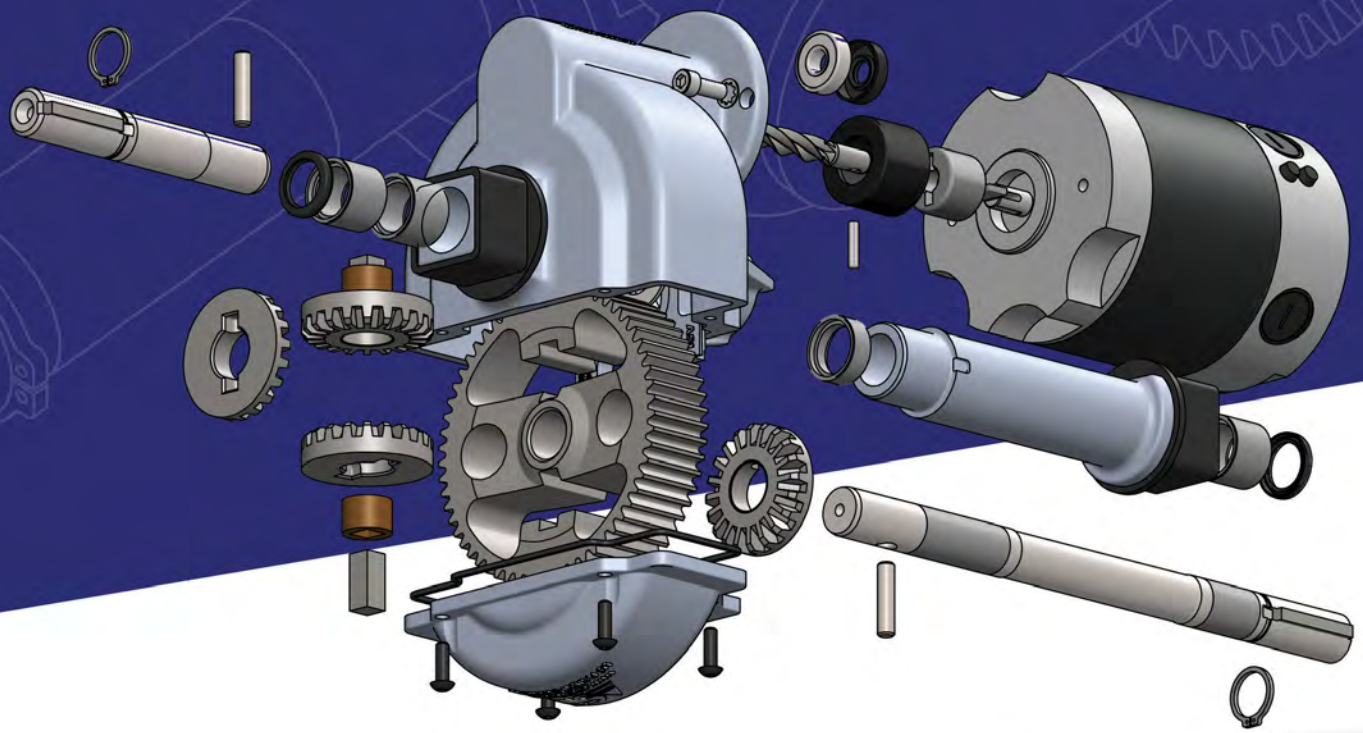
HOW A TRANSAXLE **WORKS**



ASI DRIVES
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THE MODERN TRANSAXLE IS AN INCREDIBLE FEAT OF MECHANICAL ENGINEERING.

Within one housing, it combines a gear reduction, differential, drive axle and, in some cases—as with the ASI Drives Mark 400 Transaxle—even a motor. From electric wheelchairs to floor cleaning machines to supercars, the transaxle simplifies and brings efficiencies to otherwise intricate movement challenges. In fact, it's fair to say that this single integrated component makes most four-wheeled vehicular movement possible. If you were to design a vehicle today, you wouldn't get very far without a transaxle (nor would your vehicle).

The necessity for transaxles is why it's important to understand how they work. Their innerworkings, while easy to describe, are mechanically complex, and it's difficult to find a clear explanation of this vital piece of engineering that's neither too basic nor overwhelming. Here, we'll examine the primary components of a transaxle and how they work together, ensuring you're armed with the knowledge you need to make the best-informed vehicle design decisions.

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Primary Transaxle Components

While a transaxle is designed to be a single vehicular component in and of itself, it actually integrates a series of smaller, more specialized components. Each of these ancillary components works in tandem to reliably generate and transfer power to a vehicle's drive wheels. This is why a transaxle is known as an integrated component.

One like the Mark 400 Transaxle includes seven primary components:


Motor


Brake


Gear Reduction


Differential


Mounting


Axles


Housing

Because each of these components can be fully sealed within a robust housing, transaxles are both highly efficient and easy to maintain. Let's cover each of these components, concentrating on the functional information you'll need the most.

MOTOR

Not all transaxles include a motor. Those used in a vehicle powered by an internal combustion engine—most cars, for example, will not. But at the heart of the Mark 400 Transaxle is a powerful Permanent Magnet Direct Current (PMDC) motor. This further integration only adds to the efficiencies a well-designed transaxle delivers. Why PMDC motors?

Why PMDC motors?

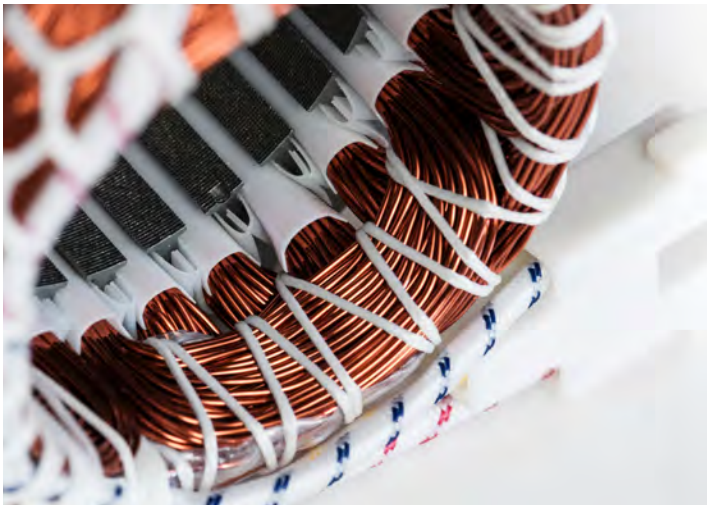
- They offer excellent, linear speed-torque curves.
- They simplify transitions between forward and reverse movement.
- They act as generators, too, reclaiming and using what would otherwise be lost power.

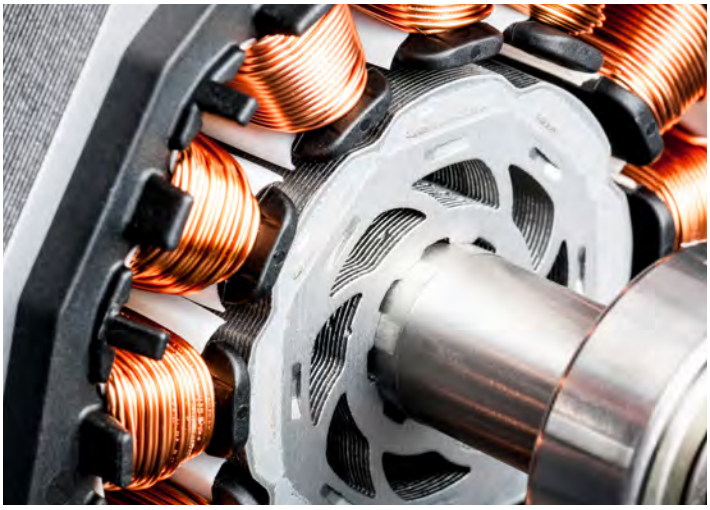
The PMDC motor speed-torque curve is ideally suited to vehicle propulsion because it naturally delivers high torque at lower speeds and less torque at higher speeds. Low-speed torque is important because it means quick acceleration from a dead stop. Meanwhile, at higher speeds, acceleration needs are minimal, decreasing the need for torque and thus energy consumption.

A PMDC motor produces rotational torque by switching DC flow to different wire coils wrapped around the motor's rotor. This produces a magnetic field that interacts with the magnetic field of the permanent magnet stator surrounding the rotor. The rotor is forced to rotate by the same physics principle that causes the north pole of one magnet to repel the north pole of a second magnet.

One challenge in the design of PMDC motors is switching the current to different coils as the rotor rotates. It's overcome by conductive "brushes" that sweep along the tops of contacts known as commutators, that rotate with the rotor. The current flows from the battery and through the brushes to the correct set of rotor coils for any point in the rotation.

You can easily imagine that reversing the direction of electrical current flow to the rotor will swap which coil is pushing and which is pulling (it's changing polarity). This reverses the rotor's direction of rotation. This ability to run the motor in reverse allows a vehicle to move in both forward and reverse directions.





Now, let's imagine what happens when you stop flowing electrical current through the rotor coils altogether.

The coils no longer generate a magnetic field, but the vehicle is still moving. This causes the rotor to rotate in the presence of the permanent magnet's magnetic field. A conductor moving through the magnetic field of the permanent magnet will generate an electrical current in the conductor. What that means is our DC motor has now become an electric generator!

The current generated by this dual capability is useful to vehicle designers in two ways. First, the current creates its own magnetic field as it flows through the rotor coils, and this magnetic field opposes the magnetic field of the stator's permanent magnet. This opposition slows the rotation of the rotor, which, in turn, causes the vehicle to slow down. It acts as a non-mechanical, non-wearing brake! Second, electrical current generated by this braking can be harvested to recharge the vehicle's battery. These two combined benefits are commonly known as regenerative braking, and one of the reason's many fully electric and electric-hybrid cars are so energy efficient.

In summary, the PMDC motor is ideal for powering electric vehicle applications. This is due to the shape of its torque curve, its ability to quickly switch between forward and reverse, and its ability to provide braking power while reclaiming energy that would otherwise be lost to friction-generated heat.

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BRAKES

Aside from being able to move, a vehicle should also be able to remain stationary when not powered.

Because PMDC motors only provide a regenerative braking force while spinning, a transaxle requires additional options to provide braking force at zero speed.

The Mark 400 Transaxle can be equipped with a power-off electromagnetic brake. A spring-loaded friction plate is engaged to prevent motor rotation when no power is applied to the brake. When a field coil is energized, the magnetic field will retract the friction plate and permit rotation of the PMDC motor and motion of the vehicle.

The power-off design provides a fail-safe that prevents a vehicle's parking brake from accidental disengagement due to a loss of electrical power. Still, there may be a need to release the brake when there is no power—for instance, during vehicle maintenance. For such cases, the power-off electromagnetic brake is equipped with a manual release. The manual switch will indicate to the vehicle operator that the electro-magnetic brake has been manually released and prevent the motor from operating.

GEAR REDUCTION

Once the force to drive the vehicle is generated there are still two challenges.

First, the motion generated by *one* PMDC motor needs to be distributed to *two* drive wheels. Second, the rotational speed needs to be optimized for any given application.

This distribution and optimization is accomplished by gear reduction between the pinion gear and the ring gear as illustrated in Figure 1. The large ratio between the pinion and the ring gear reduces the RPM (revolutions per minute) from the PMDC motor to the vehicle's drive wheels. Likewise, the large gear ratio increases torque since overall power must remain constant (power = torque x angular velocity).

The Mark 400 Transaxle design can accommodate gear ratios from 12:1 to 21:1, providing a wide range of torque and rotational speed to deliver the best performance for your vehicle. The large gear ratio also allows the Mark 400 Transaxle to provide the required torque and speed with one set of gear interfaces. This results in a smaller package, less noise and less mechanical losses (which means yet another boost to efficiency).

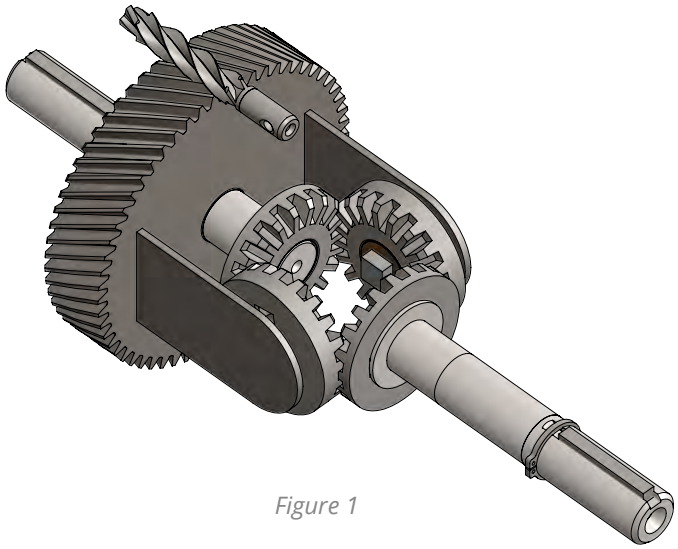


Figure 1

DIFFERENTIAL

A design challenge imposed by any four-wheeled vehicle is that, when negotiating turns, its outer wheels will travel along a circle of greater radius than its inner wheels.

But it's a challenge easily overcome by the Mark 400, which has a precision-engineered differential built right into its housing. So, what exactly are differentials?

Differentials are marvels of engineering in their own right, and they're integral components of nearly all powered four-wheeled vehicles. In Figure 1 you can see that power is transmitted from the ring gear to the drive axles by a pair of spider gears. The spider gears can also rotate between the side gears that drive the axles, allowing the side gears to rotate at *different* speeds. It's this differential rotation that allows the drive axles to turn at different rates when the vehicle is turning.

The benefits of this integrated design feature of the Mark 400 Transaxle are greater efficiency, greater traction with less tire/wheel wear and the ability for an equipped vehicle to make smooth and tight turns.

Figure 2

MOUNTING

Newton's Third Law is most often stated, "for every action there is an equal and opposite reaction."

This law is demonstrated in the torque delivered by the Mark 400 Transaxle to the wheels of a vehicle. This reaction is transmitted from the transaxle to the chassis of the vehicle by the square mounting features just inboard of the axle extensions as seen in Figure 2.

The square cross-section of this feature is robust, and ideal for taking on the Mark 400 Transaxle's reactive torque load. It also provides easy assembly of the Mark 400 Transaxle to a vehicle's chassis. The durable and long-lasting rubber fittings over this mounting feature help to isolate vehicles from shock and vibration, potentially extending vehicle life and further enhancing efficiency.

AXLES

The Mark 400 Transaxle uses separate fully enclosed axle extensions to provide vehicle manufacturers with considerable design flexibility.

Standard Mark 400 Transaxle parts can provide widths between the mounting features from 9.37 inches to 19.32 inches. Custom designs, meanwhile, can exceed this width. Heat-treated shafts and needle roller bearings designed and manufactured to exacting specifications provide efficient and smooth operation for nearly any motorized vehicle application and in any environment.

Our company was the first to design and sell a fully enclosed electric-powered transaxle.

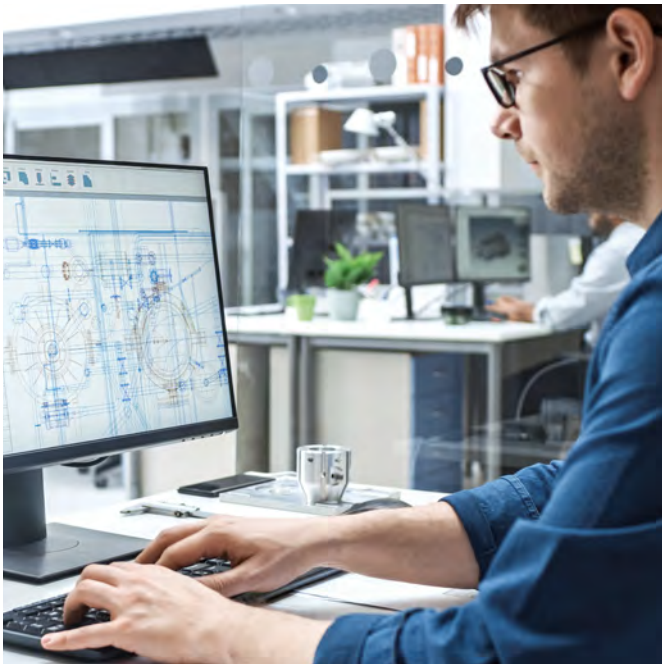
HOUSING DESIGN

Every component of the Mark 400 Transaxle is fully encapsulated within a single-piece casting.

But before ASI began manufacturing transaxles, this wasn't the case for others on the market. In fact, our company was the first to design and sell a fully enclosed transaxle. We've always been flattered to be imitated.

With its single-piece casting, the Mark 400 provides accurate gear-center distances and vastly improved gear alignments. Combined, these two characteristics result in quieter, smoother transaxle operation.

The housing also provides all required mounting features for the Mark 400 Transaxle's PMDC motor. And because the housing is sealed for life to fully enclose the axle, vehicle maintenance required of end-users is minimized while lasting performance is optimized. What's more, the housing's tube section allows for the easy manufacture of various widths without the need for multiple die-cast tools.



WHAT NEXT?

Now that you know how a modern transaxle works, you can feel more confident discussing and sourcing this crucial component to your vehicular applications. ASI Drives, of course, isn't the world's only transaxle manufacturer. But we are a team of innovators, and have spent over three decades advancing the design, engineering and manufacture of world-class transaxles.

If you still have questions about how transaxles work—or would like to dive into every nitty gritty detail—then give us a call. We're always eager to discuss the products and components that drive our passion for precision engineering. Plus, we can help guide you toward the right transaxle for your application.

ABOUT ASI DRIVES

Since 1986, ASI Drives has designed, engineered and manufactured industry-leading gear-drive systems and transaxles out of our facility in Montgomeryville, PA, USA. Our firm's products receive global recognition for their robust construction and worry-free dependability. ASI is a known and trusted partner to companies ranging from small, independent startups to large multinational firms.

TO LEARN MORE,
PLEASE CONTACT

Customer Service at **sales@asidrives.com** or **215-661-1002**.

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