

Frequently Asked Questions

1. What class of motors does NovaTorque belong to?

The NovaTorque motor is an “electronically commutated permanent magnet” (ECPM) motor.

2. What are the generic advantages of Permanent Magnet (PM) motors when compared with AC induction motors? Disadvantages?

As with all permanent magnet (PM) motors, the NovaTorque motor enjoys the following advantages and disadvantages when compared to AC induction motors.

Advantages

PM motors are inherently more energy efficient than induction motors. In an induction motor, the rotor’s magnetic field is generated by an electric current. In a PM motor the rotor’s magnetic field is produced, as the name implies, by permanent magnets. The fact that the rotor’s magnetic field need not be electrically produced reduces the electrical energy required. This same feature also eliminates the electrical energy losses associated with the induction motor’s rotor, further reducing the energy required.

PM motors operate with zero slip. Unlike induction motors, PM motors operate synchronously at their set speed. Induction motors must slip to produce torque and the slip varies as the load varies. In applications where precise speed control is required, PM motors will outperform induction motors.

The power density of a PM motor is greater than that of an induction motor. Permanent magnet motors of the same physical size as an induction motor will typically produce 30% to 40% more power. Conversely a permanent magnet motor of the same power as an induction motor will be physically smaller.

PM motors deliver high continuous torque over their entire speed range. In contrast, the continuous torque available from an induction motor decreases significantly at lower speeds. The PM motor’s ability to continuously deliver high torque at low speed, along with its high power density (that is, its ability to produce more power in the same package size) may, in many applications, eliminate the need for gearing or other mechanical transmission devices. Eliminating gearboxes or other mechanical transmissions reduces the losses associated with those components, reduces the space required, reduces necessary maintenance, increases reliability, and eliminates the cost of the unnecessary mechanical components.

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Disadvantages

Conventional PM motors are significantly more expensive than induction motors. Conventional PM motors typically require the use of expensive and difficult to obtain rare earth magnets. Motors using these magnet will often be priced 60% to 100% higher than induction motors of the same power. Further, prices are increasing due to the recent rapid rise in the cost of rare earth magnets.

Important note: This is not true for the NovaTorque motor. NovaTorque's unique geometry focuses the flux produced by the permanent magnets, allowing NovaTorque to use readily available and far lower cost ferrite (versus rare earth) magnets. NovaTorque motors are generally priced within 20% to 30% of their NEMA Premium induction motor competition.

PM motors require external commutation to rotate. Unlike induction motors, a PM motor cannot be operated directly across the line. A VFD (Variable Frequency Drive) is required for commutation. In applications that do not require speed control, the combined additional cost of the control, plus the premium for PM versus induction motor may be difficult to justify. For this reason, NovaTorque focuses on applications requiring or benefiting from the ability to vary the speed of the motor.

3. How is the NovaTorque design different from conventional PM motors? What are NovaTorque's advantages and disadvantages compared to conventional PM motors?

NovaTorque motors are offered in standard NEMA frame sizes and mounting configurations. Most PM motors are produced to IEC, versus NEMA, standards. Hence it is easier (without having to modify existing equipment) to substitute a NovaTorque motor for a NEMA induction motor than it is to substitute a typical IEC standard PM motor for a NEMA induction motor.

NovaTorque's patented rotor geometry results in greater flux concentration. Greater flux concentration allows the use of ferrite, versus rare earth, magnets. The NovaTorque rotor design consists of two conical hubs facing each other at opposite ends of the stator. The conical geometry results in more concentrated flux at the field pole, allowing for the use of readily available, low cost, ferrite magnets, versus the more expensive rare earth magnets typically required in competing PM motors. This, among other innovations, allows NovaTorque to deliver PM performance at prices more comparable to induction motors. The unique geometry also results in a more compact physical size.

The flux path is axial versus radial. The magnetic flux path in a NovaTorque motor is transmitted axially (parallel to the shaft) across the rotor hubs through the stator (versus the radial flux paths in a more conventional PM motor). Flux transmission through the field poles is more efficient due to the relatively straight path it follows through the poles.



The magnets are mounted within (interior to) the rotor structure resulting in improved motor performance and integrity. Though not unique to NovaTorque, IPM (“interior permanent magnet”) motors are less common than conventional PM motors. In an IPM motor, the magnets are embedded within the rotor structure and mechanically restrained. This is a more reliable, higher-performing arrangement than surface adhesion of magnets as is done in most conventional PM motors. Interior permanent magnets also result in increased saliency. Increased saliency generates more accurate speed control and allows the motor to operate over a greater speed range before requiring external position sensors.

The motor geometry improves heat dissipation efficiency. Because the coil surface directly faces the outside of the stator, heat is more easily dissipated, resulting in cooler motor operation, extending motor life.

NovaTorque’s unique field pole design and manufacturing techniques result in less material waste (hence lower cost) and more cost effective small volume manufacture. The NovaTorque motor’s field poles are laser-cut from strips of steel and then laser-welded in a highly automated and programmable process. Unlike traditional stamping operations, this method allows for simple modification without the need for new tooling. It eliminates material waste, thus lowering cost. Model changeover is simple, providing greater manufacturing flexibility. And, low volume runs can be produced cost effectively.

NovaTorque motors are priced significantly lower than conventional PM motors. The NovaTorque motor was designed to compete effectively with induction motors – not simply to compete with other PM motors. In comparable volumes, the NovaTorque motor will typically be priced 30% to 70% lower than that of conventional PM motor of the same power.

Disadvantages?

The NovaTorque motor’s rotor inertia is greater than is generally the case in conventional PM motors. While this is actually an advantage in many applications, it would be a disadvantage in high acceleration/deceleration servo positioning applications.

4. What are the advantages of the NovaTorque motor versus an induction motor? Disadvantages?

Much of the following is a repeat from the answers to questions #2 and #3 above. Most of the advantages of the NovaTorque motor compared with an induction motor are further improvements on the advantage generic to PM motors.

Advantages

NovaTorque motors are significantly more efficient than even NEMA Premium efficiency induction motors, and the advantage increases substantially when the motor is operated below rated speed. At rated speed, a NovaTorque motor is approximately 3.5% more efficient than a NEMA Premium induction



motor, and 5.5% more efficient than a high efficiency induction motor. (Note: As of December 19, 2010 all general purpose integral horsepower induction motors purchased in the US are mandated to meet NEMA Premium efficiency standards.)

Because the efficiency curve of the NovaTorque motor is flatter than an induction motor (which becomes significantly less efficient as the load decreases), the NovaTorque efficiency advantage increases substantially in variable torque, variable speed applications such as fans. For example, when operating at half the rated speed of the motor, the NovaTorque motor will be approximately 15 percentage points more efficient (90% versus 75%) than a NEMA Premium motor.

In a recent study commissioned by an energy utility (Sacramento Municipal Utility District) NovaTorque motors were compared to NEMA Premium efficiency motors in tests replicating a typical fan curves. The results: NovaTorque was 7% to 12% more efficient.

NovaTorque motors typically produce more rapid payback than NEMA Premium efficiency induction motors. Approximately 97% of the cost of ownership of an industrial use electric motor is the energy it consumes. Only 3% is the actual purchase price. Because NovaTorque motors are priced at a relatively small premium to NEMA Premium efficiency induction motors (typically within 20% to 30%), and because they provide significantly greater efficiency and do so over a wide speed range, the payback on the initial price premium between a NovaTorque motor and a NEMA Premium efficiency induction motor is typically less than one year. (Payback varies based on duty cycle, local cost of energy, operating range, OEM mark up, etc.)

NovaTorque provides high continuous torque capability over its entire speed range. As noted earlier, the continuous torque available from an induction motor declines significantly as speed is decreased. The ability of NovaTorque to economically produce higher continuous torque at low speed may eliminate existing application issues and/or result in the ability to eliminate the necessity for gearing.

The zero slip operation of the NovaTorque motor results in more precise speed control.

NovaTorque motors run cooler, resulting in longer motor life. NovaTorque's design improves both efficiency (less heat generated due to losses) and dissipation (for the heat that is generated), resulting in cooler operation when compared to induction motors, therefore increasing reliability and extending the motor's life.

The geometry of a NovaTorque motor results in high power density (same power in a more compact package). NovaTorque motors are generally one full frame size smaller than their induction motor equivalents.

Due to its broad operating profile, the NovaTorque motor is more versatile than an induction motor. The same motor may be employed in either constant or variable torque applications, for low or high-speed operation. Due to its smaller frame size a single



motor may be used for multiple power requirements (e.g. in both 3hp and 5hp applications). And, with a smaller footprint, the NovaTorque motor may fit where its induction motor counterpart will not.

Disadvantages?

The initial purchase price of a NovaTorque motor is higher than a NEMA Premium efficiency induction motor. As noted earlier that premium is small, typically within 20% to 30% of the price of the induction motor. When only initial purchase cost (versus the ongoing cost of ownership) is a consideration, the NovaTorque motor may be disadvantaged. But when lifetime cost of ownership, or even the first few years of ownership, is taken into account, the NovaTorque advantage is decisive.

NovaTorque motors require a drive. As a result, in constant speed applications, the additional cost of the drive, plus the price premium for the motor, may yield unacceptable paybacks. For this reason, NovaTorque targets only those applications in which variable speed is required or desired.

NovaTorque motors produce lower peak torque than induction motors. Induction motors have the advantage of being able to generate 2 to 3 times their rated torque for brief periods of time. However, this requires 3 to 6 times rated current, so operating for an extended period (measured in minutes) at those levels, the induction motor will overheat and either fault-out (if such protection is available) or fail. These high torques and currents are easily achieved when the motor is running from an AC supply, but when the motor is driven by a variable speed drive, the available current and torque will be limited by the drive. In applications where the motor might see brief intermittent spikes in load and where precise speed control during those spikes is not an issue, the induction motor may be a suitable answer.

5. How does NovaTorque achieve better low speed efficiency when compared to either induction or conventional radial PM motors?

NovaTorque motors have a very compact bobbin-type electrical winding. Unlike conventional radial motors there are no end-turns. All of the wound conductor in a NovaTorque motor is used effectively. This results in a lower winding resistance than radial motors, and therefore lower resistive (I^2R) losses.

At low speeds, resistive losses dominate. Since NovaTorque motors have less resistive loss than radial motors, low speed efficiencies are higher.

6. How does NovaTorque achieve its continuous torque advantage at low speed? On what applications would this be important?

Again, this advantage is generic to PM motors when compared to induction motors.

As stated earlier, induction motors will overheat and eventually



fail in high torque, low speed conditions due to very high losses (inefficiencies) when the motor is operated at low speed. For this reason, gearing is often employed to produce low speed at the load while maintaining higher speed at the motor. Gearing, however, introduces new inefficiencies, as well as additional cost, complexity, maintenance, and space requirements.

It should be noted that selection and proper tuning of the VFD is particularly important in high torque, low speed, open loop applications. One's drive provider or NovaTorque's application engineering department can provide guidance in this regard.

When operated with a drive that has closed-loop feedback, the NovaTorque motor can deliver full torque down to zero speed.

High torque, low speed operation can be important in variable-speed mixing, grinding, or material transport applications.

7. How do NovaTorque prices compare with NEMA Premium efficiency induction motors? With conventional PM motors?

NovaTorque's innovative design and construction has allowed the Company to establish pricing at levels more comparable (typically within 20% to 30%) to NEMA Premium efficiency induction motors than to PM motors. NovaTorque motors are priced at least 30% to 70% lower than competing PM motors.

8. How long is the "payback" on the NovaTorque price premium over NEMA Premium induction motors.

Several factors determine the number of months of energy cost savings needed to repay the additional investment (price premium) for the NovaTorque motor to provide a precise answer.

Those factors include: the cost of electricity (\$/kwh), utility demand charges or other penalties, the number of hours of operation, the speed at which the motor operates, the relative efficiencies of the alternative motors, and the delta in motor pricing.

Typically, however, the payback will work out to 6 to 12 months, or less, returning 15 to 20 times the price premium over the life of the motor.

9. Many HVAC motors are mounted outdoors/rooftop. How "weatherproof" is the NovaTorque motor? Temperature constraints?

NovaTorque motors are TEAO/IP54 enclosure type. They are dust-protected and resistant to water splashes, but are not intended for wash-down or exposure to direct rain. Covered outdoor use is clearly acceptable. Consult factory for use as condenser motors in open air, shaft-up orientation. Ambient temperature service conditions are -15 °C to 40 °C (5 °F to 104 °F).

10. How is the reliability of the motor assured?



All production motors are subjected to a series of tests prior to shipment.

HALT testing (Highly Accelerated Life Testing) is in process. Concurrently, prospective OEM customers are running their own series of performance and life tests with no issues discovered to date.

Importantly, reliability has been a central design theme, with many failure modes, common to the motor industry designed out. Most of those failure modes are heat-related bearing or winding issues. The high operating efficiency of the NovaTorque motor reduces heating due to losses, allowing the motor to run cooler, hence inherently improving reliability. Additionally, as the coils are directly exposed to the exterior of the motor, what heat is produced is dissipated more efficiently, further reducing the operating temperature of the motor.

The electrical wind of the NovaTorque motor is a compact bobbin-type with no end-turns. The simple nature of the winding improves reliability, as less stress is placed on the wire conductor during the winding operation when compared with a conventional 'stitch wound' motor.

The magnets used in the NovaTorque motor are mechanically AND adhesively restrained. This ensures that no motor failures will result due to magnet de-lamination as can occur in with surface mount magnets in conventional PM motor designs.

11. What type of magnets does NovaTorque use? Is demagnetization a potential problem?

Due to the flux concentration produced by the geometry of the NovaTorque motor, the motor produces rare-earth-like performance with the use of ceramic ferrite magnets. Unlike rare earth magnets, ceramic ferrite magnets are readily available and much lower in cost. Also unlike rare earth magnets, they are NOT subject to demagnetization at high temperature. They are susceptible to demagnetization at very low temperatures (below -20 degrees C) if full power is applied when at that temperature. That issue is easily remedied by limiting power to the motor until it reaches safe operating temperature.

12. Does the NovaTorque motor meet NEMA Premium and IE3 standards?

Yes, and then some!

The IEC (International Electrotechnical Commission) has established standard categories/designations for various levels of electric motor efficiency. They range from IE1 to IE4. IE1 designates "Standard Efficiency". IE2 designates "High Efficiency". IE3 designates "Premium Efficiency" and IE4 designates "Super Premium".

IE3 and "NEMA Premium" are essentially the same, with small differences at a few sizes (HP). NEMA Premium is mandated in the US as of Dec 19, 2010. IE3 is recommended in Europe and will become mandated in 2015.



IE4 has been defined by the IEC as a 15% reduction in motor losses from the IE3 standard. Common wisdom is that IE4 efficiency cannot be reasonably achieved with induction motors. PM motor technology will be required.

NovaTorque already meets what will become IE4 standard!

13. Are VFD induced shaft voltages an issue with the NT motor? If so, what protective measures should be employed?

Permanent magnet motors are less susceptible to shaft voltages and bearing currents than are induction motors. Provision, however, has been made for easy mounting of an Aegis grounding ring for those customers that wish to be extra cautious.

14. How is the motor commutated? Is a sensor required?

The NovaTorque motor is electronically commutated, using the back EMF of the motor for determining rotor position. No sensor is required. Variable Frequency Drives (VFDs) that support permanent magnet motors have this feature built into their algorithms. Most major suppliers offer drives that support both induction motors and permanent magnet motors. Contact NovaTorque Application Engineering for a list of drives that have been tested and approved with the NovaTorque motor.

15. Can the motor be run across the line?

No. A drive is required for the motor to operate, and it cannot be bypassed.

16. What is NovaTorque's production capacity? Where is production located?

The Company subcontracts several of its production processes, including final assembly and test, to a high volume, long established, motor manufacturer. NovaTorque motors are produced in the US (Arkansas). With reasonable leadtime, the Company can respond to the volume requirements of any OEM customer. Please consult NovaTorque regarding specific volume and timing requirements.

17. Is the NovaTorque UL listed?

NovaTorque has received ETL recognition for its motors. ETL is a generally accepted alternative to UL. ETL Testing Laboratories has been conducting electrical performance and reliability tests since 1896. Intertek Testing Services (ITS) acquired ETL in 1996. ITS is recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL), just as Underwriters Laboratories (UL), Canadian Standards Association (CSA) and several other independent organizations are recognized.

ITS tests products according to nearly 200 safety and performance standards. The ETL Listed Mark is accepted throughout the United States denoting compliance with nationally recognized standards such as ANSI, IEC, and UL.



This certification mark indicates that the product has been tested to and has met the minimum requirements of a widely recognized (consensus) U.S. product safety standard, that the manufacturing site has been audited, and that the applicant has agreed to a program of periodic factory follow-up inspections to verify continued conformance.

18. How long has NovaTorque been in business? Who owns the company?

NovaTorque was founded 2005. It is an independent, privately-owned, California corporation.

19. What are NovaTorque's plans for expanding the product line? Time frames? What will be the next model?

NovaTorque will offer a family of integral horsepower motors ranging from 2 to 30 horsepower, at rating speeds of 1800 and 3600 RPM. 2 and 3HP motors @ 1800 RPM are available now. A 5hp 1800 RPM motor will be added late 2011, and a 7.5hp and 10hp model added in 2012.

20. Will NovaTorque consider requests for custom motors?

NovaTorque entertains requests for custom motors based on our core design/technology.

21. What applications benefit most from NovaTorque's advantages and why?

The NovaTorque efficiency curve is both higher and flatter than induction motors. Hence, variable torque applications with wide speed and load requirements, such as fans and pumps, benefit significantly from the improved efficiency. A recent study commissioned by an electric utility, concluded that the NovaTorque motor would use 7 to 12% less power than a NEMA Premium motor when used in a fan application with a typical load profile.

The NovaTorque design is also characterized by high power density (more power in a small package size). The NovaTorque motor is often one full frame size smaller than a comparable induction motor. As such, it will often fit where its NEMA Premium induction motor competition will not. With the recent change in efficiency regulations, now requiring NEMA Premium efficiency versus standard induction motors, this will often alleviate a mounting/space issue otherwise created by the transition.

The NovaTorque motor is also capable of producing high continuous torque at low speeds without overheating. Induction motors cannot. Thus it is well suited for applications characterized by the need of constant torque over a wide speed range. Mixers would be an example. Treadmills would be another.

The high continuous torque and the high power density together will often eliminate the need for gearing, allowing the load to be driven



directly. Many applications (example: conveyors) would benefit from the reduction in mechanical complexity, cost, inefficiency, and maintenance.

22. How does NovaTorque go to market?

For larger volume OEMs and/or for custom, application-specific, motors, NovaTorque products are purchased from and supported by NovaTorque directly.

23. What kind of technical and/or sales support does NovaTorque provide?

NovaTorque's application engineering function is led by Kim Baker, VP-Application Engineering. Kim's team is available to our OEM customers for pre and post sale technical assistance. As customer technical support requirements typically relate primarily to the drive component of the system, support is usually best first solicited directly from the drive manufacturer.

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