NORTHERN ARIZONA UNIVERSITY

EDUCATIONAL SOLAR TRACKING SYSTEM

OPERATIONS AND MAINTENANCE MANUAL

Version *1.0*

04/25/2014

This Manual Covers Installation and Operation of the Solar Tracking System. It is not intended to cover any damage or repair of the Solar Tracking System.

VERSION HISTORY

Version #	Implemented By	Revision Date	Approved By	Approval Date	Reason
1.0	*Joshua Belsheim,Travis Francis, Jiayang He, Pengyan Liu, Anthony Moehling,Micah Ziemkowsk,i*	*04/25/2014*	*Srinivas Kosaraju*	*04/25/2014*	*N/A*

UP Template Version: 4/25/14

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1 INTRODUCTION

1.1 PURPOSE

Design and build a system that enables students to experience the fundamentals of solar tracking systems

1.2 AUDIENCE

This operations manual is intended to describe the assembling and operations of the solar tracking system to NAU students.

2 SYSTEM DESCRIPTION

2.1 INVENTORY

Parts List:

All of the steel parts used in this design were made out of AISI 1020 steel hot rolled steel.

Part	Amount	Purchasing Options
1”x1”x72” square steel tubing	3	Home Depot
1”x1”x74” square steel tubing	2	Home Depot
Cast iron bearings 1” diameter	4	McMaster
1” diameter steel shaft	1ft	Home Depot
Mounted Bronze Bearing, Flange Mounted, 7/8" Shaft Diameter	1	McMaster
7/8” diameter steel shaft	1ft	Home Depot
Everbilt 3-1/2 in. Satin Nickel Square Corner Door Hinge	2	Home Depot
1 ½” x 1”x96” angled steel bar	2	Home Depot
1 ½” x 1”x72” angled steel bar	4	Home Depot
1 ½” x 1”x48” angled steel bar	4	Home Depot
3/16”x1/2”x12” key	1	Amazon

stock		
5/16”x5/16”x12” key stock	1	Amazon
Omega 486C stepper motor	1	Omega Engineering
STR-8 control system	1	Omega Engineering
Adriano board	1	Amazon
¼” diameter bolts and nuts	12	Home Depot
¼” diameter pins	2	Amazon
3/8” diameter bolts and nuts	8	Home Depot
Steel Worm, 6 Pitch, with 3/16" X 3/32" Keyway for, 14-1/2 Degree Pressure Angle Worm Gear	2	McMaster
14-1/2 Degree Pressure Angle Worm Gear, Cast Iron, 6 Pitch, 40 Teeth, 6.67" Pitch Diameter	2	McMaster
16 gauge sheet metal 4ftx4ft	1	Mayorga's welding
¼” sheet metal 2ftx2ft	1	Mayorga's welding
48 VDC Switching Power Supply, 320W	1	Applied Motion products
Enclosure for electronics 9”x4”x3”	1	Amazon
Solar panels 48”x72”	2	Solar panel manufacturers

2.2 ENVIRONMENT

The operating environment intended for the Educational Solar Tracking System is the gated area called the “shack” located behind the Engineering building. The Solar Tracking System can be set up on any level surface with available area 9’ X 7’. To maximize efficiency of the solar panels it’s would be desired to have them face south.

2.3 SYSTEM OPERATIONS

The Educational Solar Tracking System is designed to operate 365 days a year for 16 to 10 hours each day. The solar tracking system operates in temperatures ranging from -30°C to 33°C. One side of the solar panel operates via a manual shaft rotation the other operates on a step motor that rotates a certain angle at a pre-programmed time.

3 APPLICATION INSTALLATION

3.1 INSTALLATION

Warning always use at least two people to install.

The Base Frame

The first step is to place the base frame on the ground feet down. After the base is on the ground twist the leveling pads in or out to the desired height to insure levelness on the base frame.

Figure 1: Leveling pads

Figure 2: angle support

Angle Support

To attach the angle support that is seen in Figure 2. First bolt down the higes to the base frame. Fasten the top bearing to the solar panel box if is not there. Place the solar panel box with the panel already inserted into the top bearing the shaft without a keyway is the top shaft of the solar panel box frame. Next slide on the bottom bearing to shaft on the box for the solar panel, bolt the bearings down. After the solar panel is sercured lift the angle support. Place the hydrolics on the closest hole to the hinges. There should be 7 washers between the angle support and washer. Also 7 washers betweem the based frame and hydralic. There is also a washer between bolt and the surface it is getting bolted to.

Figure 3: Connetions of base frame and angle support

Once the hydralic is inserted, you can move onto the angle adjustor. First attach the angle adjustor to the center of the support angle bar. This is done by a nut and bolt. The angle adjustor is connceted to the base frame with a locking hitch pin. Line up the holes on the angle adjustor and the base frame as shown in Figure 1 and Figure 2.

Figure 4: Holes for manual North-South tracking

Figure 5: Side view of angle supports

Motor and Gears

First place the motor in the motor housing having the shaft point away from the manual solar panel. Line up the motor holes to the housing holes use 5 mm bolt. Place the shaft key in the motor worm gear shaft keyway this can be seen in Figure 4.

Figure 6: Keyway and Key

Hammer the worm gear to the center of the shaft make sure the key way and key line up. Loosen the Allen bots on the couple. Slide the shaft couple on the motor shaft. Attach the couple to the worm gear shaft. Tighten down the Allen bolts. Place the key in the keyway on the solar panel box shaft. Slide the gear onto the shaft make sure the keyway and key are lined up. Use hammer if needed.

Manual Crank and Motor

First place the bearing on the housing. The extrude part faces inward into the housing. . Place the shaft key in the worm gear shaft keyway this can be seen in Figure 5. Hammer the worm gear to the center of the shaft make sure the key way and key line up. Attach the socket wrench to the end on the manual worm gear shaft.

3.2 CONFIGURATION

The configuration the Educational Solar Tracking System varies depending on what angle is desired. The North South pivot points allow the solar panel to be angled anywhere from 0° to 60°. Depending upon the time of the day the solar panel can be rotated anywhere from 0° to 180°.

4 SYSTEM USAGE

4.1 INSTRUCTIONS

The Educational Solar Tracking System has several components to operating it effectively such as North/South Axis Tracking, Manually Hand Crank Operation and Automatic Motor Based Tracking.

North/South Axis Tracking

This solar tracking system is capable of tracking the sun in the North/South Axis. When carrying out these procedures, please be cautious that each solar panel weighs roughly 60 lbs. It is easier to carry out this procedure with the assistance of another individual. It could be accomplished with one person, but be aware, it is difficult. To move the solar panel in the North/South Axis, please follow the ensuing instructions:

- While one person is supporting the end of the panel that is opposite from the motor, the other person can unpin support beams.
- While the solar panel is still being supported, the panel can be slowly lowered or raised to the next position.
- Once the supports reach the desired location, the pin could be reinserted to keep tracking the sun.

Hand crank

The hand crank uses a 15/16 socket wrench which is removable. The wrench is attached to a 7/8 shaft that has a worm gear which allows for only input force and no return force to user. The end of the shaft is supported by a bronze bearing with 7/8th diameter.

- The clockwise option on the wrench moves the solar panels west.
- The counterclockwise movement of the wrench moves the panels east.

Automatic Motor Based Tracking

The motor has to be installed into the motor case and fixed with 5mm bolts as shown in Figure ##.

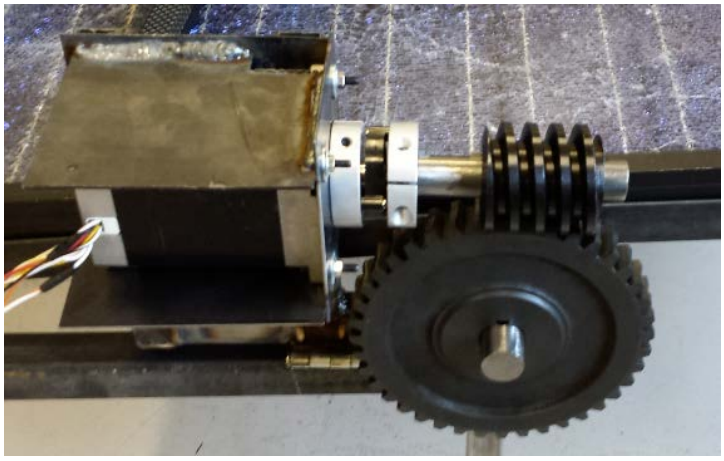

Figure 7: Motor Installation

The connection between the motor and STR-8 driver is shown in Figure 6. The driver can be set up to allow different power out puts. The driver has been preset for the motor used in the system. If different settings are needed, please reference the detailed manual from Applied Motion Product Company in attachments.

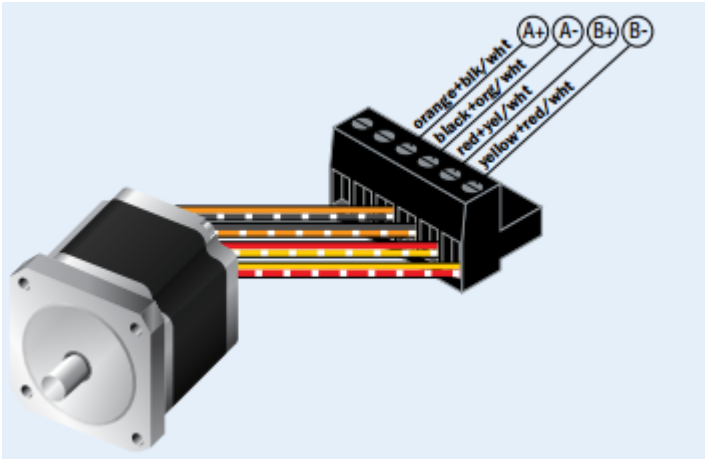

Figure 8: Connection between the Motor and STR-8 Driver

In order for the motor to work, an extra signal generation board is needed. In the current design, an Arduino UNO R3 board is used to generate signals to operate the motor. The connection between Arduino and STR-8 is shown in Figure 7. The power supply for STR-8 is a DC power source with 48 volt and 6.8 amps (included in accessories). Arduino board has a separate 9 volt power supply (included in accessories).

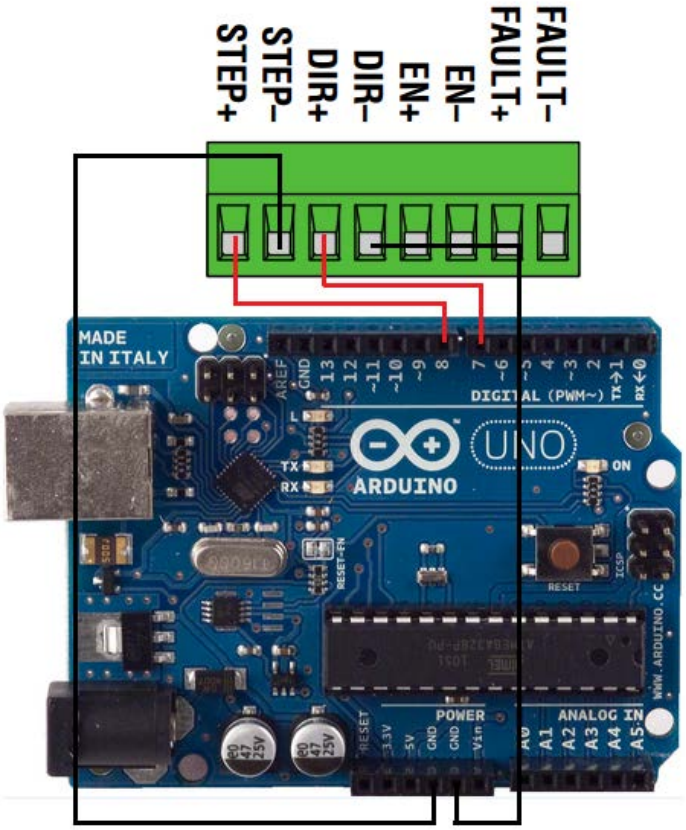

Figure 9: Connection between Arduino and STR-8

5 SYSTEM MANAGEMENT

5.1 MOTOR PROGRAM CODE

Arduino Programming

```
#include <Stepper.h>
//the number of steps on your motor
int STEPS = 200;
// create an instance of the stepper class, specifying
// the number of steps of the motor and the pins it's
// attached to
Stepper stepper(STEPS, 7, 8);
void setup()
{
  // set the speed of the motor to 30 RPMs
  stepper.setSpeed(60);
}
```

```
void loop()
{
//this for loop will tell the motor to rotate 800 steps for 4 times, and wait for 1000 ms between each rotation.
  for(int i = 0; i <= 3; i++){
    stepper.step(800);
    delay(1000);
  }
//this command tells the motor to rotate back all the way to its initial position
  stepper.step(-800 * 3);
  delay(10000);
}
```

Appendix A: Operations and Maintenance Manual Approval

The undersigned acknowledge they have reviewed the *Educational Solar Tracking System* **Operations and Maintenance Manual** and agree with the approach it presents. Changes to this **Operations and Maintenance Manual** will be coordinated with and approved by the undersigned or their designated representatives.

Signature: _____ Date: _____

Print Name: _____

Title: _____

Role: _____

Signature: _____ Date: _____

Print Name: _____

Title: _____

Role: _____

Signature: _____ Date: _____

Print Name: _____

Title: _____

Role: _____

APPENDIX B: REFERENCES

The following table summarizes the documents referenced in this document.

Document Name and Version	Description	Location
STR4/8 Quick Setup Guide	A Hardware Manual for the STR4 control system	http://www.applied-motion.com/sites/default/files/hardware-manuals/STR_Quick_Setup_Guide.pdf
Hardware Manual STR4 & STR 8 Step Motor Drives	A Hardware Manual for the Step Motor Drives	http://www.applied-motion.com/sites/default/files/PS320A48_datasheet_925-0006.pdf
PS320A48 Power Supply Hardware Manual	A Hardware Manual for the power supply that converts AC current to DC current for the step motor	http://www.omega.com/manuals/manualpdf/MSTR4_8_Series.pdf

APPENDIX C: KEY TERMS

The following table provides definitions for terms relevant to this document.

Term	Definition
Base Frame	*The bottom frame, is placed on the ground*
Angle support	*Holds the weight of the panels*
Leveling pads	*Feet that level the base frame*
Solar panel box	*Holds the solar panels in place*
Angle adjustor	*Changes the angle of the panels in the N/S tracking*
key and keyway	*Key is a square piece of metal that is wedge between two keyways to keep gears and motors attached*
Couple	*Connects the different size of shaft between motor and worm gear.*