Understanding Animatics Torque Curves

Each Set of Torque curves depicts limits of both Continuous and Peak torque for the given SmartMotor™ over their full range speed.

Peak Torque Curve:

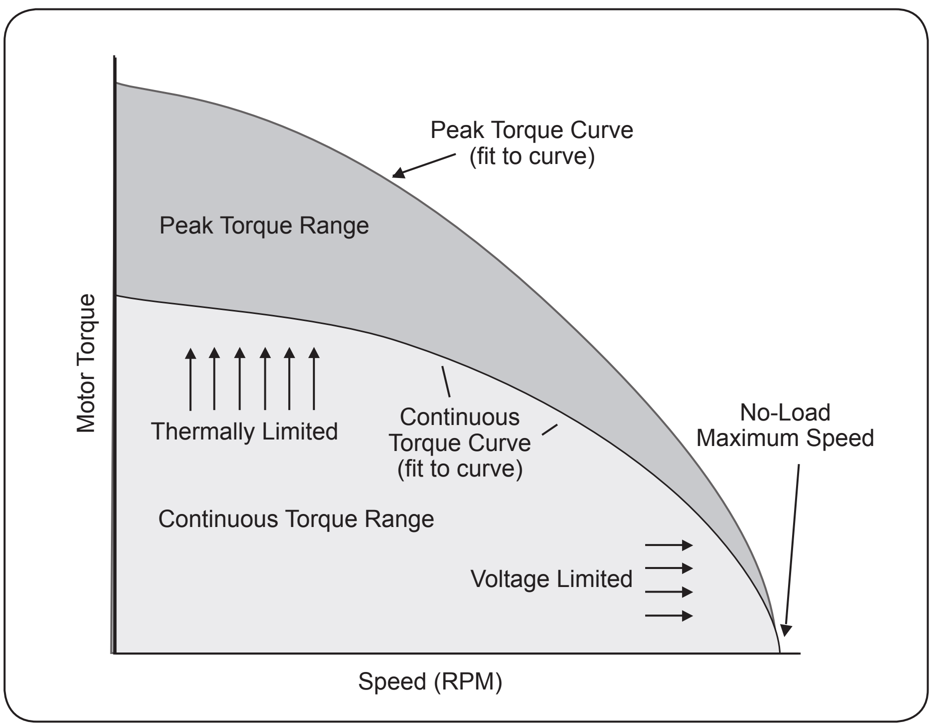
The Peak Torque Curve is derived from dyno testing and is the point at which peak current limit hardware settings of the drive prevent further torque in an effort to protect drive stage components.

Continuous Torque Curve:

The continuous Torque Curve is also derived from dyno testing, but is instead the point at which the temperature rises from an ambient of 27º C to the designed thermal limit.

For example: The motor will be placed on the dyno tester and set to operate at 1000 RPM continuously with the load slowly increased until the controller reaches its maximum sustained thermal limit. This limit is either 70º C or 85º C depending on the model number.

The far lower right side of the curve is limited by supply voltage. This is the point at which Back EMF suppresses any further speed increase. Higher supply voltages will shift the zero torque point of the curves further to the right.



Ambient Temperature Effects on Torque Curves and Motor Response:

If the motor is operated in an environment greater than 27º C, then it will reach its thermal limit faster for the same given load thereby further limiting continuous torque.

Therefore any given motor torque curve MUST BE linearly de-rated for a given ambient temperature from 27º C to 70º C (optional 85º C).

Supply Voltage Effects on Torque Curves and Motor Response:

Higher voltages have two-fold effects on torque curves. As mentioned above, raising voltage will shift the curve to the right. It will also allow higher current into the drive. However, Torque curves depict Torque at a given velocity.

If you double supply voltage, the motor can sustain twice the original velocity. But since acceleration is the differential of velocity, it can achieve 4 times the original acceleration. This is useful for high speed indexing and fast start/stop motion.

Considerations when using torque curves for motor sizing:

For any given product model number, there may be variations of as much as +/-10%.

The following diagram depicts data points collected from dyno testing of a given model motor. A best-fit torque curve is created from these data points and is then de-rated to at least 5% below the worst case data points. The de-rated curve is what is advertized. This means that within any given model number, EVERY motor sold will perform at or better than the advertized torque. Theoretically, ALL motors should be no less than 5% better than advertized and may be better than 20% higher.

The diagram shows motor loading in 4 areas.

Point 1. This is ideal and depicts a load within the normal operating range of the motor. The motor should operate well and have no problems for many years.

Point 2. The load is very close to the operating limit. The motor will run quite warm as compared to Point 1.

Point 3. The load exceeds the advertized operating limit of the motor. However, due to data scatter and de-rating, there may be some motors that will work and others that do not.

Why? Because it is in the area of +/-10% variation expected in motors for a given size. This can become a major problem. Imagine designing a machine that operates in this range. Then you replicate that machine with many of them running on a production floor.

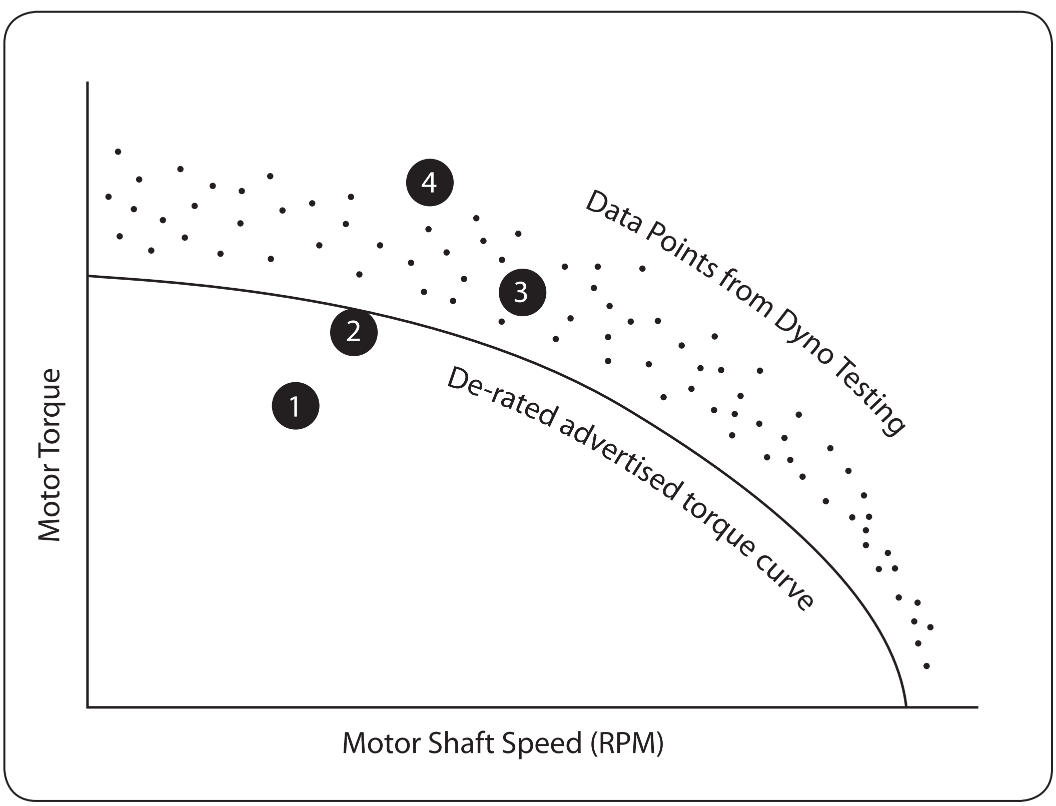
One day, a motor at the lower end of the +/-10% expected variation would be placed on a new machine and that motor would get spurious drive faults.

It would appear as though the motor is malfunctioning because…. “all the other motors work just fine”.

This is unfortunate because in reality, all motors were undersized and operating outside of their advertized limits.

This is why it is important to properly calculate load torque to insure the correct motor is designed into the application. Never assume that without proper load calculation and motor sizing, testing of one motor means all of that size may work. This is simply not the case. Try to keep operating conditions below the advertized limits to insure reliable long-life operation.

Point 4. The load exceeds the advertized level and exceeds +10% expected range of possible torque capabilities. In this case, the motor will most likely either overheat quickly and fault out or immediately get a position error because it simply does not have enough power to support the load demand.



Moment Of Inertia:

A basic understanding of Moment of Inertia serves well in insuring proper motor sizing. It is one thing to look at static points on torque curves, but it is altogether different when considering the dynamic aspects of loads being accelerated at high rates.

The Inertial mass of an object is a measure of its resistance to a change in its velocity.

The Moment of Inertia of an object is at a point of reference of rotation, which is at the pivot point or axis of rotation.

The Moment of Inertia can therefore be thought of as a measure of the resistance to any change in rotational speed.

For linear systems, the rate of change of speed, (acceleration) is proportional to the force applied. Double the mass and the force needs to be doubled for the same acceleration. Similarly for rotational systems, the angular acceleration of the load is proportional to the torque applied. Double the Moment of Inertia and the torque needs to be doubled for the same angular acceleration. Moment of Inertia is therefore a measure of a load's resistance to angular speed change; of how much effort (torque) is required to cause acceleration or deceleration.

Matching Motor To Load:

A common rule of thumb for SmartMotor™ sizing is that the load should have no more than 10 times the Moment of Inertia of the motor rotor that is driving it. This gives a good starting point and typically allows for safe sizing over a wide range of applications.

Since a rotating load wants to maintain the same velocity, then when a motor attempts to accelerated or decelerate the load, it must overcome the Moment of Inertia of that load by applying enough torque to accelerate it or decelerate it.

It takes more torque to change speed than it does to maintain a given speed.

In the same manner, for the motor to slow down a load, the load's Moment of Inertia will keep the motor going the same speed and will in effect, back drive the motor turning it into a generator.

In extreme cases, this can result in over voltage damage to the Drive stage.

How to improve Moment of Inertia Ratio Between Motor and Load :

Adding gear reduction to a motor gives it more leverage to prevent back driving and also gives it a better advantage in accelerating a load up to speed.

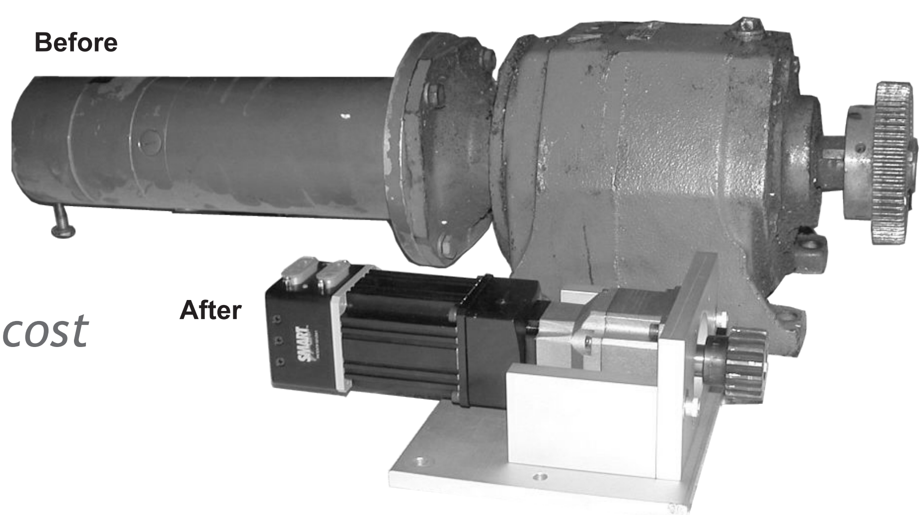
For any given change in gear reduction, you get a proportional change in speed and static torque but you get a squared change in acceleration and dynamic rate of change of torque. The result is that by adding gear ratio you gain a squared decrease in the ratio of Moment of Inertia between motor and load.

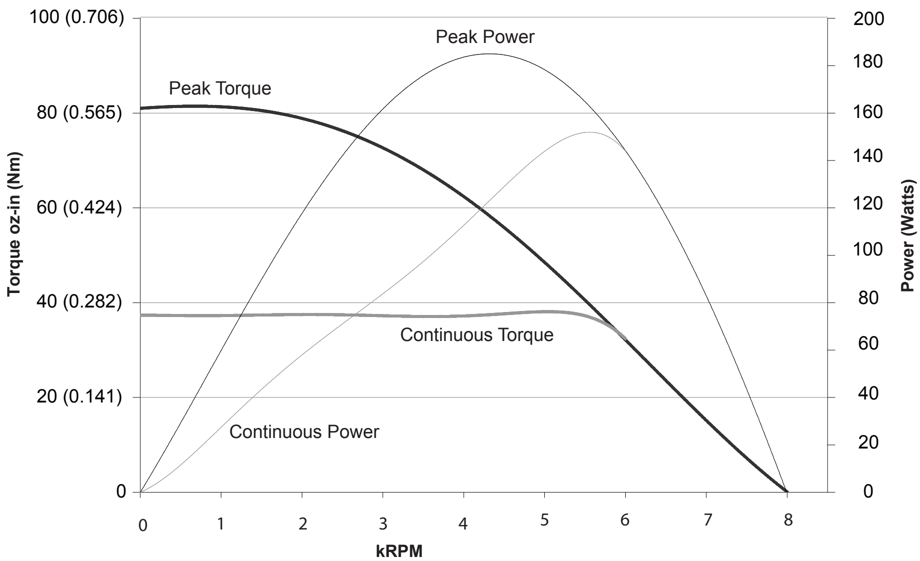
Therefore the motor has a greater advantage in both accelerating and deceleration the load. It adds protection against damage to the system as a whole.

Lower System Cost

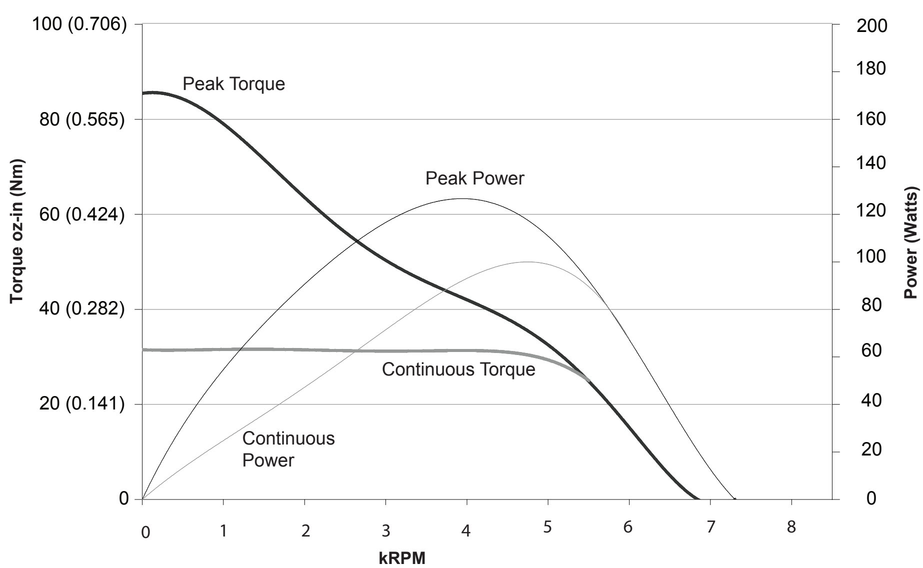
To give an idea of how much effect you get from additional gear reduction, take a look at the example below. This is an actual photo of the before-and-after drive system of a given application. The larger motor with low gear reduction and larger pulley was replaced by the smaller Animatics SmartMotor™ with much higher gear reduction and smaller pulley. The result was a smoother operating machine with higher resolution and better acceleration.

Optimize gear reduction to improve load dynamics and motor efficiency & reduce system cost

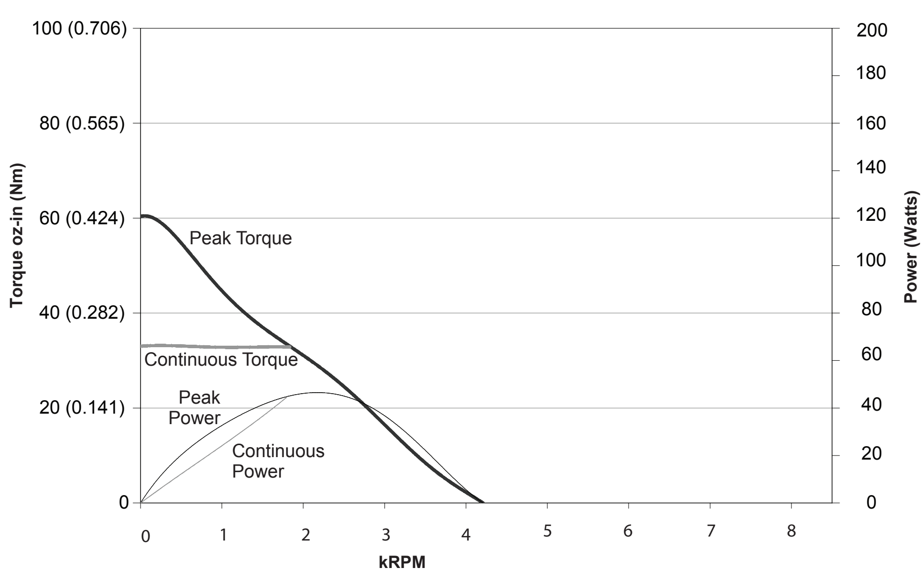




SM1720D85C
at 48 VDC
at rise to 85°C

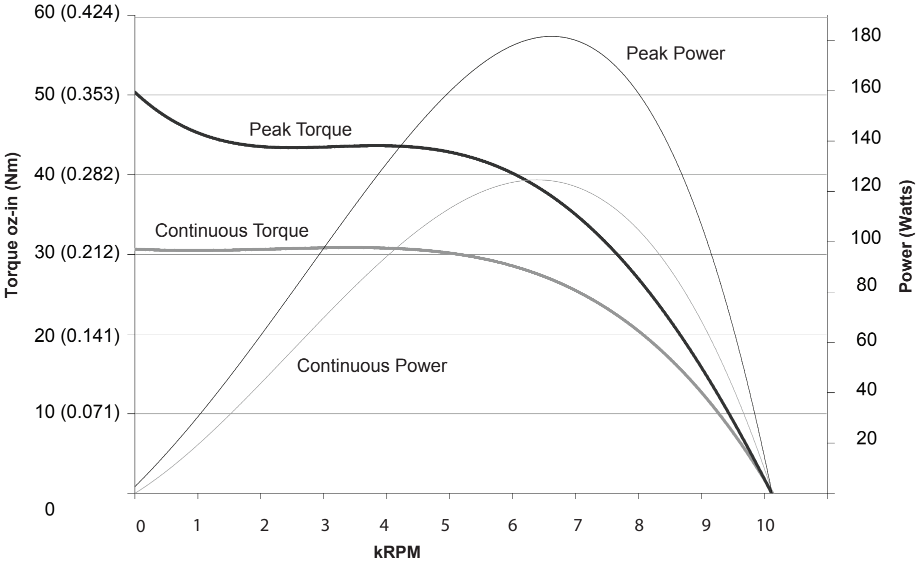


SM1720D85C
at 42 VDC
at rise to 85°C

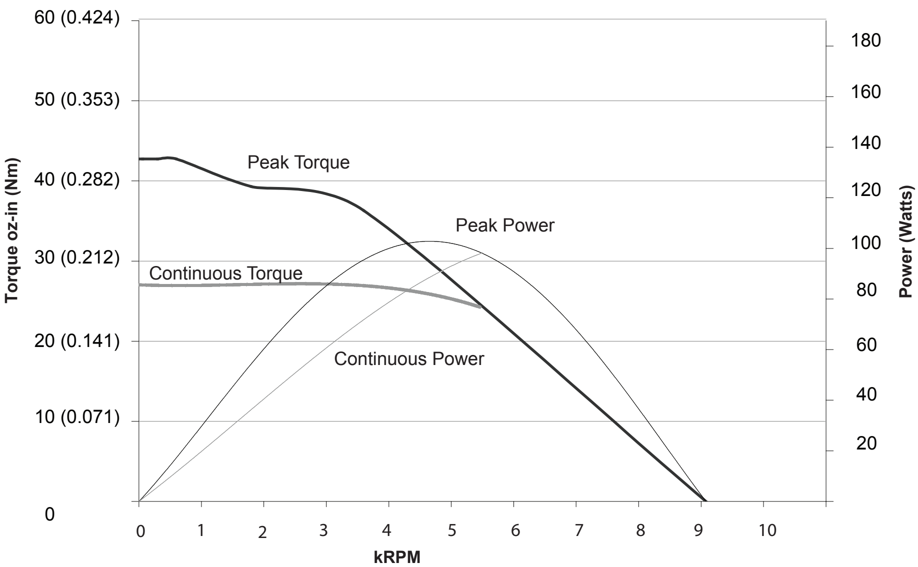


SM1720D85C
at 24 VDC
at rise to 85°C

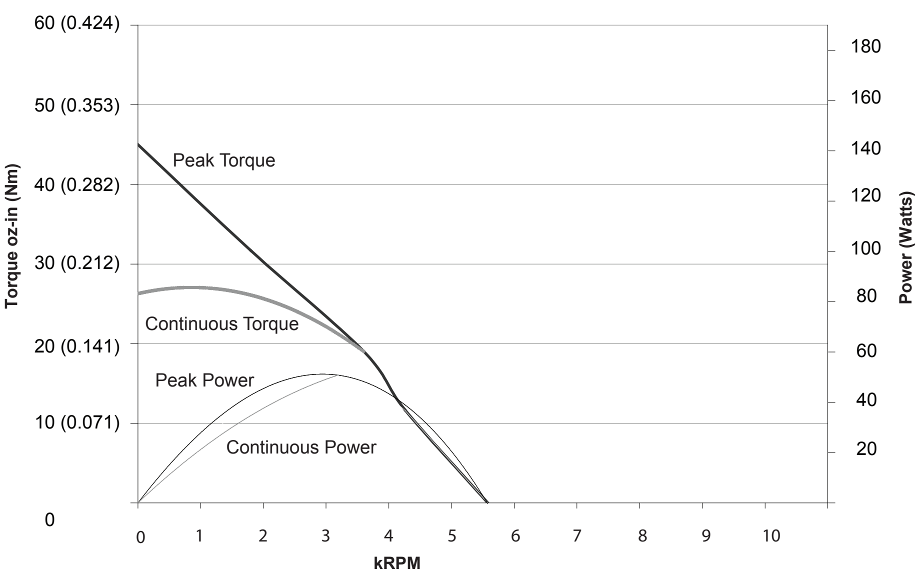
TORQUE CURVES



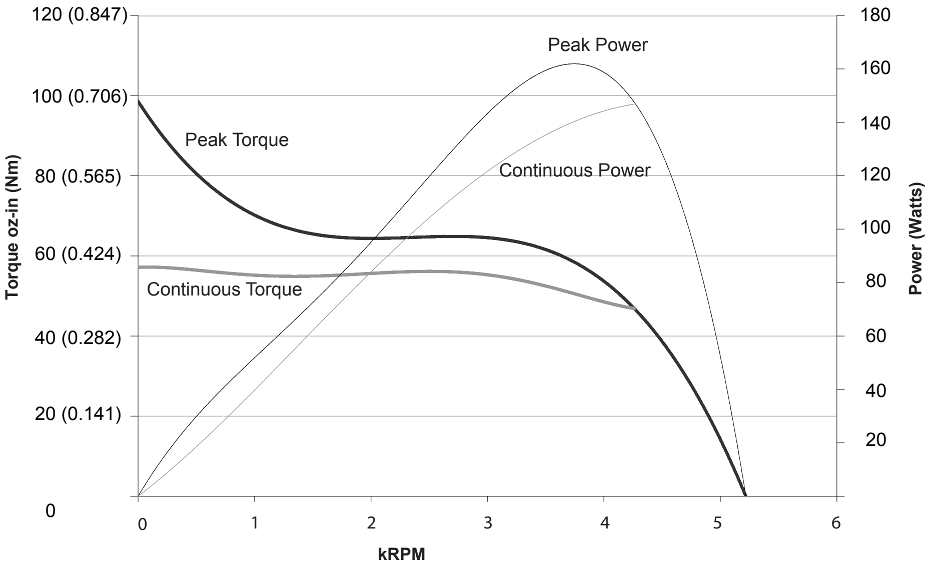
SM2315D
at 48 VDC
at rise to 70°C



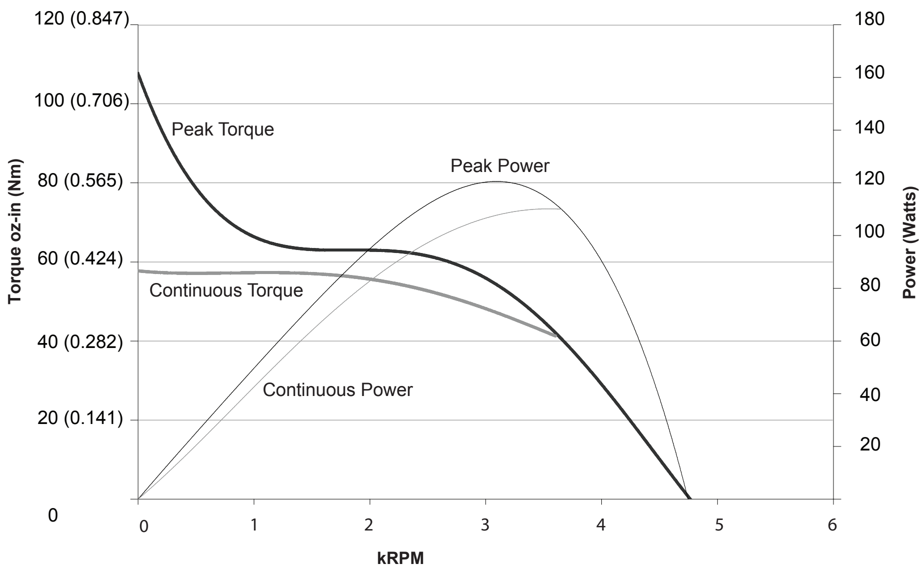
SM2315D
at 42 VDC
at rise to 70°C



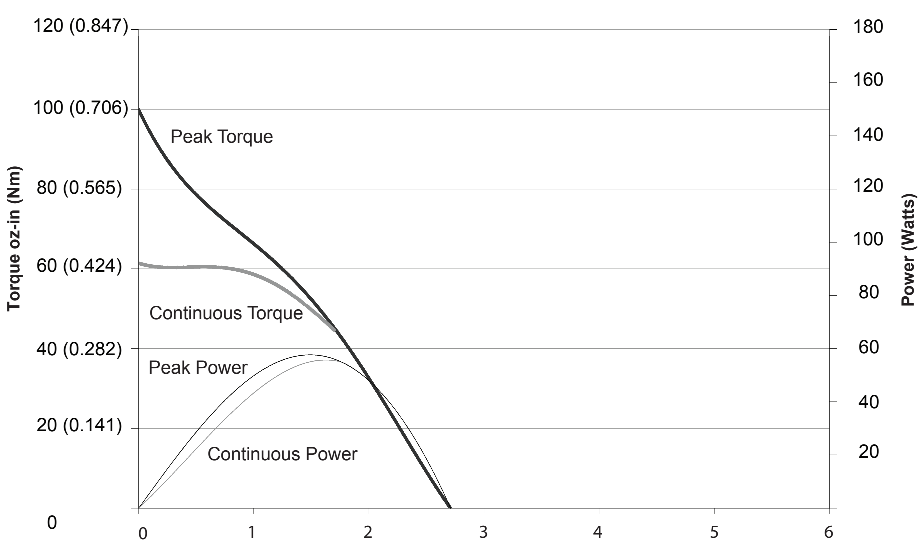
SM2315D
at 24 VDC
at rise to 70°C



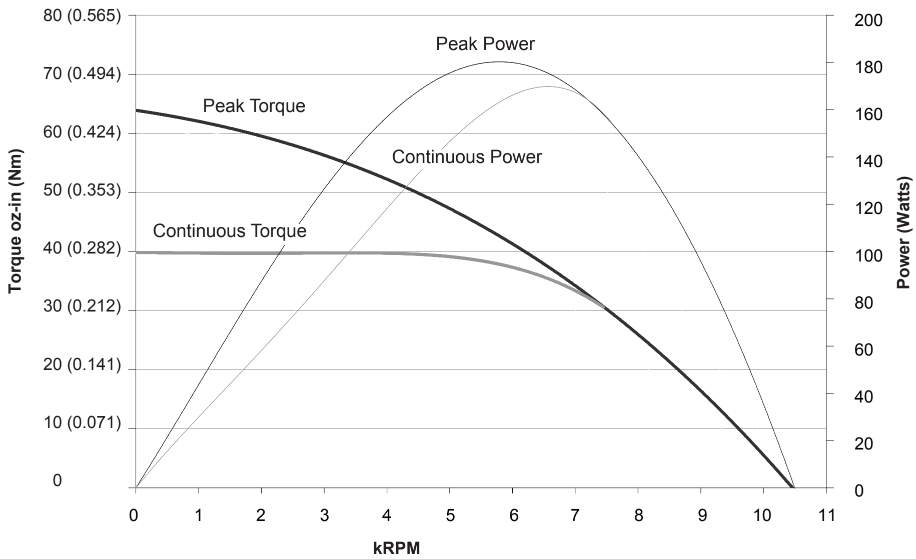
SM2315DT
at 48 VDC
at rise to 70°C



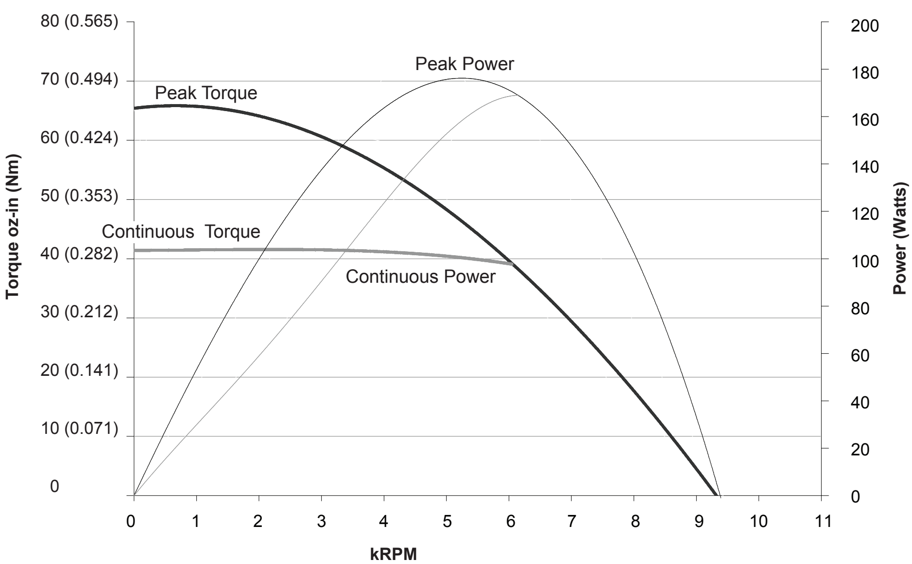
SM2315DT
at 42 VDC
at rise to 70°C



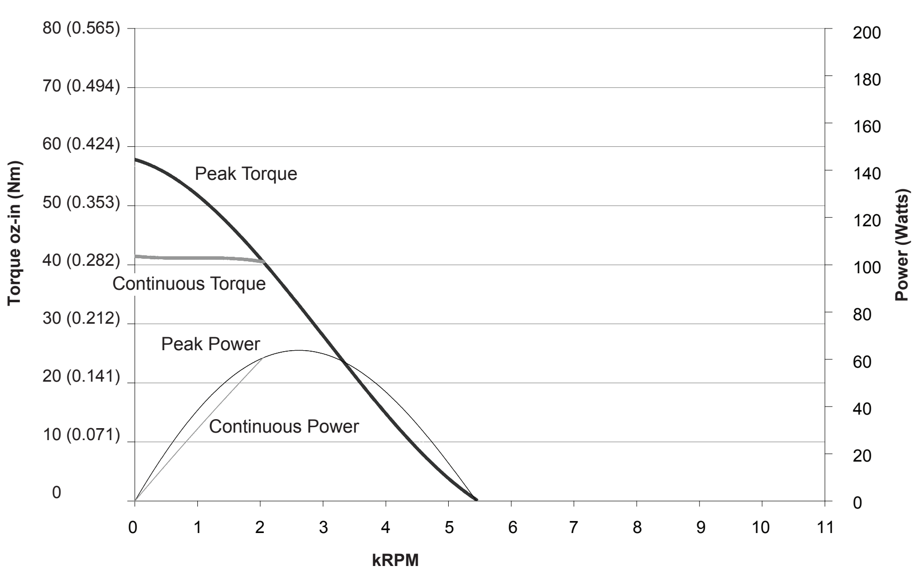
SM2315DT
at 24 VDC
at rise to 70°C



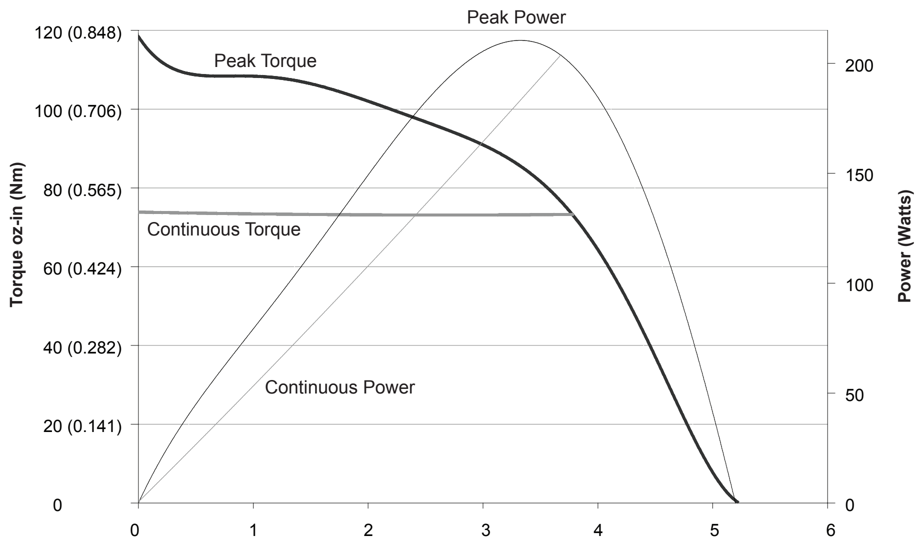
SM2316D
at 48 VDC
at rise to 85°C



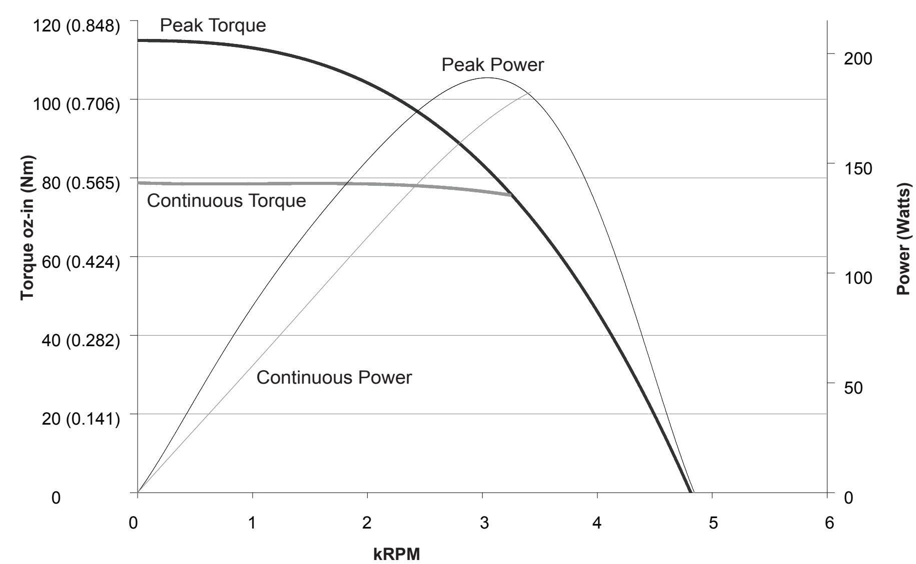
SM2316D
at 42 VDC
at rise to 85°C



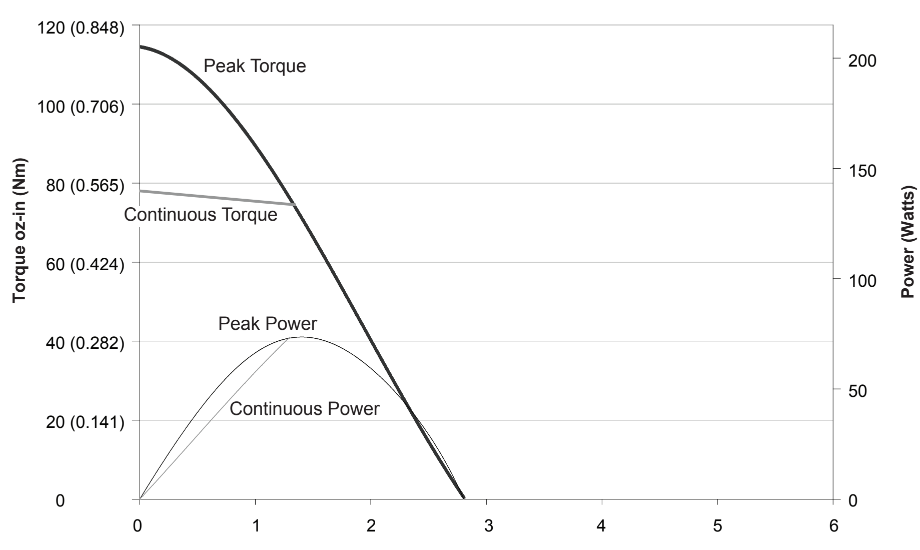
SM2316D
at 24 VDC
at rise to 85°C



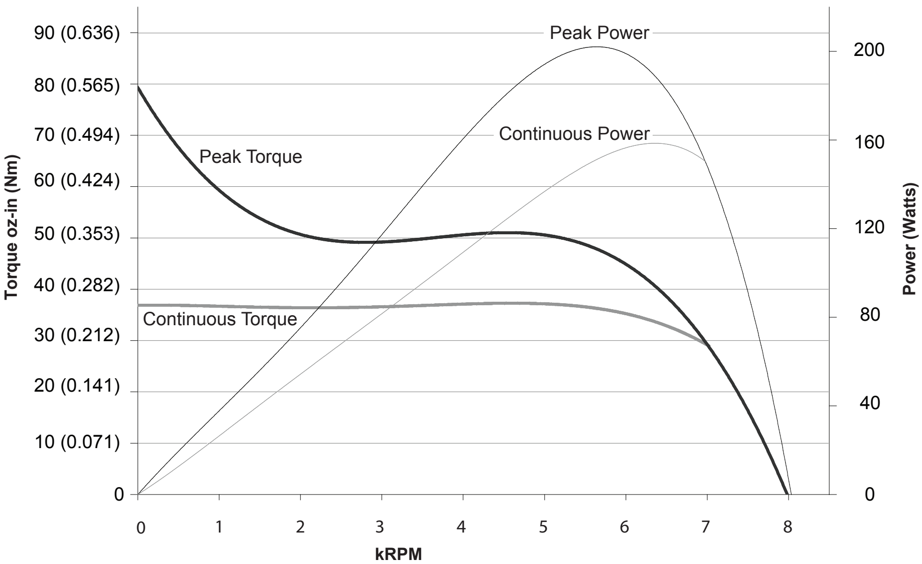
SM2316DT
at 48 VDC
at rise to 85°C



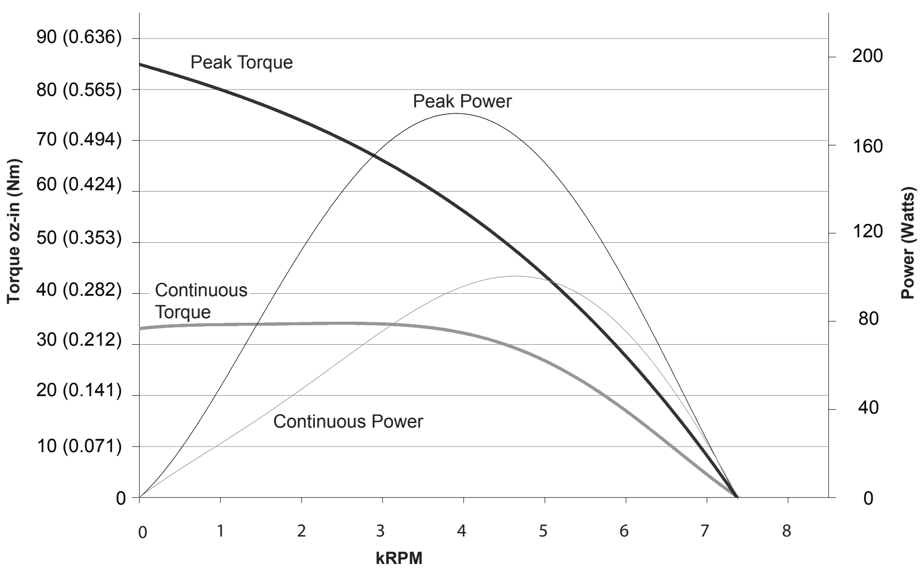
SM2316DT
at 42 VDC
at rise to 85°C



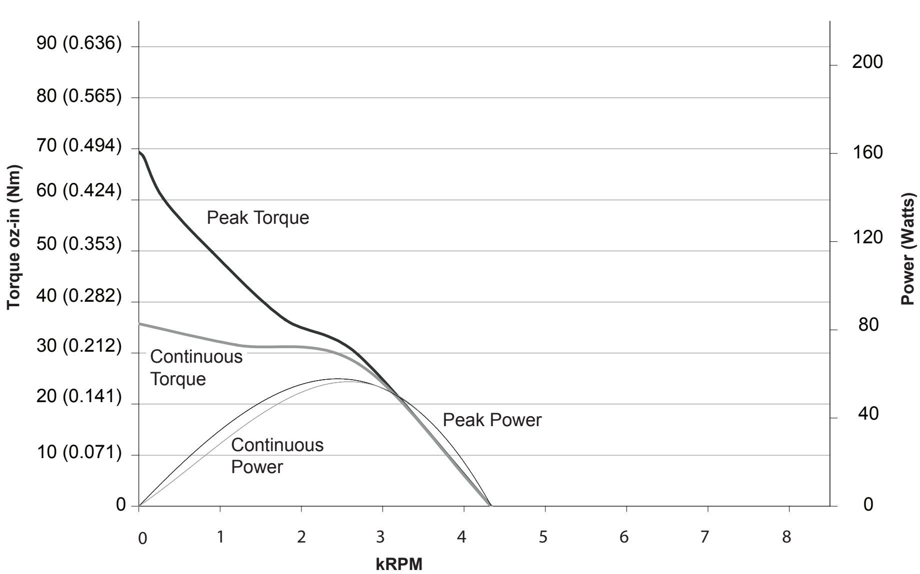
SM2316DT
at 24 VDC
at rise to 85°C



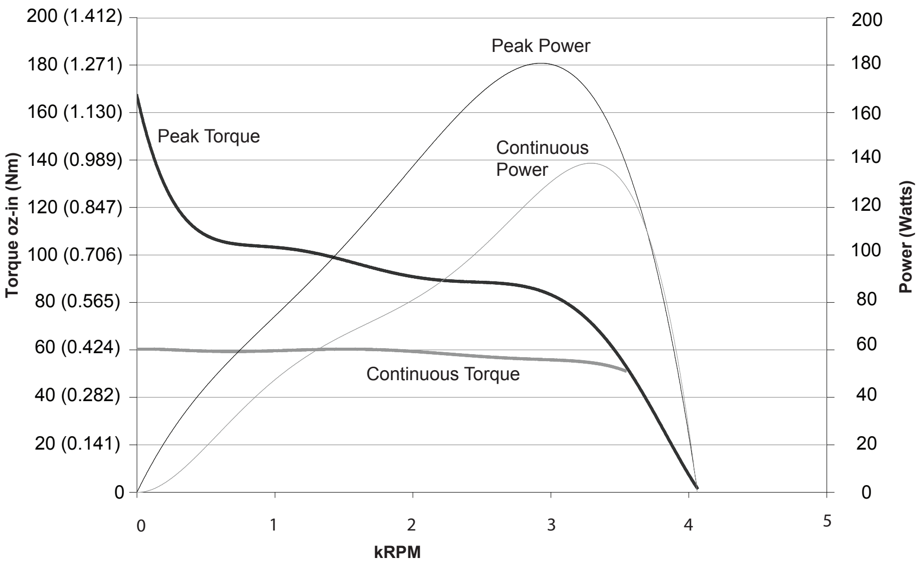
SM2337D
at 48 VDC
at rise to 70°C



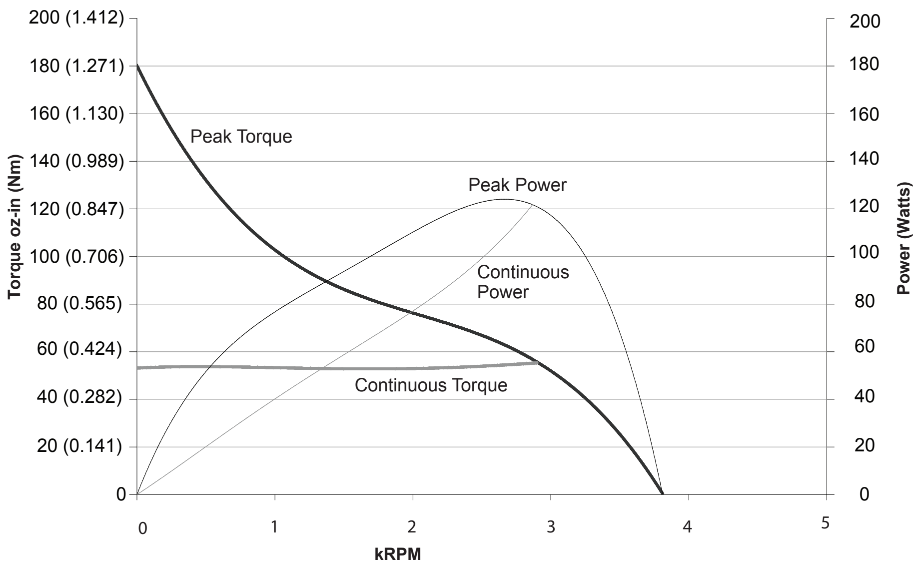
SM2337D
at 42 VDC
at rise to 70°C



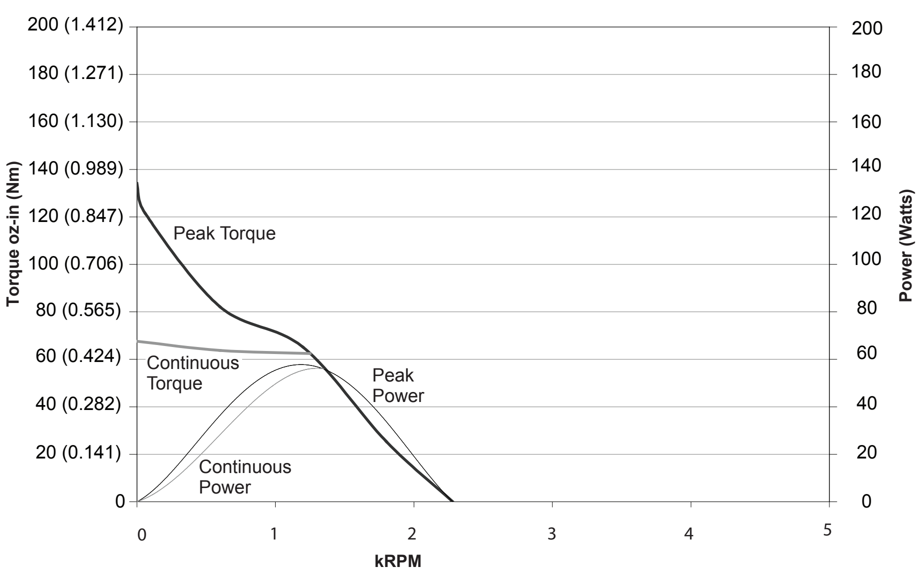
SM2337D
at 24 VDC
at rise to 70°C



SM2337DT
at 48 VDC
at rise to 70°C



SM2337DT
at 42 VDC
at rise to 70°C



SM2337DT
at 24 VDC
at rise to 70°C