thin gap

Technology Brief

Understanding Torque Ripple and its Impact on Coggless Motors

Non-sinusoidal torque-versus-angle curves cause a non-linear phenomenon, known as "torque-ripple"

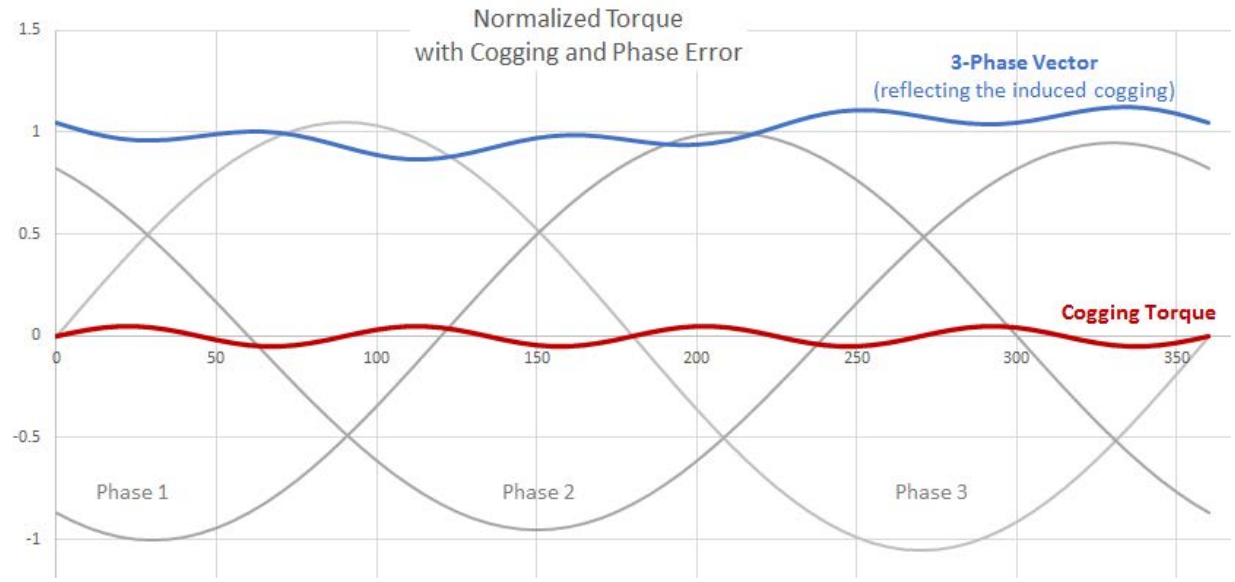
Continuous sinusoidal commutation produces optimal results by minimizing torque ripple, but only if the motor is free of higher order harmonics that can be influenced but cogging torque and phase imbalance.

August 2020 – ThinGap's aerospace, medical and industrial customers demand high-torque, high-efficient, yet zero cogging motor solutions. Zero-cogging is a key and inherent feature of ThinGap's precise stator wrappings and slottless architecture. But beyond the motor's core design, in order for customers to achieve the performance advantages of smooth, coggless motion, integration factors like drive electronics need to be considered. Torque ripple is one important factor to be aware of.

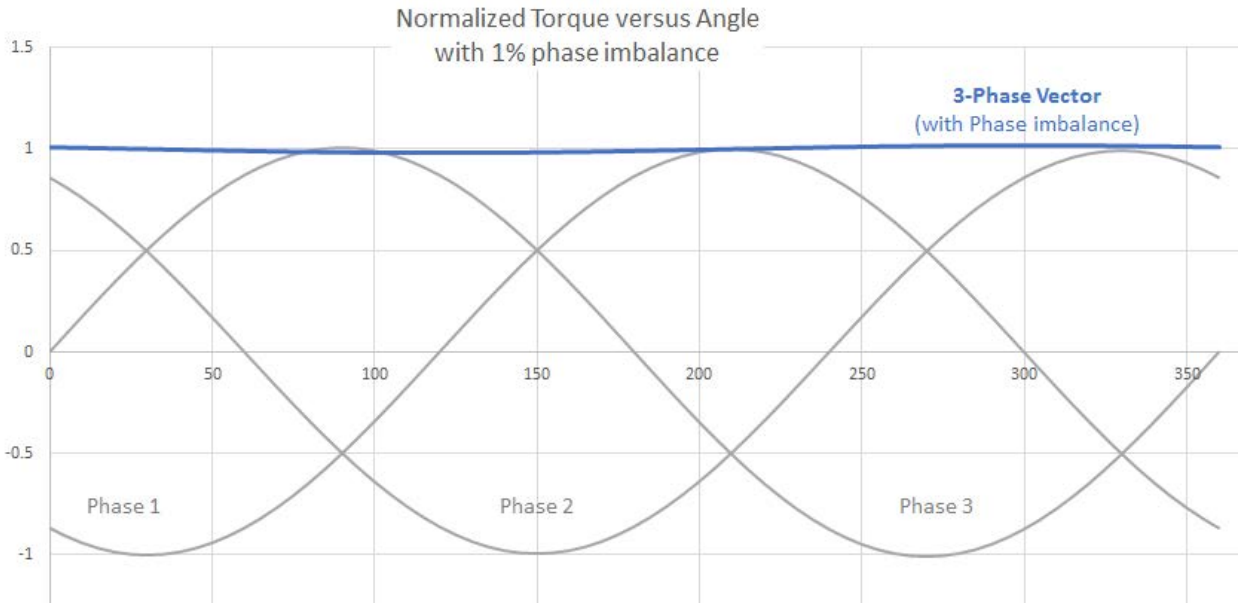
Central to the zero-cogging feature of ThinGap motors is the relationship between torque, current, and angle. The torque of each permanent-magnet synchronous motor is proportional to both current and angle. Typically, there are three electrical phases separated by 120 electrical degrees. The torque versus angle relationship for each phase is generally sinusoidal in shape, thus making these motors compatible with motor controllers producing sinusoidal current control or field-oriented control. Continuous sinusoidal commutation produces optimal results by minimizing torque ripple.

Torque versus angle curves will be non-sinusoidal as a result of cogging torque, (un-energized detent positions), and phase balance errors, (in angle and amplitude). When driven by a sinusoidal current from a servo drive, non-sinusoidal torque versus angle curves cause undesirable variations in torque production that interfere with smooth motor rotations. The result of this phenomenon, known as torque-ripple, is a non-linear torque production. Below is an example of motor with both cogging torque and phase imbalance of 5%, it represents a typical motor available on the market.

The blue line indicates the type of torque ripple that will be induced as the motor is run with a sinusoidal motor driver.



The benefit of ThinGap slotless and ironless motor designs is that they eliminate cogging torque. Their uniquely constructed phase windings produce a balanced phase amplitude and angle relationships between phases. In addition, due to these patented unique design features, ThinGap motors exhibit torque versus angle curves with good phase balance resulting in less than 1% harmonic distortion minimizing torque ripple. ThinGap motors also produce linear torque output with current which ensures minimum torque ripple even at high load conditions. It doesn't get any smoother than this!



About ThinGap

For over fifteen years, ThinGap has been a world leader in the design and manufacturing of USA-made, high performance frameless electric motor and generator kits. ThinGap's patented ultra-thin coil stator and optimize permanent magnet design results in a step increase in performance relative to conventional slotted motor technologies, as well as other available slotless motors. ThinGap motors have very high-power density, high torque density, zero cogging smoothness, and operate at high efficiency. These frameless motor kits offer unsurpassed mechanical design flexibility, are highly scalable in size, shape and power, and easily integrate into complex mechanics.