

## **ENCODER CALIBRATION FOR AZ & EL**

### **PLEASE READ COMPLETELY BEFORE START OF CALIBRATION**

Install AZ encoder in the field to obtain 20,000 to 60,000 counts (If possible & practical), from 0 to 360deg. , Or 5 to 15,000 counts for 0 to 360deg. AZ when using the X4 mode on the encoder board. Or what ever is practical for your installation.

**NOTE:** Cable to the encoder's should be 4 wire, aluminum wrapped, with the drain wire grounded at each end.

If the direction of rotation is not correct "i.e." is CCW when it should be CW you can change this in one of a number of ways.

**A/** Switch (swap), the "A" & "B" encoder lines at the box input connector .

**B/** Switch (swap), the "A" & "B" lines at the encoder, etc, etc

#### **NOTE:**

Never operate U8 with pin 6 **NOT** connected in one of the following manners.

If you wish to use the X4 mode of the LS7084, U8, install a 100K-1/8W resistor between points "A" and "B" on the PC board near U8. If X4 mode is NOT required place a grounding jumper between points "A" & "C" near U8

Increasing the "encoder" counts by X4 does not increase system accuracy, but it does assist the math processing within the MPU. Also, if for any reason a stray count occurs at the input it has a much, much lesser effect if the processor is dealing with larger counts per degree. Try not to exceed 65 to 70,000 counts for full scale (360 degrees AZ), Anything between 20,000 and 65,000 is FB

**NOTE: DO NOT** operate U8 with pin 6 FLOATING unless you have a spare handy.

### **AZ Calibration**

- 1/ Rotate Dish, or Array, to a "0" (zero), degree location. This position can be any position that is convenient for you.....near your moon rise location for example. At this point in the calibration procedure it does not matter.
- 2/ Depress the "zero" push button, then depress the MPU "Reset", This operation clears the MPU registers and set the "touch memory" to zero.
- 3/ Using an accurate compass ( I borrow a surveyors compass and tripod ), rotate the Dish exactly 360 degrees from the "zero" position.  
If you chose to use "Half" span calibration, then rotate 180 degrees rather than the full 360 degrees.

For example: You can set the " zero" location somewhere near 80 degrees ( moon rise ??), for AZ. Using a surveyors compass, I then rotate EXACTLY 180 degrees, somewhere near

260 degrees.

- 4/ When 360 , or the 180, degree position is located, depress the ""Full" or "Half" span button, SW-3 or 4 on schematic. Again depress the MPU "Reset", SW-1 push button. This combination forces the MPU data registry to "touch memory".

You should now be calibrated "exactly" 0 to 360 degrees. Do NOT depress anymore buttons switches.

- 5/ Make sure your **computer clock** is accurate in both time and date before continuing. Computer clock should be within one second of correct time.
- 6/ Bore Sight the Dish, or Array, on the moon, using your echoes, listening to someone else's echo etc, etc. Write down the exact position of the moon on the a piece of paper. Disregard the position displayed at this time.
- 7/ Without moving the Dish, or Array, manually rotate the encoder SHAFT, so that the display indicates exactly the same position you noted for the moon location on the piece of paper above.( remember, the "moon" may not be at that location right now, because time has elapsed).

There are any number of ways to calibrate the exact heading, "ie" use the sun noise to peak on, using the compass select a object to point at, etc, etc.

I recommend using sun noise, or moon echoes, especially if you are using a dish. Because this method would automatically adjust for any **unknown** feed offset errors.

### **THE SYSTEM IS NOW CALIBRATED FOR AZIMUTH**

You may note on the schematic that I show an encoder built into the system for display position calibration. This is entirely optional. In my installation I use a spare encoder that I have for my TS-950SDX. And two DPDT spring loaded "off" min. rocker switches.

The same thing can be accomplished by simply using nearly any quadrature encoder, and installing a connector on it that will mate with the connector you use to land the field encoder devices.

Example: I use 5 pin Mike jack & plugs on my system to connect to the field.

Then to calibrate the display indicators simply disconnect the field encoder device and connect your shack spare encoder. After calibrating the display, reconnect your field encoder.

### **Brief Description of an ENCODER , Touch-memory & CALIBRATION**

You can think of an ENCODER as simply a potentiometer **without** an end stop.

Although there are many ways of achieving the same results , I will attempt to explain an encoder using "optical" devices, "ie" an infra-red "source" and "detector".

The Infra-source is usually in the form of an LED ( **L**ight **E**mitting **D**iode ), similar to those you might see in some piece of equipment you have to display perhaps power "on" power "off", etc, etc.

The infra-red detector is simply a transistor that allow electrons "i.e." current to flow when

exposed to the infra-source.

The encoder disk, or wheel, that turns this infra-source on and off, as far as the detector is concerned is just that, a disk.

The disk has, for this description, one thousand slits, or windows, laser cut, or stamped into the disk that allows IR (Infra-Red), energy to pass through to the detector. These windows are the same width as the distance between the windows.

These encoder's may have any combination of source and detectors, for simplicity we will use an encoder with two sources and two detectors. Each pair, source and detector, is assigned a channel number, i.e. "A" & "B", E1 & E2, etc, etc.

When the shaft of the encoder is rotated CW (clock wise), channel "A" will generate a square wave pulse that is approx. 5 VDC in amplitude. At "nearly" the same time channel "B" will start generating a square wave pulse. The pulse from channel "B" will actually be lagging, or following, the pulse generated on channel "A" by 50% of the positive "half" of channel "A" pulse, or **90 degrees** in "phase" relationship.

Remember, a full cycle of 60 Hz household electrical voltage equals 360 degrees, or 4 X 90 degree quadrants.

When the encoder shaft is rotated CCW, (counter clockwise), the phase relationship between pulse "A" and "B" is switched, "ie" pulse "B" is now 90 degrees ahead of pulse "A", rather than 90 degrees behind as stated for the CW direction of rotation.

A "quadrature counter" is a device that not only counts the number of pulses it receives, it also determines if pulse "A" is leading "pulse "B", or lagging pulse "B". By doing this it determines if it should be counting the pulse upward, or downward, forward or backward, subtracting, or adding, etc.

How the counter handles the pulses is pre-determined by the firmware (software), in the EPROM. In this case the counter, an 80C31, simply counts up, or counts down from a pre-determined number. The direction of counting is determined by U8, an LS-7084, which is simply called a "quadrature clock converter".

The LS-7084, quadrature clock converter, in this application, serves several purposes.

First it determines if the pulse it is seeing is a true quadrature pulse, it does this by checking to see if both pulse "A" and "B" are present. If they are not, or not in a correct relationship to each other the pulse is ignored and not counted at all, in either direction.

If both "A" and "B" pulses are present, and have a correct relationship, the LS-7084 then determines which pulse is leading, or lagging the other. By doing this it knows if pin 7 should be set "high", approx. 4.8VDC or "low", approx. 0.4VDC, and it will also generate an output pulse at pin 8.

If pin 6 of U8 is connected via 100K resistor to the VCC line, U8 will output a pulse for each "rising" and "falling" edge of the two channel pulses, "ie" "A" & "B" each have a "rising" and a "falling" edge..... $2 \times 2 = 4$ . Hence the so called X4 mode of operation.

The output pulse at pin 8 on U8, is a negative going pulse, so it has to be inverted, "i.e." turned upside down, to become a positive going pulse. This operation is performed by U7, an inverter. U7 is much more than an inverter, but for this demonstration just consider it a simple inverter.

This inverted pulse produced a pin 8 of U8, is inverted as above, then applied to pin 12 of U1,

the 80C31 MPU (Micro Processor Unit), quite often called a Micro-Controller.

The MPU, 80C31 will count the pulse either up-ward, or down ward depending on the condition on pin 14 of U1. If pin 14 is high the pulse is added, if pin 14 is low the pulse is subtracted from the counts in an internal registers.

When the MPU, by instructions from U3 the 27C256 EPROM, has converted these pulses To a useful number, "i.e." a number that represents an AZ or EL position it converts these serial (one pulse following the other), pulses to 16 bit wide parallel data, that number is now "clocked" to the output registers, or latches, the 74HCT573's, U4 & U5.

These latches can be considered doors that are opened by the presents of a voltage at pin 11 on the device, one pin 11 at a time.

The outputs of these 74HCT573 devices are either "high" or "low" depending on the state U1 set them at.

At the same time, or nearly the same time, U1 "writes" data to the output latches it also "writes" the same data to the "touch memory" device.

This DS-1992 "touch memory" device is very similar to the hard drive on your computer, it can be formatted, directories made on it, deleted from it, files stored in the directories, files deleted form directories etc, etc.

The only feature of the device that is used in this application, after it is formatted, is what is called the "scratch pad", or if you wish the "root" directory.

If a new device is installed, for whatever reason, the very first thing that happens, is the "touch memory" get formatted, no directories, just formatted. The MPU will first think that there is no "touch memory" connected. It will then attempt formatting the device, if formatting is successful everyone is happy, if formatting is not successful the MPU comes to a complete stop, the end.

While not shown on the latest schematic, you can if you wish, connect via another inverter section on U7 (pin 1 "in" pin 2 "out"), pin 11 of U1 (TXD), directly to a com-port on your computer.

Then using nearly any communication software (pro-Comm, etc), on your computer you can monitor the formatting event, but only when formatting is NOT successful. If formatting is not successful the output on pin 11 of U1 will simply ask you to install "touch memory".

Rather useless, since I have never seen an UN-successful format, if the "touch memory" is installed.

The line from pin 15 on U1 to the touch memory will always be sitting at approx. 4.8VDC, assuming no action (pulses), is occurring at pin 12 of U1. Each time U1 updates the output latches there will be data appearing at pin 15 of U1, in the form of negative going pulses. Also if you depress the MPU "reset" switch you MUST see data being written to the touch memory.

All data written to touch memory will be retained by the touch memory, until it is overwritten by the next update from U1. The touch memory will also retain any data it has on the internal "scratch pad" AFTER power (VCC), is removed. This is where U1

Will look for data when VCC is reapplied.

When VCC is reapplied the last valid data written to touch memory will be, after a request from U1, be written BACK to U1.

Simply stated, this is how the “encoder board” knows where your dish, or array, was pointing when you shut the system down last. From here on you might want to say that I was not entirely truthful earlier when I said that we did not make directories in the touch memory, well really we don't. Let's just say the drive was partitioned, except we call partitions pages, rather than additional logical drives, D: E: F: etc.

When formatting occurred, there was four (4), pages in memory (touch memory) established. Each page being 256 bytes in size for a total of 1024 byte's of memory in the DS-1992. The “scratch pad” uses the first page of 256 byte's, the second page in touch memory is used to store a number that is placed there when you calibrate the system.

During calibration, when the “zero” switches is depressed, page 2 is wiped clean, “i.e.” set to zero counts. When you position your dish, or array to the desired heading and depress either the “half”, or “full” span...NOT both.... That number (data), is written into page two of touch memory. As long as no calibration buttons are depressed that data will remain in touch memory for the live of the touch memory cell, which is approx. 10 years.

Yes, there is a very small “lithium” battery within the touch memory cell itself.

And NO, you can NOT discharge that battery by shorting the two cell case components. From the outside it may look like a” lithium” battery, but it is NOT, hi.

### **EL Calibration:**

There are at number of techniques for indicating, displaying, and or controlling, elevation using this system.

You can simply add a second encoder if you use a “jack screw” to elevate. You can enclose a small encoder into a TVRO actuator arm, etc, etc, etc.

If these approaches are used then nearly the same procedure for calibrating the AZ can be used.

If you have decided to use an Inclinometer (an encoder without an output shaft), tilt sensor, etc. (As long as the device generates TTL (+5VDC), level linear, quadrature pulses as described above). Select the calibration procedure below that is required for the EPROM you are using for EL.

### **BCD-EL Code. As used with 7 segment display and, or the VK3UM Tracking System.**

Locate the tilt sensor on the dish, or array, so that it rotates in a linear manner as the system is elevated. Depress the “zero” switch, then the “reset” switch as was done earlier for AZ. Now elevate the system to EXACTLY 45 degrees for “half” span calibration, or EXACTLY 90 degrees for “full” span calibration. There are many methods of doing this, so it will be left to the user as to what method is used.

Try to be as accurate as possible at the “zero” degree position and the elevation position you chose to calibrate too. Again, if you are using a tilt sensor (Inclinometer), the zero position does NOT have to be “zero” degree elevation. It can be - 10 degrees, but now “full” span MUST be at 80 degrees elevation.

Once you are happy with the calibration, simply calibrate the “display” in perhaps the same manner used for AZ.

## **Binary-EL calibration, as used with the F1EHN Tracking System.**

There is really very little difference between this calibration procedure and the one just performed above; exactly the same rules apply. The major difference is in how the tilt sensor is manipulated. In fact both the above procedure and this procedure could have been performed indoors out of the rain, snow, ice, wind, etc that you may now be working in. Perhaps HOT sunshine

Position the tilt sensor so that it can be rotated EXACTLY 360 degrees. Depress the “zero” switches, then the “reset” switch. Now rotate the tilt sensor EXACTLY 360 degrees and depress the “full” scale switch. You can perform this operation as many time as you feel you need to, too feel secure that it is accurate.

When the rain has stopped, or the ice has melted, take the tilt sensor, perhaps in a box of some kind, out to the dish and attach it to the system using tape, bolts, tie-wrap, or whatever is available. Try to install the unit so the rotation of the unit is as near a right angle with the plane of the elevation axes as possible, but it is NOT critical.

Now calibrate the display in perhaps the same manner as was used for calibrating for AZ.

**CAUTION: Do NOT depress the “zero”, “half” or “full” calibration switches again, unless you decide to re-calibrate, or you have an identical spare in the shack. You can depress the “Reset” switch all you wish, all it will do is restart the MPU, it will not force a “write” too “touch memory” page two.**

Someone asked sometime ago what the advantages of an “encoder” were over other techniques Of measuring, or controlling dish, and array headings ...If you have the same question, please read this procedure again and really think about it.

Hope you have as much trouble free success and fun with the system as I have had over the past few years

Many Thanks & GL. If you need assistance, or detect errors, please contact me, I will try to help, and or, correct as best I can.

[Encoder Boards may be obtained from FAR Circuits](#) See Silkscreen & Schematics Below

**Darrell, Ve1ALQ**  
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QUADRATURE LINEAR  
ENCODER TO 16 BIT  
PARALLEL BINARY OR  
BCD DATA. BY  
VE1ALO  
REV. 3. 1997

C15

7 6 5 4 3 2 1 0



C9

8 7 6 5 4 3 2 1 0



C16  
C17  
XTAL

+C12



C10

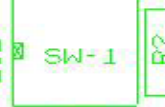
14 13 12 11 10 9 8 7 6 5 4 3 2 1 0



C18



C14



RESET

R3



R4



R5



TOUCH MEMORY



C14

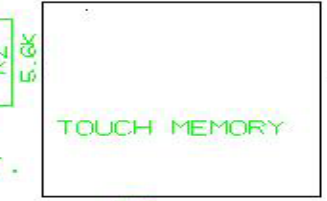


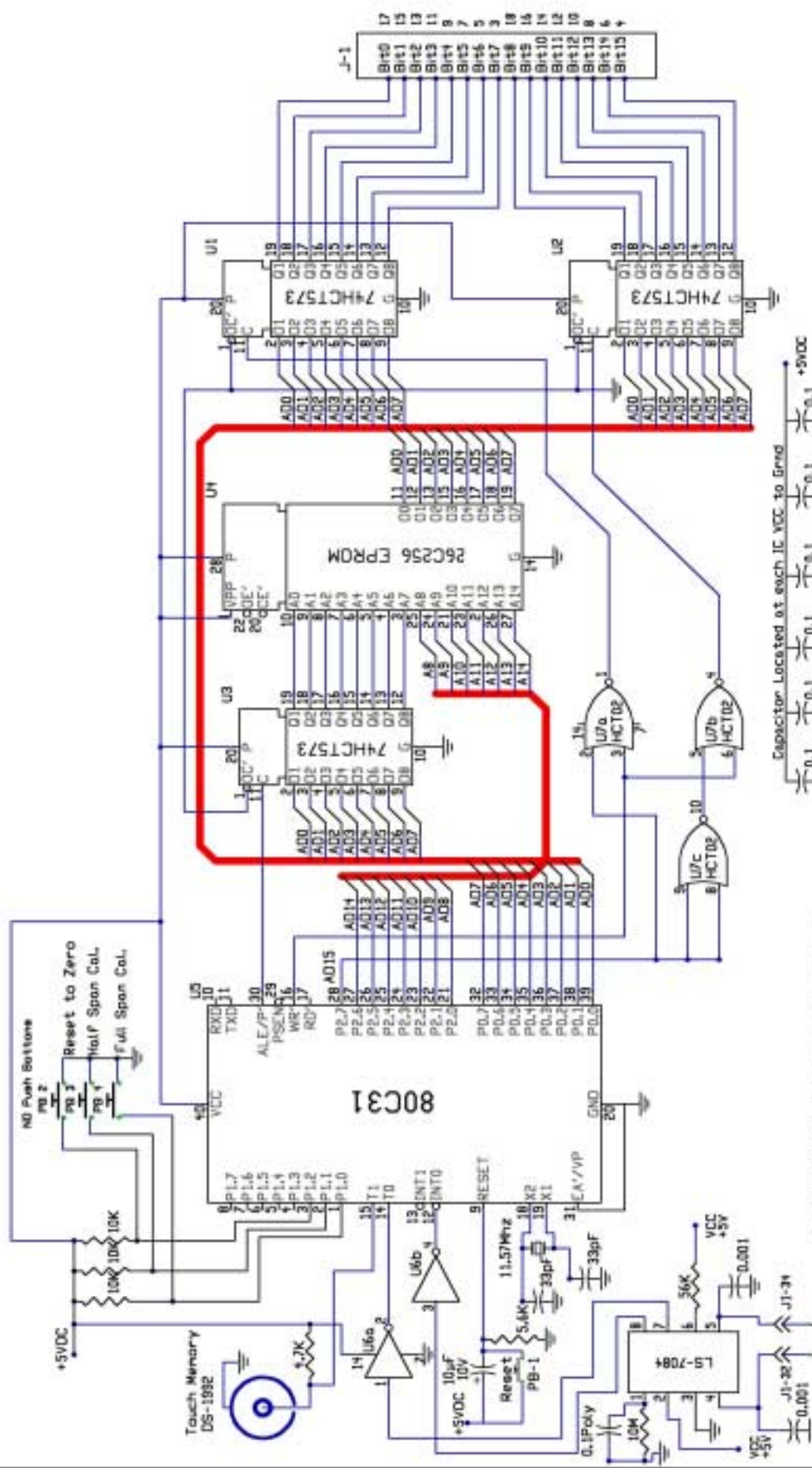
C4

+C1 +C2 +C3

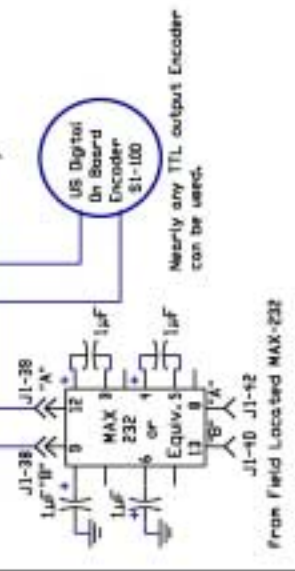
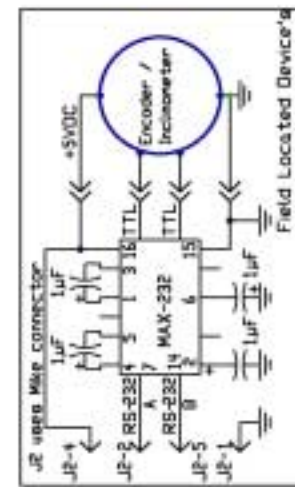
R2

5.6K





Capacitor Located at each IC VCC to GND



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 Board: Linear Encoder to 16 Bit  
 Author: Darrell G Ward REV: B1  
 Date: Aug 2000 Sheet 1 of 1

From Field Located MAX-232

Nearly any TTL output Encoder can be used.

To Second DPDT Switch on EL or AZ Board





