ELECTRIC DRIVE POSITION SENSING FOR UAM/AAM/EVTOL APPLICATIONS

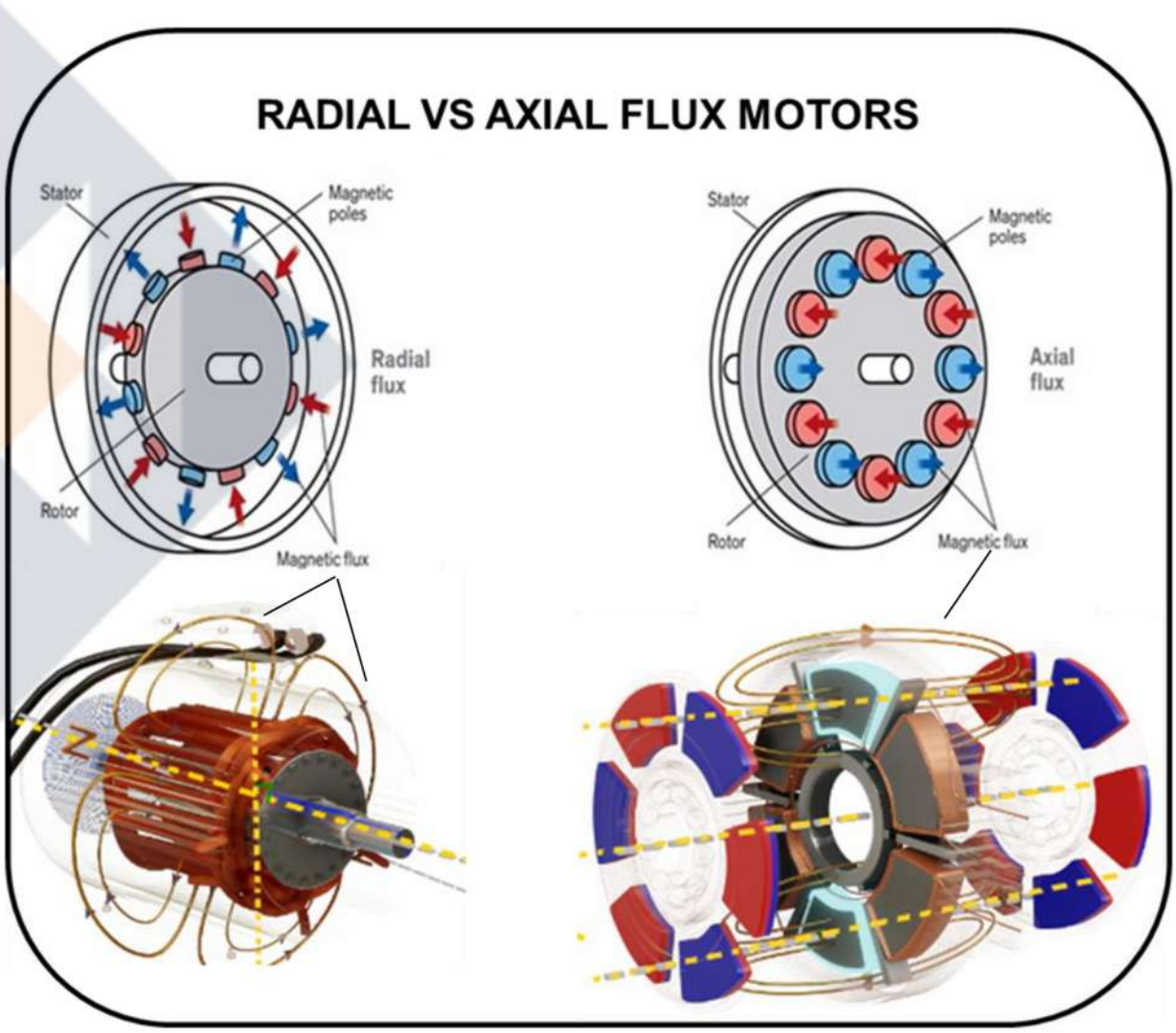
The adoption of electric motors (e-motors) in UAM / AAM / EVTOL electric vehicles (EVs) requires accurate, low profile position sensing to achieve the efficiency that axial flux e-motors are capable of. This paper discusses how Sensata's Electric Drive Position (EDP) sensors can provide an effective means of achieving position sensing for the demanding needs of these aerospace EVs.

Sensata Technologies

INVENTECHS

WHAT IS AN E-MOTOR IN AEROSPACE APPLICATIONS?

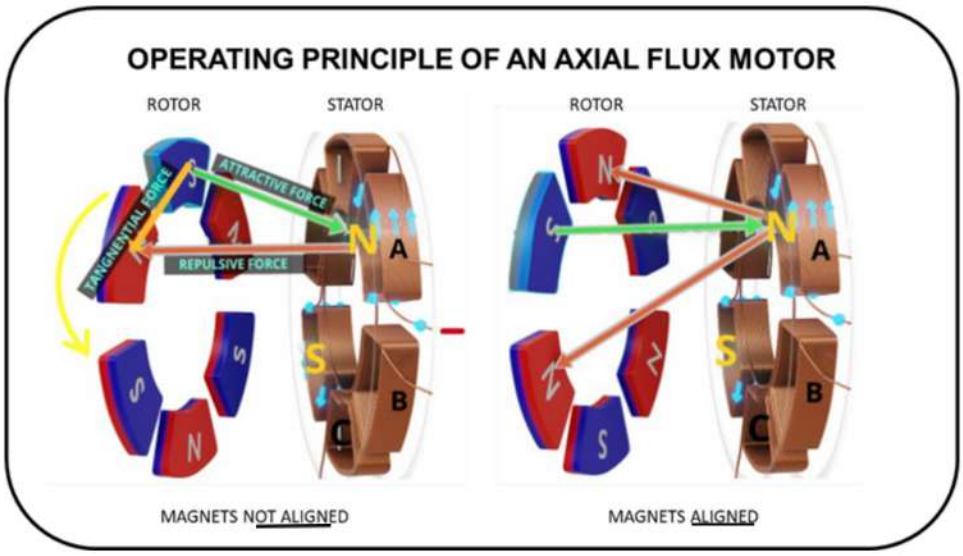
Several emerging UAM/AAM/EVTOL EVs utilize axial flux e-motors in their new applications. An axial flux e-motor (also known as an axial gap motor, or pancake motor) is an e-motor technology where the gap between the rotor and stator, and therefore the direction of magnetic flux between the two, is parallel to the axis of rotation. Conventional e-motor magnets are radially oriented.



In the radial flux e-motor, the magnetic flux has a 2-dimensional path. Thus, non-grain-oriented electrical steel (NGOES) must be used in these motors. In the axial flux e-motor, however, the magnetic flux path is unidirectional which allows the use of grain-oriented electrical steel (GOES). Due to the higher permeability of GOES, the iron losses in an axial flux motor can be reduced, increasing motor efficiency.

HOW DOES AN AXIAL FLUX E-MOTOR WORK?

Axial flux e-motors utilize the interaction between permanent magnets on the rotor and coils on the stator. When magnetic poles in the rotor and stator are NOT ALIGNED, coil A in the image below is energized with DC current. The south (S) pole of the rotor is attracted to coil A's north (N) pole. Simultaneously, the N pole past A repels the N pole at A. The resulting tangential force moves the rotor in this stage of motion.



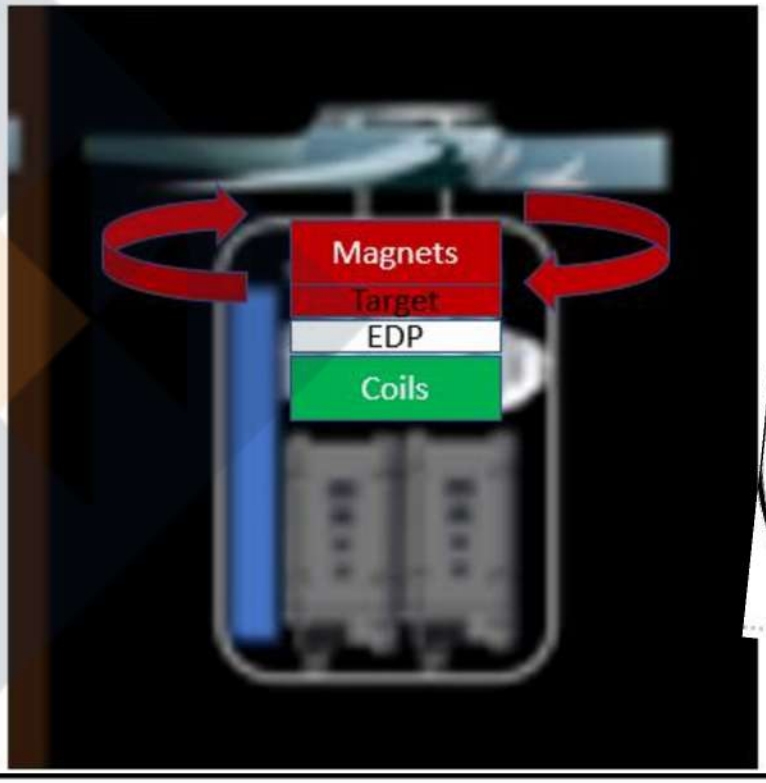
In the next stage of motion, the rotor's S pole is ALIGNED with the N pole at coil A. The net force acting on the permanent magnet becomes zero, but inertia causes the rotor to continue its travel ahead of the energized A coil. The A coil is then de-energized while the B coil is energized, and the same forces during misalignment continue to move the motor to C, and so on. Precise measure of the e-motor's angular position at any given moment is necessary to provide DC energy pulses with the right timing to generate high efficiency rotation and torque.

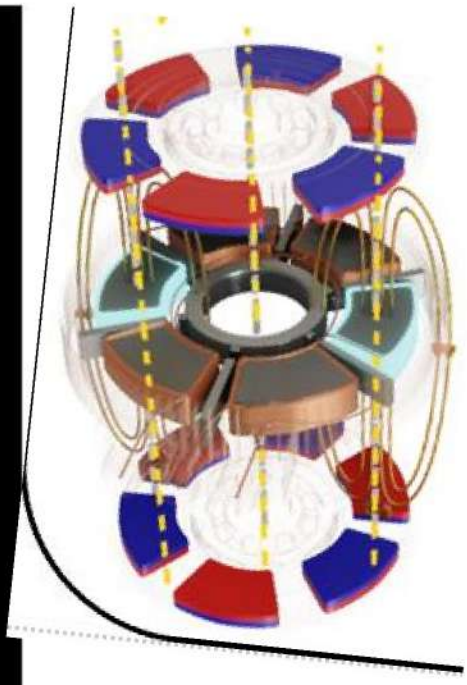
A comparison of axial and radial flux e-motors shows that for the same output, the axial flux e-motor has a larger diameter, but a substantially lower profile (active length) and mass as shown in the chart below. The low mass and low profile make the axial flux e-motor an attractive choice for aerospace UAM/AAM/EVTOL EV applications.

SENSATA AEROSPACE EDP SENSORS ARE ACCURATE E-MOTOR POSITION SENSING SOLUTIONS.

Sensata's EDP sensors consist of sinusoidal traces built into a printed circuit board, encapsulated, housed, and attached to the e-motor's stator. A thin steel or aluminum target is attached to the rotor. The closeness of the rotating target generates eddy currents detected by the coils of the EDP which form the basis of the position measurement.

Conventional radial flux e-motors use resolvers to measure angular position. Resolvers are wound components constructed like an e-motor. Resolvers are shaft mounted and tend to have a higher profile and weight. They do not have onboard electronics for signal processing.





EDP ROTARY SENSOR VS RESOLVERS

EDP ROTARY SENSOR

EDP ROTARY SENSOR TARGET

RESOLVERS

Sensata's EDP sensors have many advantages over resolvers in aerospace applications aside from their low profile, and low weight.

- True power on sensor with superior accuracy delivering optimum motor efficiency
- ≤ ± 1° electrical accuracy over life at nominal tolerance conditions
- Independently powered and grounded, redundant, dual channels
- Integrated signal processing eliminates the need for expensive and heavy sub-systems
- Immune to stray magnetic fields without shielding
- Light-weight, low profile, and flexible packaging that can be easily adapted to custom:
    - Pole-pair count
    - Motor diameters
    - Connectorization
    - Optional air cavity temperature sensors
    - Mounting for Axial and Radial Flux E-Motors
- Contactless and magnet-free solution
- Environmental robustness improves overall quality and system longevity. Resilient to:
    - Vibration
    - Dust and humidity ingress
    - Oil and wear debris exposure
- Electronically conductive target for eddy current generation

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