

Using a US-Digital MA3-P12 rotary magnetic encoder with the VK5DJ Beam Indicator Project

The MA3-P12 (abbreviated to MA3 in this document) is a small device intended to provide a pulse width modulated 0-5V level signal that may be used to indicate direction in a count of 4096 positions.

See <http://www.usdigital.com/products/ma3/>

Accuracy is quoted as +/- 0.5 degree with a possible error to +/- 0.9 degree in high temperatures. The error could be as much as 5% if only the pulse width was measured as this is the accuracy of the internal oscillator. However my software calculates the duty cycle which cancels out any errors resulting from oscillator drift.

The MA3 requires a 3 pin Molex connector. I recommend buying the pre-assembled connector with an appropriate length of 3 core wire as the connectors are quite hard to solder. The connections for the encoder are very clearly marked.

Pin 1 is +5V DC at approx 20mA.

Pin 2 is PWM out (0-5V) at a frequency of approximately 244 Hz.

Pin 3 is 0V common to power and PWM.

The encoder is used with the VK5DJ Beam Indicator project's AZ/EL unit. See my website for PCB ordering and costs. <http://vk5dj.mountgambier.org/Beam/Beam.html>

The wiring/components of the AZ/EL units are identical for all variations of the input device (MA3, screwjack, AS5040/45 or the AH-05 devices). Only the software for the 16F628/16F648A varies. The AZ/EL unit is not needed for the potentiometer solution.

Connections

The 3 wires from the MA3 are attached to J1 of the AZ/EL board as follows:

MA3-P12 encoder (PWM output)	J1 connector on AZ/EL unit
1 (+5V)	1 (+5V out)
2 (PWM out)	4 (PWM in)
3 (Earth – 0V)	2 (Earth)

Load the software into the PIC (either 16F628/A or 16F648A) remembering to set your programmer for the correct PIC and ensure that all Code/Data/Config locations are programmed into a blanked chip.

Note there are 3 values programmed into the bottom of EEDATA. At location 0 there should be a '00', at location 1 there will be a '0D' and at location 2 there will be a '0B'.

The first value at location '0' sets the AZ/EL unit for normal use. See more on this later.

The value at location '1' (default '0D') sets a multiplier adjustment while the value at '2' (default '0B') sets a figure to be subtracted from the pulse width.

The latter two items are necessary because of the need to fine tune timings as a result of differences in the way each encoder unit responds and, allow for the fact that even at zero degrees there is a short pulse. The duty cycle never quite reaches 0.

To assist your understanding of the problem, the calculated duty cycle is normally multiplied by 4096 to produce a number that represents the 4096 steps. To correct for the above factors the 'multiplier' in EEDATA position 1 is added to 4096 to re-establish a 360 degree spread of readings once an adjustment is made for a non-zero starting point.

The duty cycle is always less than unity. Here is an example of how this affects things. The default values are used for illustration. The value '0D' is added to 4096 to create a modified 'multiplier' equal to 4109. This modified number is multiplied by the duty cycle. Conversely, the pulse width is always greater than zero. To compensate, there is a subtraction correction factor. I'll call it the 'subtractor'** and it is used to create an adjusted zero reference.

The method then becomes:

1. measure the pulse width in timer1 counts (for example 476 counts)
2. measure the period in timer1 counts (for example 7000)
3. subtract the 'subtractor' from the pulse width to achieve a zero correction
For example a pulse, 476 counts wide, becomes $476 - 11 = 465$ as the modified pulse width.
4. add the 'multiplier' to 4096 to form a 'modified multiplier' to give a full 360 degrees coverage.
5. multiply the modified pulse width by the modified multiplier eg. $465 * 4109$ and divide by the period (7000) to give a number corrected to 4096 counts represented by the original duty cycle of $476/7000$. In this case the resulting number would be 273 in a scale of 0 to 4095 (or 24.0 degrees, a correction of about -0.5 degrees).

In practice it may not be necessary to change the values at EEDATA positions 1 and 2 but I have been unable to test multiple devices.

To identify if you need to adjust these values proceed as follows. Set the 'shack unit' so that Averaging is OFF. Once the system is working on the bench, rotate the encoder so that it is at the change over from 0 degrees to 359.9 degrees.

If this changeover 0 to 359.9 and vice versa is as you expect, smooth and no obvious delay/gap then leave the values unchanged. Otherwise use this table as a guide, repeating until you have a nice smooth transition at the 0-359.9 point.

** Please forgive my invented word 'subtractor' as the correct word 'subtrahend' would have everyone diving for the dictionary, myself included.

Result	Multiplier at posn '1'	Subtractor at posn '2'
Option 1: Degrees won't go to zero		Each 0.1 of a degree equates to about 1. Increase value of EEDATA by one for each 0.1 of degree.
Option 2: Degrees don't reach 359.9	Each 0.1 degree equates to about 1 unit. Increase value of EEDATA by one for each 0.1 degree	
Option 3: Dead area between 0 and 359.9 with a steady 359.9 or 0 beyond what you would expect.	Decrease value of EEDATA by 5. Repeat option 3 until you see a non dead area between 0 and 359.9 and then go back to the first two options to reach desired result.	Decrease value of EEDATA by 5. Repeat option 3 until you see a non 0 minimum and then go back to the first two options to reach desired result.

Although this procedure seems complex you get a feel for it after a while. I had to reburn the PIC and use this strategy about 5 times before I reached the default values. I did both options 1 and 2 simultaneously and it saved some burns, but my short cut method is a little more error prone. Once done you will never have to do it again. Don't forget that the EEDATA values must be in hex notation.

The switches on the AZ/EL unit perform slightly modified functions for this piece of software.

If SW1 on, rotate all readings by 180 degrees

Some users may have a specific requirement to add 180 degrees rather than rotate the encoder mount.

If SW2 on, use terminal mode and send data to terminal program on computer

If a zero in location 0 of EEDATA then the AZ/EL unit outputs an ASCII string beginning with a 'A' which may be read at 9600baud, 8data bits, 1 stop bit, no parity by any terminal program providing that your serial port will respond to TTL levels.

If there is a 1 or any other non zero value in location 0 of EEDATA then the AZ/EL unit outputs an ASCII string beginning with a 'E' which may be read at 9600baud, 8data bits, 1 stop bit, no parity by any terminal program providing that your serial port will respond to TTL levels.

The distinction between 'A' and 'E' is to help anyone who wants to write some software and distinguish between two units feeding data into a computer serial port, one being an 'A' zimuth unit, the other an 'E'levation unit.

If SW3 on, reverse count for alternate mounting.

Normally the count increases clockwise but this may be made to increase in an anti-clockwise direction when viewed from the front of the encoder. Some users may find it solves a mounting problem to be able to change the direction of rotation.

Summary

When using this software with a US-Digital MA3-P12 the shack unit must be set for 12 bit operation for the appropriate azimuth or elevation encoder.

The MA3-P12 costs US\$34 each. Be wary of freight costs if you live anywhere other than the US. You are likely to receive a large carton designed for hundreds of units with a proportionate cost. Check the freight cost with US-digital before ordering. They will try to help you. There are a number of models so make sure you buy the 12 bit, PWM unit. You will not need the roller bearing version for the speeds and number of rotations involved.

I am impressed with the MA3. It works very smoothly and should be an excellent choice for satellite work and EME work on the lower frequencies where beam width is 1 degree or more. The readout will suggest 0.1 degree accuracy but keep in mind that the device is rated at +/- 0.5 degree.

Enjoy,

John
VK5DJ
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