SubArc: An Inexpensive, High Resolution, Open Source, Absolute Magnetic Rotary Encoder

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High resolution absolute rotary encoders are essential to precision applications like tracking telescopes, semiconductor manufacturing, low-tolerance machining, and robotic mechanisms. However, high-end encoders are extremely expensive ranging from hundreds to thousands of dollars for those with 20 to 22+ bit resolution, respectively. The cost and proprietary information barriers of these encoders prevent independent researchers, small institutions, and others with limited budgets from researching, developing, and using precision equipment. To address this issue, a novel, low-cost, customizable, open source, high resolution, absolute magnetic rotary encoder was invented with a similar performance and environmental robustness to the high-cost counterparts. The final engineering goal was to create a base prototype, easily modifiable to further increase resolution, for less than $40, with a calibrated 20-bit resolution, sub 150 arcsecond accuracy, sub 3-in diameter, and ability to compensate for fluctuating temperatures and external magnetic fields. After much iteration and tuning, the final design successfully had a 20-bit resolution with detectable +-10 microtesla changes per tick. The average accuracy was successfully under 150 arcseconds at 0.0384 degrees with a standard deviation of 0.0308 degrees in comparison to the calibration encoder. Temperature, external magnetic field, and encoder mounting compensations were all successfully integrated. The unit cost was $24.84, and the diameter was 2.17 inches. Finally, high-precision robotics is now accessible, and robotics and manufacturing companies can save millions and reduce prices with the successful encoder design made open source for any person or entity to replicate, modify, and use.

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