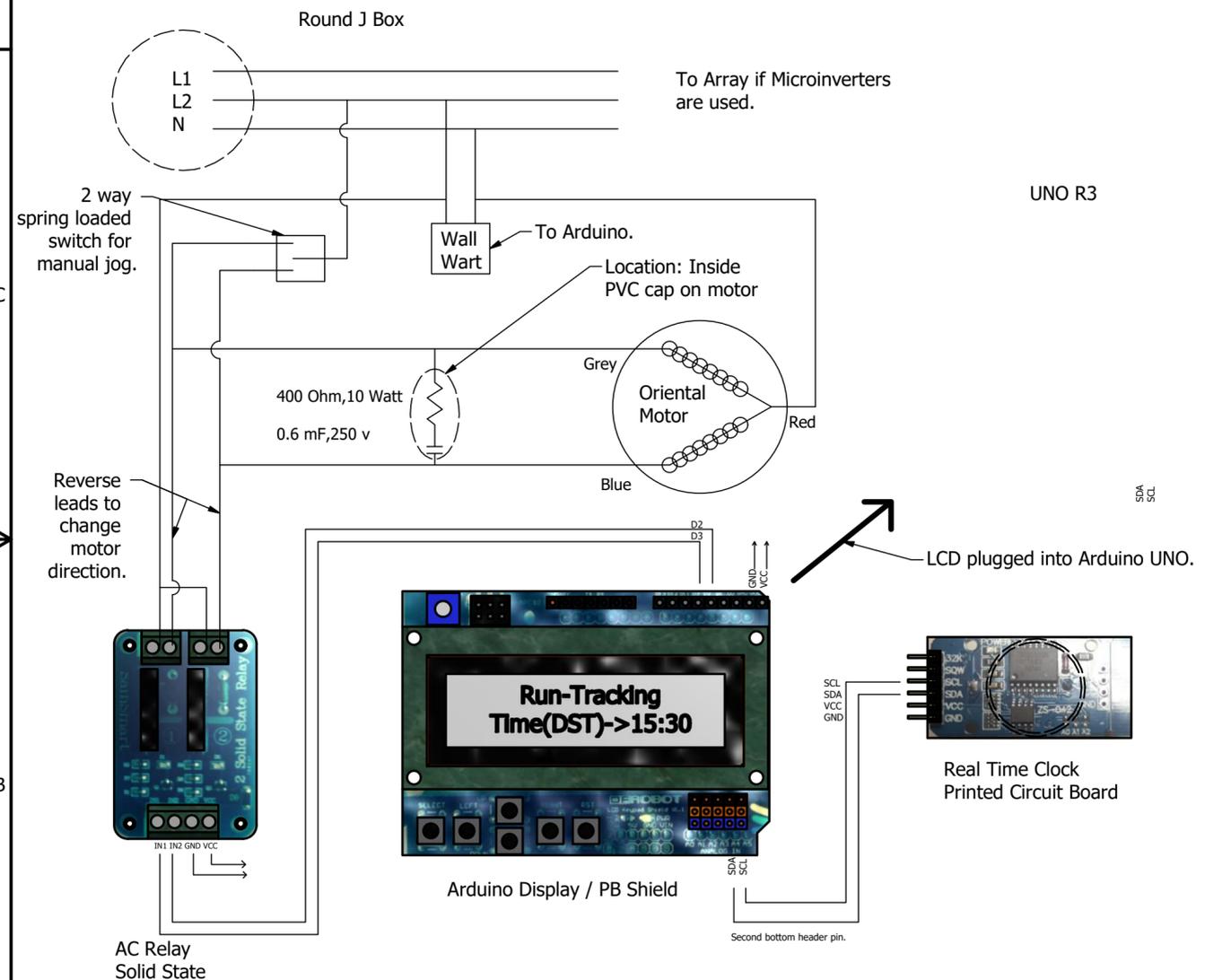
PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	MtgPlate_VextaMotor	Mounting plate,Vexta Motor
2	1	ANSI B18.2.2 - 3/8 - 24	Hex Nuts (Inch Series) Hex Nut

PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	EMT1p25	EMT, 1"
2	1	Bushing_1p5EMT	Motor Coupling
3	6	ANSI B18.3 - 1/4-28 UNF x 0.38	Hexagon Socket Set Screw - Flat Point
4	2	ANSI B18.3 - 3/8-16 UNC x 0.625	Hexagon Socket Set Screw - Flat Point
5	1	90264A243_LOW-STRENGTH STL HEX CPLG NUT	

DRAWN	1/14/2019	Watt-Tracker, LLC	
BiLLS		TITLE	
CHECKED		Actuator parts	
QA		SIZE	DWG NO
MFG		C	2X_V3_Simple
APPROVED		SCALE	REV
		SHEET 12 OF 15	

AC Actuator Schematic

On Grid - The AC power output from the 1200 watt array slows down the Grid meter.



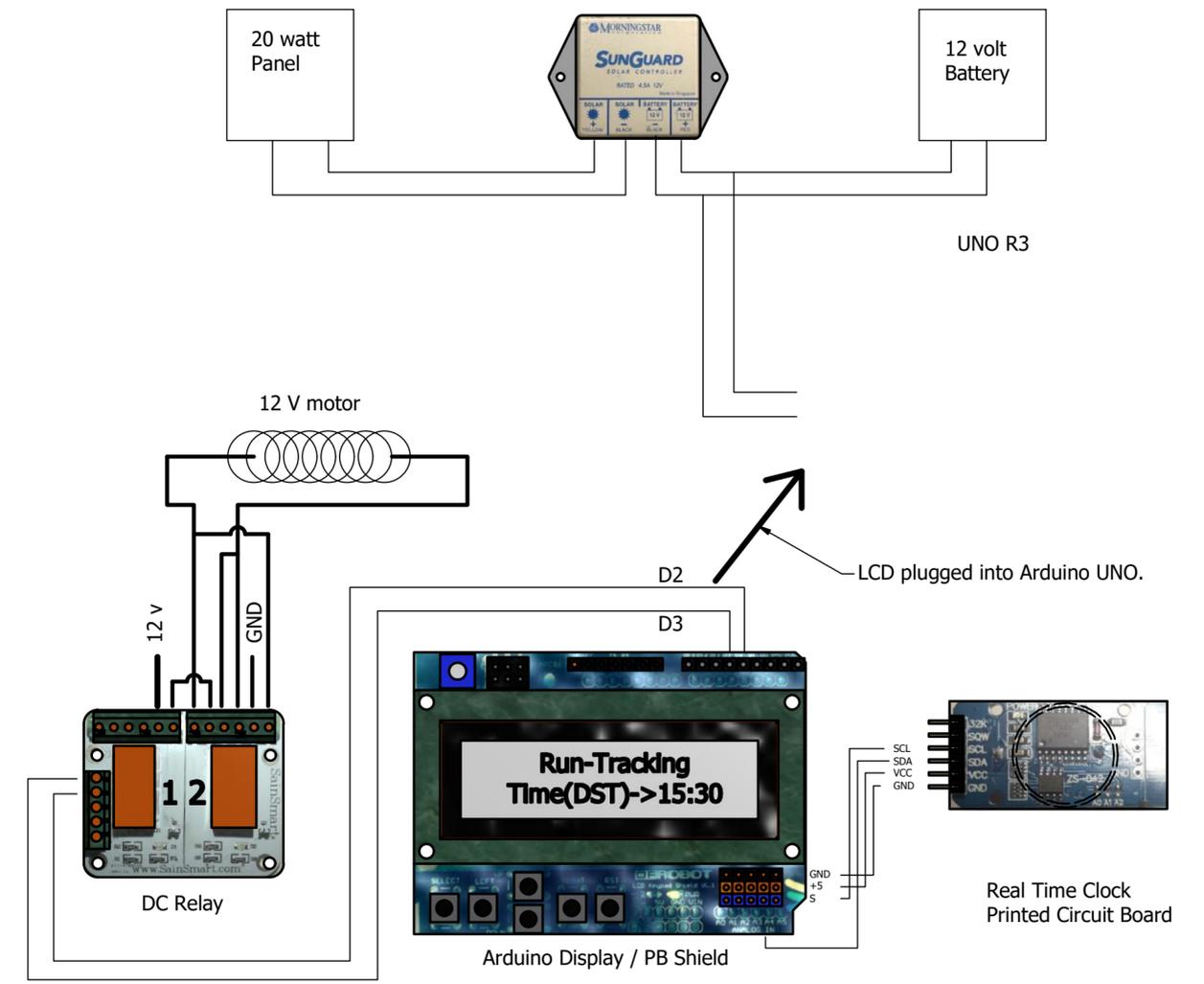
Test all wire connectors/ male sockets for continuity. Solder if necessary.

Note that some solid state relays may switch on a positive (+5 volt) signal, and some on a negative volt signal.

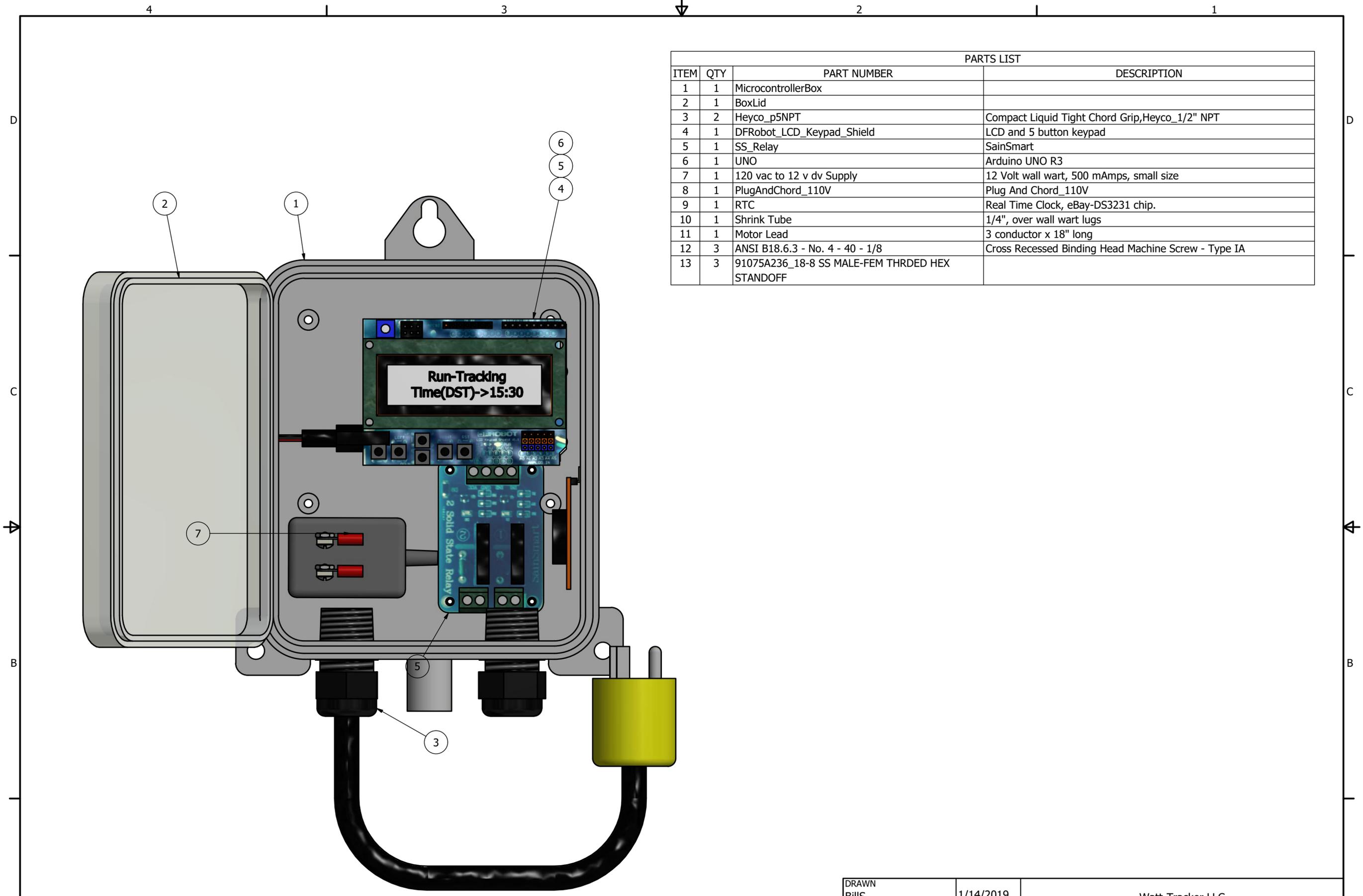
- Notes: I encourage users to let me purchase the UNO, display, SS switch, RTC and program and verify operation.
1. The LCD, UNO and Solid State switch are nested with standoffs.
 2. Locate UNO so 12 volts from wall wart will access UNO 12 volt connection.
 3. LCD / pusbutton unit: These are sold by SainSmart and DF Robot. Get one with male headers on the AN1-6 inputs. The + 5v and Gnd pins on the lower right header are different between DF Robot and Sain Smart.
 4. The Real Time Clock is available at Ebay. The unit uses a DS3231 chip. And the Label on the board is DS-042.
 5. The AC Relay Board is from Sain Smart, and uses Omron solid state switches.
 6. UNO Power supply is 7 - 12 volts input. I use 300ma, but suspect it could be less watts.

DC Actuator Schematic

Off Grid - The 1200 watts of solar can feed a charge controller. A small panel - 20 watts can feed a small charge controller and a 12 volt battery for motion control.



DRAWN	1/14/2019	Watt-Tracker, LLC		
BILLS CHECKED		TITLE		
QA		Control J Box		
MFG		SIZE	DWG NO	REV
APPROVED		C	2X_V3_Simple	
		SCALE	SHEET 13 OF 15	



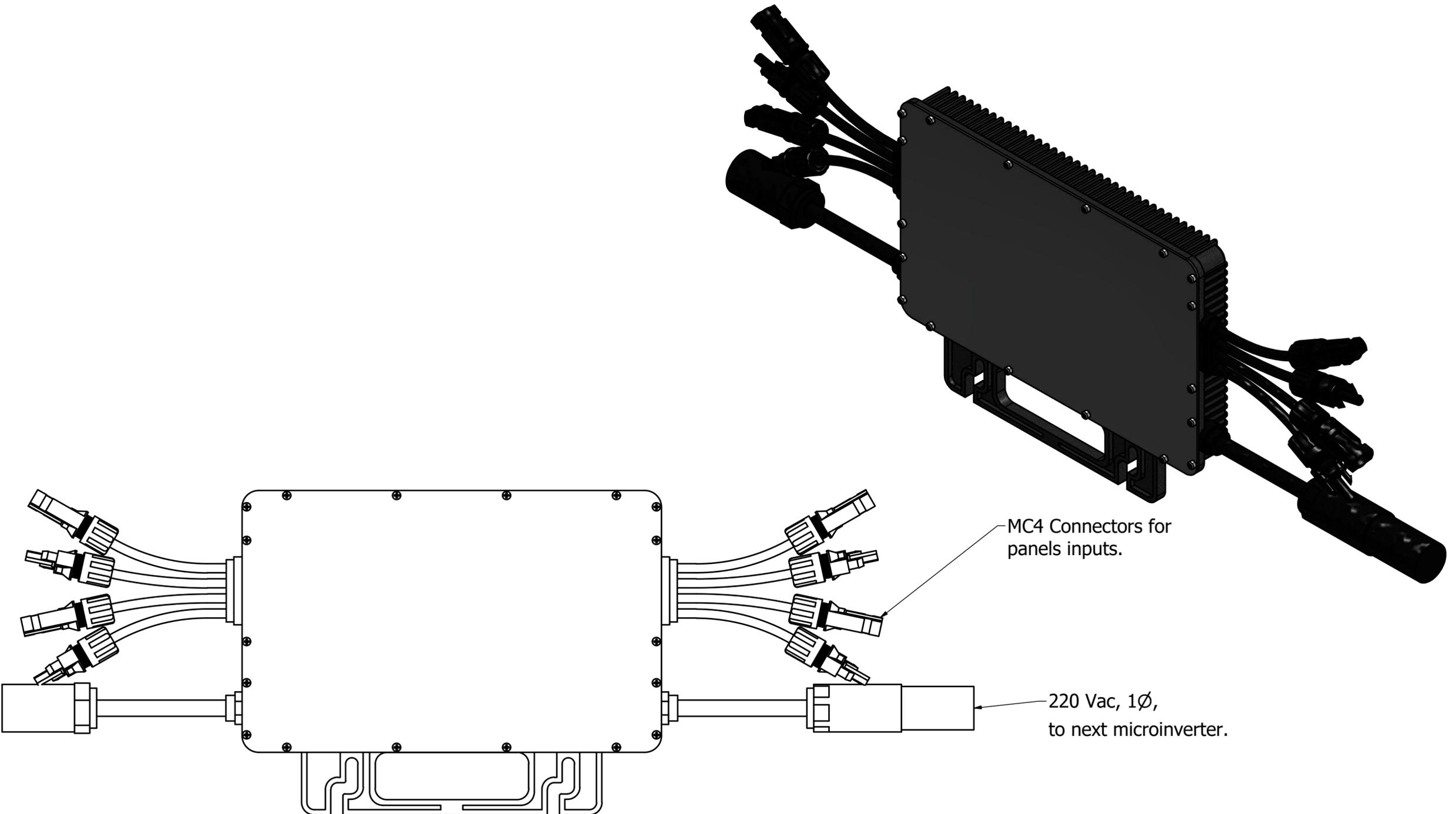
PARTS LIST			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	MicrocontrollerBox	
2	1	BoxLid	
3	2	Heyco_p5NPT	Compact Liquid Tight Chord Grip,Heyco_1/2" NPT
4	1	DFRobot_LCD_Keypad_Shield	LCD and 5 button keypad
5	1	SS_Relay	SainSmart
6	1	UNO	Arduino UNO R3
7	1	120 vac to 12 v dv Supply	12 Volt wall wart, 500 mAmps, small size
8	1	PlugAndChord_110V	Plug And Chord_110V
9	1	RTC	Real Time Clock, eBay-DS3231 chip.
10	1	Shrink Tube	1/4", over wall wart lugs
11	1	Motor Lead	3 conductor x 18" long
12	3	ANSI B18.6.3 - No. 4 - 40 - 1/8	Cross Recessed Binding Head Machine Screw - Type IA
13	3	91075A236_18-8 SS MALE-FEM THRDED HEX STANDOFF	

Construction Notes:

1. Place LCD/UNO in box. Leave room to make the 12 volt connection to the UNO on the left.
2. 2 wires per one lug on wall wart. Insert shrink tube, 1 inch, before tightening screws. Shrink tube with heat.
3. It is convenient that the J Box used has a clear cover to see the LCD.
4. The chord to the motor is 3 conductor. Neutral and connects to the red lead on the motor.

DRAWN	1/14/2019	Watt-Tracker,LLC		
BILLS		TITLE		
CHECKED		Junction Box		
QA		SIZE	DWG NO	REV
MFG		C	2X_V3_Simple	
APPROVED		SCALE	SHEET 14 OF 15	

This is a 4 in 1 Micro inverter, that takes inputs from 4 panels, and inverts to 220 volts, single phase.
 This one is manufactured by NEF Power for \$180. Enphase makes a similar product, but only 1 per panel.
 The Enphase IQ7 retails for \$120. 4 Ea = \$480. Compare! 3/8 the cost!



DRAWN	1/14/2019	Watt-Tracker, LLC		
BILLS		TITLE		
CHECKED		4 in 1 Micro Inverter		
QA		SIZE	DWG NO	REV
MFG		C	2X_V3_Simple	
APPROVED		SCALE	SHEET 15 OF 15	