

Manual for Screwjack Solution

Firstly it should be noted that screwjacks use a pulsing system to keep track. They are not absolute systems (generally). Whenever the power is lost from the AZ/EL unit the direction will be lost. When this happens, the antenna will have to be taken back to 0 heading and the re-calibrate switch triggered.

Screwjacks are a method of moving a small dish. They often contain microswitches or magnetic reed switches that operate when the dish moves. It is also necessary to provide information about the direction of travel. So in essence there are three switches.

1. Pulse count of movement
2. Up switch
3. Down switch

My solution makes use of the AZ/EL board, part of the set of 5 boards provided for my beam indicator project. Essentially, the following connections are made on the encoder board connector on the AZ/EL unit – J1

1. "Count in" connects to pin 7 of the connector
2. Direction switch "Up" connects to pin 5
3. Direction switch "Down" connects to pin 6

Either the old or new AZ/EL boards can be used for this purpose. The circuit of the AZ/EL board remains substantially the same except for the interconnections described in this document. The correct software must be loaded. This is called Screw.hex

The 16F628 (or A) is again used, although a 16F648A would also be suitable.

The program adjusts to the range of the screwjack but in order for this to happen some values must be placed in eedata of the PIC.

Because each screwjack arrangement is different the user will have to develop their own corrections table as described here, so programming facilities will be required.

When Screw.hex is loaded into a programmer you should be able to 'see' and also 'edit' the eedata. The last 4 bytes of eedata memory of the PIC are the storage locations for the two important numbers that change with each screwjack and its mechanical arrangement.

The Screw.hex file was developed for a screwjack that has 1628 counts from 0 to 100 degrees. So why do the numbers not align with the numbers in the eedata table? The numbers in the eedata when converted to decimal are 1680counts and 103 degrees.

CountInMaxDta (1680 in the sample file)

In the distributed file, CountInMaxDta occupies the last two bytes of eedata. Inspection of the distributed file once loaded into your programmer will show this to be stored as \$9006. In most hex systems the low byte is stored first, so you have to swap these to get the way we are used to reading numbers \$0690. Note \$ sign indicates a HEX number.

To convert \$0690 to decimal:

$$6*256=1536$$

$$9*16=144$$

$$\text{So } 0690 = 1536+144=1680$$

DegSpreadDTA (103 in the distributed file)

In the distributed file the 3rd and 4th to last entries in the eedata are 103 stored as \$6700.

Again swapping the position, we get \$0067.

To convert \$0067 to decimal:

$$6*16 = 96$$

$$7*1=7$$

$$\text{So } \$0067=103 \text{ decimal.}$$

So why 1680 and 103? These two numbers are used by the PIC16F628 to calculate how many counts in a degree and to work out any corrections needed for the count.

This part of the process is a bit tricky, so pay attention.

In the above example the actual max count was actually 1628 for a 100 degree movement.

Now to adjust for ongoing errors due to the nonlinearity of screwjacks moving dishes, and to allow for the use of integer arithmetic in this portion of the PIC, an adjustment has been made to “maxcount” and “degrees covered” numbers.

If real numbers (those with a decimal point) had been used for this part of the calculation there is a small change the wrong part of the error correction table may be hit.

There are 120 error correction locations available in the PIC (actually 124 but 120 works better and leaves some space for other items). Dividing the maximum count by 120 gives a non integer result (13.56666). This makes table hopping awkward.

Where is the smallest multiple of 120 above 1628? Answer 1680. This results in a multiplier of 14 (14*120=1680). Consequently we can fit the range from 0 to 1628 counting steps comfortably in 14 equal increments in 120 bytes of memory with a bit left over.

Now convert the new maximum count to HEX (use the calculator in Windows with Scientific ticked), reverse the bytes and enter them into the eedata in your programmer.

Because the count interval has been altered we also have to adjust the degree spread. Use this formula substituting your numbers for 1680 and 1628:

$$\text{New count (1680) * Old degree spread (100) / Old max count (1628)}$$

$$1680 * 100 / 1628 = 103$$

This is your new maxdegree spread.

So convert to hex, reverse the bytes and enter into your eedata.

That's the hard part done.

Now for the error correction table:

The AZ/EL unit outputs a number from 0-4096 equating with a movement from 0-360 degrees. For EME work, users will not need 360 degrees of azimuth or elevation.

In this system all data is converted to a 12 bit 0-4096 range over a range of 360 degrees. This enables the shack unit to convert the input to degrees irrespective of what input device is being used viz AS5045, pot or screwjack. The 10 bit AS5040 system is not used in screwjack applications.

Example:

If we have a count of 45 in a system where there is a maximum count of 1000 over 100 deg (corresponds to 10 counts per degree), the AZ/EL unit converts to a reading of :

$$X = ((\text{Totalcount} * 4096 * \text{DegSpread}) / 360) / \text{CountInMaxDta}$$

In the above example we calculate the output number like this:

$$X = 45 * 4096 * 100 / 360 / 1000$$

$$X = 51$$

The value of X is sent to the shack unit where it converts 51 to 4.5 degrees for display and calculation.

The table in the AZ/EL unit corrects for errors, it does not provide a read out in degrees, this latter conversion is handled in the shack software as described above.

If your screwjack and its mounting provides a linear count you do not need any data in the eedata error table from address 0 to 121. Just make them all 0s. Don't forget to set CountInMaxDta and DegSpreadDTA as described above.

If your mechanical arrangements are not linear then you will need to adjust the error table. The error to be added to the count is derived by breaking the counts up evenly through the error table, and where necessary, extrapolating between readings to obtain more accurate adjustments. The table assumes that 0 degrees has its error at address 0 and as the count progresses higher so does the table address.

The table has 120 positions to store corrections for your real count. In the example provided each location has a range of 14 counts. Table position 0 coincides with the first setting of your counter so will usually have a 0 error correction. The next position (1) coincides in the above example with 14 counts. You will need to develop a set of corrections based on what is being read by the shack unit and what it should be. These can then be hand entered into the eedata table when the PIC is to be programmed. The errors will be cumulative.

Have a look at the example provided below.

Example: Max count of 1680; spread of 103 degrees and therefore 16.3 counts per degree.

By experiment it is found that every 21 counts it is necessary to add 1 to the count

In this example the step in the table is 14 counts (see P2):

| Count | Degrees | Address of table | Error val in table |
|-------|---------|------------------|--------------------|
| 0 | 0 | 0 | 0 |
| 14 | 0 | 1 | 0 |
| 28 | 1 | 2 | 1 |
| 42 | 2 | 3 | 2 |
| 56 | 3 | 4 | 2 |
| 70 | 4 | 5 | 3 |
| 84 | 5 | 6 | 4 |
| 98 | 6 | 7 | 4 |
| 112 | 6 | 8 | 5 |
| 126 | 7 | 9 | 6 |
| 140 | 8 | 10 | 6 |
| 154 | 9 | 11 | 7 |
| 168 | 10 | 12 | 8 |
| 182 | 11 | 13 | 8 |
| 196 | 12 | 14 | 9 |
| 210 | 12 | 15 | 10 |
| 224 | 13 | 16 | 10 |
| 238 | 14 | 17 | 11 |
| | | etc | |

This is going to take time but just think how worthwhile it will be when it is working.

Note that because errors may be negative the PIC program recognizes that numbers from 0-127 (0-7F hex) are positive corrections while numbers from 128-255 (80-FF) are negative corrections. For example 129 equates to -1, while 135 equates to -7 (just take 128 from the number to find its negative quantity).

This could be a long process and may require some retakes, you only have to do it once unless you change the mechanical arrangements of the screwjack.

I suggest you peak the antenna on noise from the sun using the shack unit to determine the sun's position. This is a quite an accurate calculation, better than 0.1 degrees.

Offset

By placing SW2 in the ON position an offset may be added to the readings. This will be useful where the unit is rotated a certain amount to cover a different part of the sky. In this case put the value of the offset required in memory location 123 (hex 7B) in hex. Eg \$5A = 90 degrees, \$4B = 75 degrees, \$51 = 81 degrees and operate the switch SW2.

Location 123 is the 5th to last eedata location. The default is \$5A or 90 decimal. This can be any value you need, although normally in the range 0-180. Only whole degree offsets are possible. The arithmetic involved in the conversion is integer arithmetic so there is a small possibility that the offset may be a degree out.

As offset may only be positive SW2 should be ON for the higher of the two uses. Calibration should be conducted in the position where SW2 is off.

Switch functions

SW1 when low resets count (low = on for all switches). Only momentary action required

SW2 when low adds an offset set in eedata at location 123 decimal (\$7B)

SW3 when low reverses the count when your screwjack works the reverse way. The internal workings of the error table still operate on an increasing number from 0 to MaxCount, irrespective of the position of this switch, so all error calculations should just consider *counts* not degrees. Also remember to swap your down and up (or left and right) inputs if this switch is used.

Suggestions

Extend the active end of SW1 to the serial port DB9 socket pin 2 (this is currently unused).

Take a wire to the shack unit and then connect the calibrate switch to pin 2 of the corresponding DB9 connector. If you are using 2 AZ/EL units the wires could be connected together and this would result in a simultaneous reset of the counters to zero.

In fact one advantage of using a screwjack is that the AZ/EL units can be located in the shack with only the “Count in” pulses coming front the antenna, the rest being available in the shack.

SW2 and SW3 could have external switches mounted on the box containing the AZ/EL units to make their functions locally available during alterations to setups.

When using reverse count with SW3 ON you will have to reverse the connections of the Up and Down switches to the board.

As an important postscript. Make sure that the CountIn from the screwjack and the Up/Down/Left/Right pulses are bounce free or you might get some funny results.

I recommend that when calibrating you should use the best program (or internet site) you can find for calculating the position of the moon.

<http://www.moshier.net/aadoc.html> provides [AA.zip](#) (a dos moon position calculator that seems to provide the best answers I could find). Next I would use Doug VK3UM's EME2006 from <http://www.sm2cew.com/download.htm> or here's one from the US Navy <http://aa.usno.navy.mil/data/docs/AltAz.html> judging from its name may be AA in action. The shack unit is usually within 0.1 degree but may have errors up to 0.2 degree.

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On the next three pages is information that will help you generate the error table

Use the formula: $\text{Count} = \text{degrees} * 4096 / 360$ or $\text{Degrees} = \text{Count} * 360 / 4096$
 This table shows the relationship between degrees (360) and count (4096). This was calculated with count rounded to the nearest whole number.

| Deg | Count | Deg | Count | Deg | Count | Deg | Count |
|-----|-------|-----|-------|-----|-------|-----|-------|
| 1 | 11 | 91 | 1035 | 181 | 2059 | 271 | 3083 |
| 2 | 22 | 92 | 1046 | 182 | 2070 | 272 | 3094 |
| 3 | 34 | 93 | 1058 | 183 | 2082 | 273 | 3106 |
| 4 | 45 | 94 | 1069 | 184 | 2093 | 274 | 3117 |
| 5 | 56 | 95 | 1080 | 185 | 2104 | 275 | 3128 |
| 6 | 68 | 96 | 1092 | 186 | 2116 | 276 | 3140 |
| 7 | 79 | 97 | 1103 | 187 | 2127 | 277 | 3151 |
| 8 | 91 | 98 | 1115 | 188 | 2139 | 278 | 3163 |
| 9 | 102 | 99 | 1126 | 189 | 2150 | 279 | 3174 |
| 10 | 113 | 100 | 1137 | 190 | 2161 | 280 | 3185 |
| 11 | 125 | 101 | 1149 | 191 | 2173 | 281 | 3197 |
| 12 | 136 | 102 | 1160 | 192 | 2184 | 282 | 3208 |
| 13 | 147 | 103 | 1171 | 193 | 2195 | 283 | 3219 |
| 14 | 159 | 104 | 1183 | 194 | 2207 | 284 | 3231 |
| 15 | 170 | 105 | 1194 | 195 | 2218 | 285 | 3242 |
| 16 | 182 | 106 | 1206 | 196 | 2230 | 286 | 3254 |
| 17 | 193 | 107 | 1217 | 197 | 2241 | 287 | 3265 |
| 18 | 204 | 108 | 1228 | 198 | 2252 | 288 | 3276 |
| 19 | 216 | 109 | 1240 | 199 | 2264 | 289 | 3288 |
| 20 | 227 | 110 | 1251 | 200 | 2275 | 290 | 3299 |
| 21 | 238 | 111 | 1262 | 201 | 2286 | 291 | 3310 |
| 22 | 250 | 112 | 1274 | 202 | 2298 | 292 | 3322 |
| 23 | 261 | 113 | 1285 | 203 | 2309 | 293 | 3333 |
| 24 | 273 | 114 | 1297 | 204 | 2321 | 294 | 3345 |
| 25 | 284 | 115 | 1308 | 205 | 2332 | 295 | 3356 |
| 26 | 295 | 116 | 1319 | 206 | 2343 | 296 | 3367 |
| 27 | 307 | 117 | 1331 | 207 | 2355 | 297 | 3379 |
| 28 | 318 | 118 | 1342 | 208 | 2366 | 298 | 3390 |
| 29 | 329 | 119 | 1353 | 209 | 2377 | 299 | 3401 |
| 30 | 341 | 120 | 1365 | 210 | 2389 | 300 | 3413 |
| 31 | 352 | 121 | 1376 | 211 | 2400 | 301 | 3424 |
| 32 | 364 | 122 | 1388 | 212 | 2412 | 302 | 3436 |
| 33 | 375 | 123 | 1399 | 213 | 2423 | 303 | 3447 |
| 34 | 386 | 124 | 1410 | 214 | 2434 | 304 | 3458 |
| 35 | 398 | 125 | 1422 | 215 | 2446 | 305 | 3470 |
| 36 | 409 | 126 | 1433 | 216 | 2457 | 306 | 3481 |
| 37 | 420 | 127 | 1444 | 217 | 2468 | 307 | 3492 |
| 38 | 432 | 128 | 1456 | 218 | 2480 | 308 | 3504 |
| 39 | 443 | 129 | 1467 | 219 | 2491 | 309 | 3515 |
| 40 | 455 | 130 | 1479 | 220 | 2503 | 310 | 3527 |
| 41 | 466 | 131 | 1490 | 221 | 2514 | 311 | 3538 |
| 42 | 477 | 132 | 1501 | 222 | 2525 | 312 | 3549 |
| 43 | 489 | 133 | 1513 | 223 | 2537 | 313 | 3561 |

| | | | | | | | |
|-----------|------|------------|------|------------|------|------------|------|
| 44 | 500 | 134 | 1524 | 224 | 2548 | 314 | 3572 |
| 45 | 512 | 135 | 1536 | 225 | 2560 | 315 | 3584 |
| 46 | 523 | 135 | 1536 | 226 | 2571 | 316 | 3595 |
| 47 | 534 | 137 | 1558 | 227 | 2582 | 317 | 3606 |
| 48 | 546 | 138 | 1570 | 228 | 2594 | 318 | 3618 |
| 49 | 557 | 139 | 1581 | 229 | 2605 | 319 | 3629 |
| 50 | 568 | 140 | 1592 | 230 | 2616 | 320 | 3640 |
| 51 | 580 | 141 | 1604 | 231 | 2628 | 321 | 3652 |
| 52 | 591 | 142 | 1615 | 232 | 2639 | 322 | 3663 |
| 53 | 603 | 143 | 1627 | 233 | 2651 | 323 | 3675 |
| 54 | 614 | 144 | 1638 | 234 | 2662 | 324 | 3686 |
| 55 | 625 | 145 | 1649 | 235 | 2673 | 325 | 3697 |
| 56 | 637 | 146 | 1661 | 236 | 2685 | 326 | 3709 |
| 57 | 648 | 147 | 1672 | 237 | 2696 | 327 | 3720 |
| 58 | 659 | 148 | 1683 | 238 | 2707 | 328 | 3731 |
| 59 | 671 | 149 | 1695 | 239 | 2719 | 329 | 3743 |
| 60 | 682 | 150 | 1706 | 240 | 2730 | 330 | 3754 |
| 61 | 694 | 151 | 1718 | 241 | 2742 | 331 | 3766 |
| 62 | 705 | 152 | 1729 | 242 | 2753 | 332 | 3777 |
| 63 | 716 | 153 | 1740 | 243 | 2764 | 333 | 3788 |
| 64 | 728 | 154 | 1752 | 244 | 2776 | 334 | 3800 |
| 65 | 739 | 155 | 1763 | 245 | 2787 | 335 | 3811 |
| 66 | 750 | 156 | 1774 | 246 | 2798 | 336 | 3822 |
| 67 | 762 | 157 | 1786 | 247 | 2810 | 337 | 3834 |
| 68 | 773 | 158 | 1797 | 248 | 2821 | 338 | 3845 |
| 69 | 785 | 159 | 1809 | 249 | 2833 | 339 | 3857 |
| 70 | 796 | 160 | 1820 | 250 | 2844 | 340 | 3868 |
| 71 | 807 | 161 | 1831 | 251 | 2855 | 341 | 3879 |
| 72 | 819 | 162 | 1843 | 252 | 2867 | 342 | 3891 |
| 73 | 830 | 163 | 1854 | 253 | 2878 | 343 | 3902 |
| 74 | 841 | 164 | 1865 | 254 | 2889 | 344 | 3913 |
| 75 | 853 | 165 | 1877 | 255 | 2901 | 345 | 3925 |
| 76 | 864 | 166 | 1888 | 256 | 2912 | 346 | 3936 |
| 77 | 876 | 167 | 1900 | 257 | 2924 | 347 | 3948 |
| 78 | 887 | 168 | 1911 | 258 | 2935 | 348 | 3959 |
| 79 | 898 | 169 | 1922 | 259 | 2946 | 349 | 3970 |
| 80 | 910 | 170 | 1934 | 260 | 2958 | 350 | 3982 |
| 81 | 921 | 171 | 1945 | 261 | 2969 | 351 | 3993 |
| 82 | 932 | 172 | 1956 | 262 | 2980 | 352 | 4004 |
| 83 | 944 | 173 | 1968 | 263 | 2992 | 353 | 4016 |
| 84 | 955 | 174 | 1979 | 264 | 3003 | 354 | 4027 |
| 85 | 967 | 175 | 1991 | 265 | 3015 | 355 | 4039 |
| 86 | 978 | 176 | 2002 | 266 | 3026 | 356 | 4050 |
| 87 | 989 | 177 | 2013 | 267 | 3037 | 357 | 4061 |
| 88 | 1001 | 178 | 2025 | 268 | 3049 | 358 | 4073 |
| 89 | 1012 | 179 | 2036 | 269 | 3060 | 359 | 4084 |
| 90 | 1024 | 180 | 2048 | 270 | 3072 | 360 | 4096 |

The count above is that which is put out by the AZ/EL unit after conversion to the 4096 standard.

To identify what is coming out of the count routines before 4096 conversion take the count above and plug into the formula:

Observation

CountBeforeConversion = ((CountFromTable * CountinMax * 360) /4096)/DegSpread

Using our example above:

Deg on shack unit = 8

4096 count from table = 91

CountinMax = 1680

DegSpread = 103

CountBeforeConversion = $91 * 1680 * 360 / 4096 / 103 = 130$

If your calculator overflows doing this calculation change the order to:

$$91 * 1680 / 103 * 360 / 4096 = 130$$

What is wanted

Deg on shack unit = 9.6

4096 count from table = 108 (by extrapolation from table)

CountinMax = 1680

DegSpread = 103

CountBeforeConversion = $108 * 1680 * 360 / 4096 / 103 = 155$ (to nearest integer)

The difference between the wanted and the observed is 25 counts added.

Now the table is divided into blocks of 14 counts so working from the OBSERVED 130 counts $130/14 = 9.28$

So in the 9th block an error correction of 25 decimal or \$19 in hex is required.

The above approach is near enough to get you in the ballpark. Finer tuning may be necessary. If you use the reverse switch on the AZ/EL unit I refer you to Charlie VK3NX's description below.

It's over to you now, my brain is tired!

Charlie, VK3NX, describes below how he calibrates the error table

“I found the following procedure to be the best for me in calibrating:

First establish degree spread and count of set up then, referring to the above instructions, I work out the Max degree spread and Max count to plug into the EEDATA....these numbers are also utilised for the correction table. It is very important to take note of how many counts are associated with every error correction entry.

eg 1680 counts means every 14 counts there is an entry in error correction (1680 / 120), and if Max spread is 100 degrees then that equates to every $100/120 = 0.83333$ degrees

First I place 00 in all 120 entries in EEDATA. ie. no correction.

Then I use sun / moon noise to build data up “Indicated vs Actual” at least 1 reading every 1 degree or so of sun / moon travel.

A more sophisticated approach is to use 0.83333 degree from the above formula (so the averaging is more consistent) eg 0.4 degrees, then 1.2, then 2.0, 2.8, 3.6 etc.

Referring back to John’s technique and tables, all the equation conversions simplify as such:

Indicated count:

Real count = indicated count * Max count / Max degree spread

eg display says 21 degrees so Real count = $21 * 1680 / 100 = 352$

Real count wanted, let's say it should be 23 degrees, so real count for 23 degrees should = $23 * 1680 / 100 = 386$ (rounded to nearest integer)

Difference = $386 - 352 = 34$.

34 decimal = \$22 (hex) so at table entry $352 / 14 = 25.142$ie 25th entry we enter 22 into the EEDATA table.

What does this mean ? Well when the unit has gone through 352 counts, the code looks at the (352 / 14) 25th table entry and applies an error correction of +34 to our real count

That way our display will read the number we wanted.

NB: Some averaging occurs in the software based on the values above and below our specific location in the error correction table) so a couple of trials are required.

I have found that with one set of calibration figures every 1 degree for my 0-90 degree elevation set up, I was able to have the display reading within 0.2 degrees of the indicated elevation from the internal position locator of the sun/moon. I expect another 1 set of similar calibration points will land me within 0.1 degree.

REMEMBER...once you have applied 1 set of correction points to the table, any subsequent changes must add in the original amount of correction.

IMPORTANT POINTS:

1. Because the mechanical arrangement may potentially be non-linear do the calibration point measurements with the mechanical arrangement finalised.
2. If you plan to count in reverse then set the unit for reverse counting before gathering calibration data.
3. If you plan to use an offset in the "shack unit" then apply that to the shack control unit prior to acquiring your calibration data. Make sure your indicated offset is the TRUE beam/dish heading with your jackscrew at 0 count.
4. If counting in reverse, eg starting at 360 degrees and counting down remember to subtract the indicated count from the starting point to get the true amount of travel.

For example, on "shack unit"Az offset in value is -4 degrees so indicates 356 degrees as initial start. Calibration then says 340 degrees indicated and this equates to 344 true

$$356-340 = 16 \quad \text{and} \quad 356-344 = 12$$

Now we compare 16 and 12 as these figures are the real and wanted amount of travel / count required.

If the above is not done then you will potentially enter data into the wrong locations in the EEdata table.”

End of Charlie's description