Refurbished, Donated and Modified: Putting the pieces all together

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The University of Michigan Amateur Radio Club, W8UM, has benefitted greatly from its many members and donors. Through their generosity, both monetary and equipment donations have provided the resources to remain an active club. During the recent months, the club has received a 3-element SteppIR antenna (6-20M; SteppIR Communications Systems, Bellevue, WA.), without a controller, a 35' crank up steel tower, and a single axle trailer. In addition, due to renovations of the Michigan Union Building, the circular polarized 144 MHZ and 444 MHZ antennas, erected during 1982, were removed from the roof top and refurbished. This is our experience in assembling these donated, refurbished and modified items into our mobile tower.

Trailer: The single axle trailer and the 35' crank-up tower were provided by the Department of Naval Architecture and Marine Engineering. It was not known how this trailer and tower were used in the past. The trailer had been supported off the ground by its 4-outriggers. This likely prevented any damage to the tires, wheels, bearings or axle during its time of inactivity. After determining the frame, axle, bearings, tires and tire pressure were all safe, attention was then directed to the manual winch and wire cable that elevates the tower from its resting horizontal position to a vertical position. Noticing that the winch and winch cable were in poor condition, both were replaced with a 1500-pound capacity electric winch with a remote switch (Harbor Freight). During our first attempt at raising the tower, the "horseshoe" connection, on the winch cable became pinched at the location where the tower base locks into the trailer frame. This prevented the tower from any further movement (Photo 1A). By altering the pivot point on the tower base, and the addition of a washer (Photo 1B), the tower based aligned perfectly into the trailer hinge. Once the tower was vertical, the tower base was secured with a 1" diameter bolt (Photo, 1C). The tower was then easily extended to its full height, and then retracted fully, without encountering any difficulties.

Azimuth Rotor and Rotor Bracket: Finding a rotor of the appropriate size, to fit into the tower and rotate a "large" antenna proved to be difficult. Of the 2 rotors available, a High-Gain was too large to fit into this tower. An Alliance rotor (Alliance HD-73-1; Genie Co.), with controller, donated by KA8POZ was also slightly too large, however, by removing the rotor tower plate (Photo 2A) and repositioning the plate beneath the welded supports on the tower and then securing with right-angle brackets allowed the rotor to fit and rotate freely.

Elevation Rotor: The azimuth rotor (Alliance U-100 Tenna Rotor, Alliance Mfg., Alliance, OH.), that once held the circular polarized satellite antennas (144 MHZ, 444 MHZ), was taken apart and examined. Immediately noticed was the worm gear had a significant gouge (Photo 3A). This damage may have occurred from uneven balance, improper mounting and / or wind stress over the past 38-years. The rotor was taken apart, thouroughly cleaned and a replacement worm-gear was purchased from Norm's Rotor Service (Photo 3B).

Circular Polarized Satellite Antennas: Surprisingly, both the 144 MHZ and 444 MHZ satellite antennas were in very good condition. While each antenna had bent or broken elements, all coax connections were in excellent condition; like it was put together yesterday. The connections had been thoroughly taped, protected with boot covers and sufficiently lubricated. All connections were easily un-done!

SteppIR Antenna: The family of W8ERN (SK) generously provided our club with a 3-element SteppIR antenna. Since our goal was to limit the use of this antenna to "special event" situations, the shrink-wrap holding the element support tubes (EST's) in their extended position was cut and removed at each of the 4-sections of each EST. This allowed the EST sections to collapse and retract to approximately 4' sections. An patio umbrella cover was used as a protective carrying case for the EST's, the Director EHU and the Reflector EHU.

Element Housing Unit, "Disassembly" Required: The SteppIR antenna proved to be challenging, especially without a control box to switch bands i.e. advance and retract the copper conductor tape. The wiring to all 3- element housing units (EHU's) had been cut and the wire casings had deteriorated and required rewiring. With an EHU cover removed, we could see the tape-drive gear and the spring-loaded spools. We carefully checked that the copper conductor tape could move – no issue. But what about the motor? Of course, this required additional "disassembly" to access. Unfortunately, during the process, the "loading" spring released on one of the spools (Photo 4A). Was this the end of the project? Unable, and unaware of any tricks to remedy this, we purposely removed the "molded bullet" that prevents the tape from retracting fully into the EHU. This allowed us to remove both the spool and the remaining unwound tape from the EHU. Later, after some online research, a video demonstrating how to replace a SteppIR spool was located.

During the process of removing the tape and spool, the contacts of the EHU's were inspected and cleaned (Photo 4B). Not knowing any specifics about the SteppIR workings, the tape of each EHU was fully extended to verify and compare their length, sprocket hole diameter and spacing, and tape width.

The rewinding of the tape, setting of the spool tension spring and the proper amount of spool tension initially proved to be frustrating. Our first attempt exceeded 90 minutes. This was reduced to 10 minutes on subsequent EHU's. Perhaps a much easier method to fix an "unwound" tape, is to completely unravel the tape without removing the "molded-bullet", remove the small screw on the spool, replace the spool (without attaching the tape), insert the spring, add counter-clockwise tension to the spool, attach the tape and screw and then allow the tension on the spool to fully and slowly retract the tape onto the spool.

Making a Controller for the SteppIR Antenna:

Justification: The base controller, for the SteppIR, alone itself runs $250 to $550 ($250 used; eBay, $550 new; SteppIR). Replacing the controller would be a significant cost for any "club". Having the most expensive part "in hand", the SteppIR antenna, could the additional expense be justified? What if what we have doesn't even work?

Getting the Stepper Motor to Move: Using an Arduino, EasyDriver (Sparkfun Electronics) and a stepper motor, from an abandoned medical project, test code was written that would move the stepper motor in either a clockwise or counterclockwise direction. A Hewlett Packard power supply, from an All-In-One printer scanner, with an output of 32V (1.65 amps), was used. Our initial code sent 200 pulses with the "DIRection" pin HIGH and the motor turned 1 full revolution. Next, set DIR LOW and the motor reversed direction one full turn. By increasing the pulse count, the motor completed "more" revolutions. GREAT! We now have a way to control the SteppIR motor(s).

Testing the Real Thing: The SteppIR manual mentions use of either a 24V or 33V power supply. Additionally, the SteppIR website "suggests" using a 33-volt power supply, fortunately, the EasyDriver was rated to 30V. Using a 32V / 3A power supply (purchased from Amazon) we then "wired" in one of the EHU's in place of the "test" stepper motor – it WORKS! The copper conductor tape moved both out and in using our "test" code. The remaining EHU's were then tested, individually, with the same results. One important lesson was learned, while exchanging EHU's, into the circuit, remember to disconnect the motor winding wires when they are not powered otherwise it will result in blue smoke from the driver chip!

While altering the code we noticed how consistent the tape movement was. Pulse count equates to the length of tape extended from the EHU. So, sending a set number of counts and recording an "approximate" measurement of the tape extension would provide a pulse count per inch.

Determining Element Lengths: Controlling the element lengths, simultaneously, for each of the 3 EHU's was the next task. From the many websites on Yagi-Uda antennas, the driven element equates to a dipole. The Director is 93% - 95% of the Driven element, and the Reflector is 105% of the Driven element. Spacing of the elements on the SteppIR was fixed, so no calculations were necessary. We decided to use: 0.473 * wavelength for Driven element, 0.93 * Driven for Director, and 1.05 * Driven for Reflector.

Our crude measurements of pulses per inch was used to set the number of pulses to send to each EHU motor. A spreadsheet, that included macros, to determine pulse count per element per band (at the band center), was created. This would ensure the desired lengths of tape extended, while switching between the bands, would be achieved.

On a breadboard were mounted 3 generic A4988 drivers with an Arduino Nano (with screw terminals). Using the separate power rails for the SteppIR motors (32V) and the drivers and Arduino (5V), we could now test all 3-EHU copper tapes at once. As expected, we were not very accurate in prediction the length of copper-tape extended. What we needed was a large count to distance measurement to improve accuracy. We set the Arduino to output a duration that would advance the copper tape to its near-maximum length of the EST support tube (approximately 17 feet 6 inches).

Having recorded the number of pulses per foot, we calculated the pulses required to extend each copper tape, on each band, and updated the Arduino firmware. Now to drive all 3 elements at once and see what happens. During our first attempt, the tape in 2-EHU's extended to the desired lengths while the remaining EHU stepper motor attempted to retract. After some troubleshooting, a broken wire was located. A second trial resulted in all 3-EHU's advancing to our pre-set distance on each the 6, 10, 12, 15, 17 and 20M bands. Last, we made sure the elements all retracted to zero, or completely into the EHU, by command. To this time, all testing had occurred in a hallway with the tape running on the floor (not in the EST's).

A project box with band and Zero buttons and a 4-line LCD display were added to complete the SteppIR controller (Photo 5). The LCD displays the; band, antenna length (in feet), programmed counts and frequency (MHZ). This display facilitates with any troubleshooting. Inside the box was still the breadboard and Arduino with screw terminals.

Assembly and Tower Crank-Up: With the trailer positioned and leveled, the Driven element section of the boom attached to the mast, the "shorter" Director and Reflector sections were added, and the entire boom positioned parallel to the ground. The "top" 3 ESTs were then secured onto each EHU (Photo 6A). Using the electric winch, the tower was raised slightly to then allow the "lower" EST support tubes to be secured onto the lower half of each EHU. Again, the tower was raised slightly which allowed the EST tubes to passively extend downwards. This process was continued until each EST support tube was fully extended (Photo 6B). The tower was then raised to its vertical position and secured into the trailer hinge with the large diameter bolt. What had not been taken into consideration was the effort required to crank the tower to its full height; the additional weight of the azimuth rotor, mast, SteppIR antenna, elevation rotor with boom, 144 MHZ and 444 MHz Yagi antennas and 150' of coax and wiring (Photo 6C).

On the Air? With all the connections between the SteppIR antenna to the ”new” controller box in place, the coax connected to the radio, and power to both, the “20M” button on our controller was pushed! (Photo 8). We could hear the SteppIR motors extending the elements, but when we keyed the radio – HIGH SWR. The radio was disconnected and an MFJ antenna analyzer (MFJ Enterprises Inc.,) inserted into the coax. A laptop, with the programming code, was connected to the Arduino to access our “incremental tuning” function. Adjustments were made in the code to adjust the antenna length and obtain a minimum SWR. These new values were then uploaded into the Arduino firmware. Similarly, testing and changes were made to each of the remaining bands. We were fully functional!

Excited that everything worked and satisfied at what we had accomplished, we decided it was time to make the first of 70 contacts for the afternoon.

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