Celera MOTION
A Novanta Company

Micro Motion Absolute, Technology Overview & Programming

REV200323

THE CHALLENGE

Incremental encoders provide position change information therefore, the actual position is unknown at startup. Separate from the scale incremental track, an index/marker defines the zero position of the device. At startup, the system must execute a "homing" move to detect the encoder index. Depending on the initial position relative to the index, the homing move may be a long distance requiring a significant amount of time, particularly in situations where high gear ratios are used between the encoder and motor. Homing can be eliminated by using absolute encoders. Absolute encoders are, however, typically much larger devices and can be more expensive.

THE SOLUTION: MICRO MOTION ABSOLUTE

Micro Motion Absolute (MMA) technology combines the small size and cost-effectiveness of an incremental encoder with the ability to acquire absolute position. MMA is an OEM solution that employs standard MicroE optical encoders with MMA-specific scales. A decoding algorithm enables the calculation of absolute position with minimal movement at startup. The decoding algorithm must be implemented by the customer unless a Celera Motion Ingenia servo drive is used.

HOW MMA WORKS: THE INDEX SCALE

In addition to the incremental main track for position decoding, the encoder scale incorporates a second track with multiple index marks, arranged in a specific pattern across the full range of motion. MMA employs distance coded index marks - the spacing between any two consecutive index marks is unique to that pair only. In Figure 1 below notice how the separation between index marks gets larger and larger as you travel around the scale clockwise.

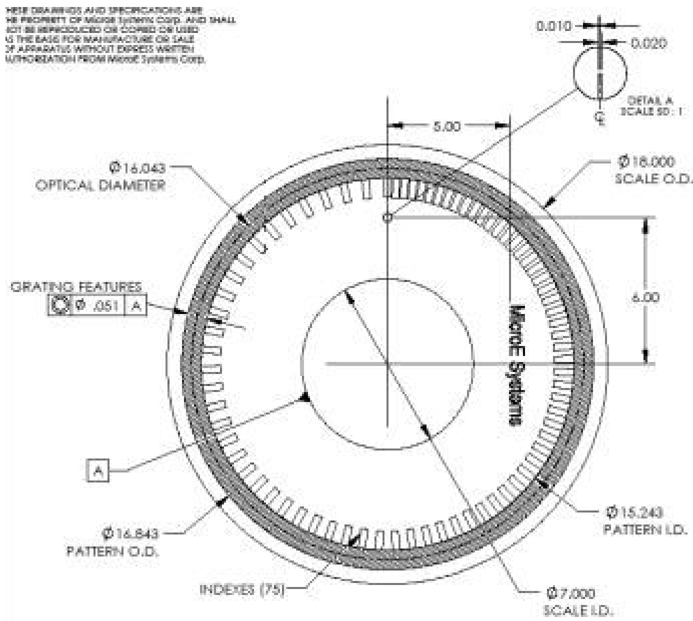

Figure 1

At the end of the path of travel, larger scales will have larger distances between index marks than smaller scales. The maximum size of the initial homing movement, or "bump," is equal to the greatest distance between two consecutive index marks. For linear scales, this maximum bump size gets larger when larger scales are used, but for rotary encoders, the maximum bump size *in degrees* actually decreases when scales with larger diameters are used. See the table below for comparisons between scale size and maximum bump size.

Optical Diameter	Max Bump
0.5 inch	8.0°
1.0 inch	5.4°
2.0 inch	3.7°
3.0 inch	3.0°
4.0 inch	2.6°

Linear Travel	Max Bump
50mm	1.0mm
100mm	1.4mm
500mm	2.9mm
1000mm	4.1mm
2000mm	5.7mm

HOW MMA WORKS: THE ALGORITHM

The output signal from the decoding of the index scale is a digital signal, which is approximately one period wide. The period is either 20 µm or 40 µm wide depending on which sensor model is used. The signal is high when the detector is over an index mark and low when it is not. This digital signal is called the Index Window. The variables in the algorithm are explained below.

AP =	Absolute Position
IW =	Index Window signal level
RP =	Encoder position Relative to the Position at power up (position 0)
SII =	Starting Index Increment
II =	Index Increment
DI =	Distance between Index marks
RE1 =	Index 1 Rising Edge
FE1 =	Index 1 Falling Edge
RE2 =	Index 2 Rising Edge
FE2 =	Index 2 Falling Edge
CIP1 =	Index 1 Center Position
CIP2 =	Index 2 Center Position

For a distance coded index scale, the spacing between each index mark will have a starting index increment (SII), with each proceeding mark having an additional index increment (II) added to the previous distance between index marks (DI). So the first index is at position 0, the next index is at position SI, the next index is at position SII + II, the next is at position SII + 2*II, etc.

The MMA algorithm is:

1. Power up the encoder. The encoder position at power up is position 0. Once the encoder moves, the encoder position relative to position 0 is RP.

2. If the Index Window signal level (IW) is high at power up, move the encoder until the signal goes low.

3. Move the encoder in any direction until there is a transition in IW from low to high and back to low. Record RP for the IW rising edge (RE1) and falling edge (FE1) for index 1.
    a. A valid index window width must be between 0.5 * the fundamental period of the encoder and 1.5 * the fundamental period of the encoder. If this is not the case, the signal should be ignored, and the control system should keep searching for the next index signal.

4. Move the encoder in the same direction until there is another transition in IW from low to high and back to low. Record RP for the IW rising edge (RE2) and falling edge (FE2) for index 2.

   a. A valid index window width must be between 0.5 * the fundamental period of the encoder and 1.5 * the fundamental period of the encoder. If this is not the case, the signal should be ignored, and the control system should keep searching for the next index signal.

5. Calculate and record the center index position for each of the two index marks (CIP1 and CIP2)
   a. CIP1 = RE1 + ((FE1-RE1) / 2)
   b. CIP2 = RE2 + ((FE2-RE2) / 2)

6. Calculate the distance between the two index marks (DI)
   a. DI = CIP2 – CIP1

7. A table will be provided with each scale which contains the absolute position (AP) in counts for each index mark and the associated DI for each index.

8. The AP of the two index marks may be determined by matching up DI with the closest value in the scale index table.
   a. Due to encoder alignment and scale run out on rotary scales, DI will not necessarily match any of the table entries exactly, so rounding to the closest value is valid.
   b. The DI should be within the scale index table range (smallest DI in table to largest DI in table) to within +/- 0.5 * II. If it is not within that range, return to step 2 and find two more index signals.

9. Once the AP of the index marks are determined, the AP of the encoder may be determined:
   a. Encoder AP = (RP – CIP2) + Index 2 AP
   b. It is important that the encoder does not move during this calculation, so the position value of (RP – CIP2) is not variable

Additional robustness may be added by detecting more than two indexes at start up and real time monitoring of the absolute position is possible by continuously monitoring the location of the index marks and comparing the calculated absolute position values to the incremental counter.

INTEGRATING MMA

An MMA product requires an MMA scale, a read head with index window output, and decoding software which contains the MMA look up table. As each customer's requirements vary, there is no set of standard scales or encoder systems which include MMA technology, requiring that each new application of MMA will be engineered and developed for the specific purpose detailed by the customer.

CONCLUSION

Micro Motion Absolute provides a cost-effective way to report absolute position at start up with minimal movement by the decoder. Celera Motion looks forward to evaluating the application to determine if an MMA OEM solution is a fit for the requirements.