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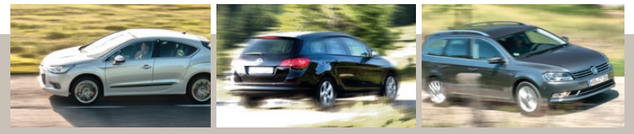
Clutch Systems



For Passenger Cars up to 800 Nm

Driveline and Chassis Technology

Comfort, Performance, Environmental Protection: Powertrain Components and Systems for Passenger Cars

The demands placed on suppliers in the automotive sector are changing dramatically. Increasingly, suppliers are being called upon to integrate components into complex systems – a development task that can only succeed on the basis of close partnerships with vehicle manufacturers. The future will bring continued demands for reduced fuel consumption, emissions, weight and installation space, along with enhanced comfort, safety, and driving dynamics. To meet these goals, innovative solutions and new products are essential.

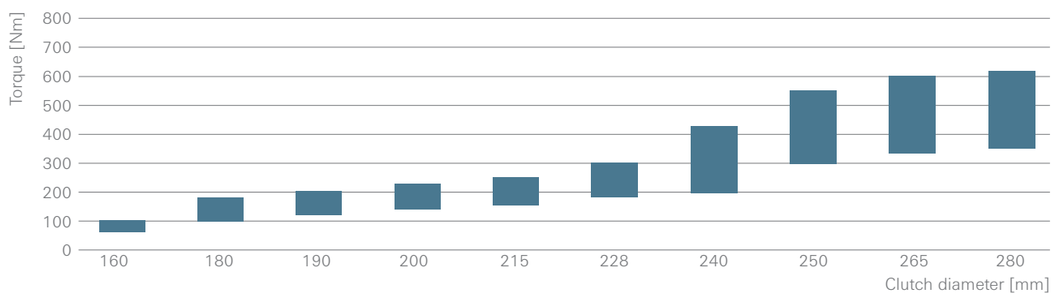
ZF has taken responsibility here, demonstrating expertise in generating comprehensive solutions with its integrated powertrain systems. In doing so, it consistently pursues a systems approach in developing and manufacturing new products and technologies that represent real advances. ZF provides overall solutions that meet the demands of overall systems.

One example: As a powertrain specialist and manufacturer of electric drives, ZF can also provide superior integration for the full spectrum of hybrid powertrain designs and thus offer production-ready solutions that are already reducing fuel consumption and emissions for the vehicles of tomorrow.

Clutch System

A complete clutch system generally consists of a flywheel or dual mass flywheel, clutch disc, clutch cover, releaser, and the clutch actuator. Among the numerous criteria used to determine clutch size and clamp load configuration, maximum engine torque and the resulting friction energy are especially significant.

The greater the clamp load, the smaller the friction radius can be. The diameter should be as small as possible, because it greatly affects clutch weight and cost. But the clutch disc also has to be large enough to handle thermal loads and facing wear.



Clutch Cover / XTend® Clutch Cover

The clutch cover transmits engine torque via the clutch disc to the transmission input shaft. There is a variety of clutches with diaphragm spring for passenger cars. As clutch facings are subject to normal wear, the longer they are used the greater their actuation forces needed on the clutch covers and therefore the greater the pedal forces. With XTend®, this problem is solved by decoupling the wear on the facing from the movement of the diaphragm spring.

Clutch Disc with Torsional Damper

Clutch discs are subject to immense loads during the vehicle's life cycle, and are complex components with compact dimensions. Besides transmitting torque, they have additional tasks such as damping torsional vibrations, ensuring good operating comfort, and offering high thermal resistance.

Clutch Actuation

The clutch actuation system transfers the pressure of the driver's foot on the pedal to the clutch, in order to disengage it. It has to ensure absolute reliability, ergonomic operation, and a high level of comfort throughout its entire service life. Actuation components include the hydraulic transmission line with the master and slave cylinder as well as the mechanical element with the release bearing and lever.

Multi-Disc Clutch

With powerful car engines, single-disc clutches often reach their limits. To bring high performance levels reliably onto the roads, multi-disc clutches are used.

Hybrid Clutch

Many hybrid drives need an additional separable clutch to be integrated into the existing space in addition to the electric motor. This clutch takes on all conceivable hybrid functions, such as electrical driving, especially for electric motors of parallel hybrid drivelines in cars.

Automated Manual Transmission

For automated manual transmissions, the clutch is opened by an electromechanical clutch actuator. After the clutch is opened, the shift operations within the gearbox are taken over by an electromechanical transmission actuator. These two actuators are controlled by an electronic control unit. ZF is a single-source supplier and integrator for all the components including the transmission control unit and software.

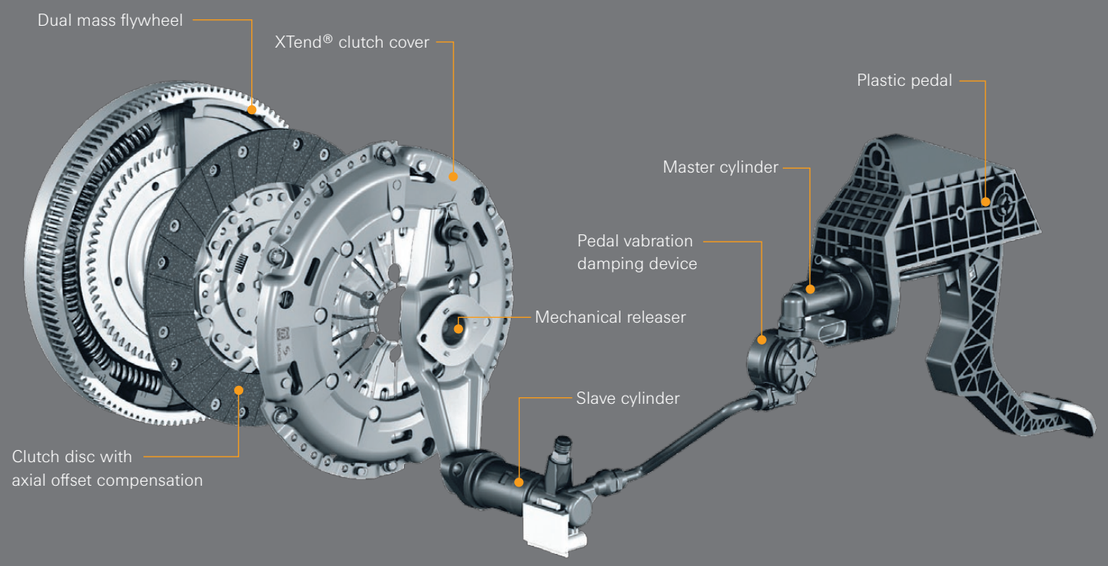
Dual Mass Flywheel DMF

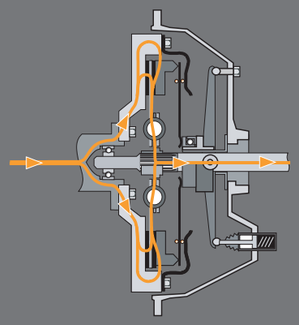
ZF provides different dual mass flywheels to meet the requirements of different powertrains. The entry level is the Mechanical Torsion Damper (MTD) for lower and medium torque ranges. The DMF is made for different power levels as required: The single-row DMF contains a powerful external spring set. In the double-row DMF this is complemented by an internal damper. For very demanding applications the DMF is equipped with an rpm-adaptable damper.

The Clutch System – Cutting-Edge Power Transmission

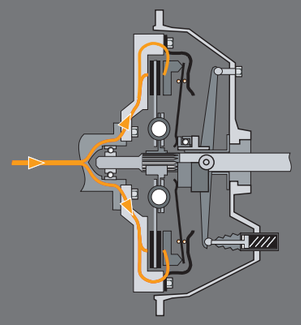
The task:
The technical demands placed on modern clutch systems are many and varied. They include rapid and reliable control of torque transfer, ergonomic operation, maximum service life with no loss in comfort, constant pedal forces, vibrational damping, and minimum installation size.

ZF clutch systems for manual transmissions consist of components that have proven themselves millions of times and that meet the highest standards in all categories.





Power flow – engaged

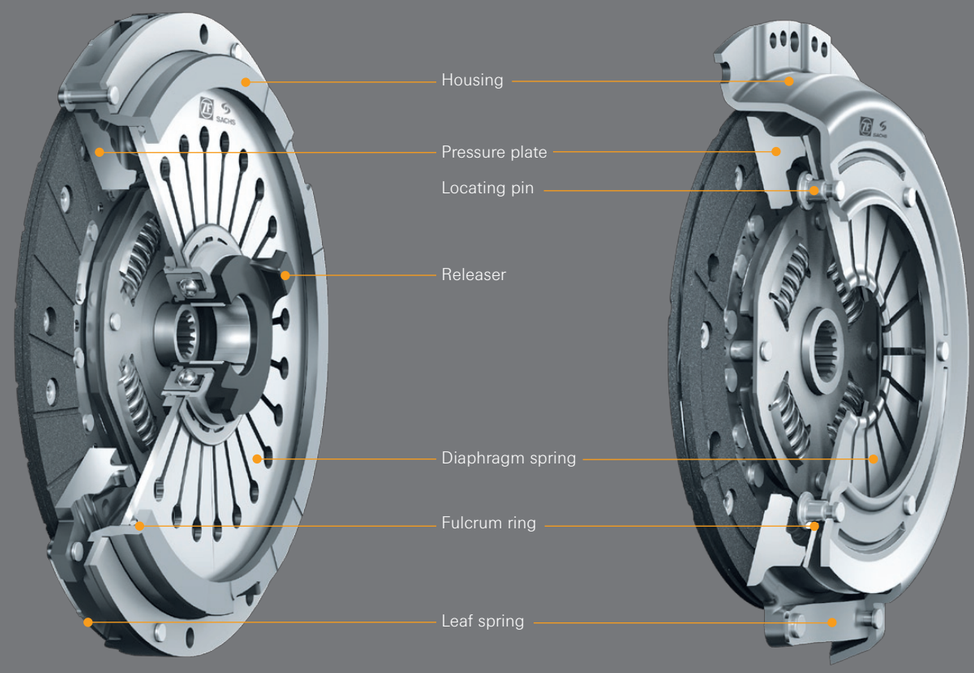


Power flow – disengaged

Benefits
- High torque capacity, compact dimensions
- Low release forces thanks to high degree of efficiency
- Simple design
- Proven technology
- Long service life
- Low weight

Clutch Covers – Reliable Torque Transfer

The technology:
The clutch cover transmits engine torque via the clutch disc to the transmission input shaft. The clutch cover is bolted securely to the engine flywheel and consists essentially of a metal housing and a diaphragm spring with integrated actuation levers. This spring presses the axially displaceable pressure plate against the clutch disc and the flywheel when the clutch is engaged. Its characteristic force curve determines the actuation forces needed to release the clutch. Vibrations, torque, and friction-induced heat – the clutch is subjected to some of the highest levels of stress in the powertrain. The spring must perform reliably after many thousands of shifts, even when the inevitable systems-based wear on the clutch facings in every vehicle alters the load/travel configuration.



Pull-type clutch cover

Push-type clutch cover

XTend® – Clutch Cover with Automatic Wear Compensation

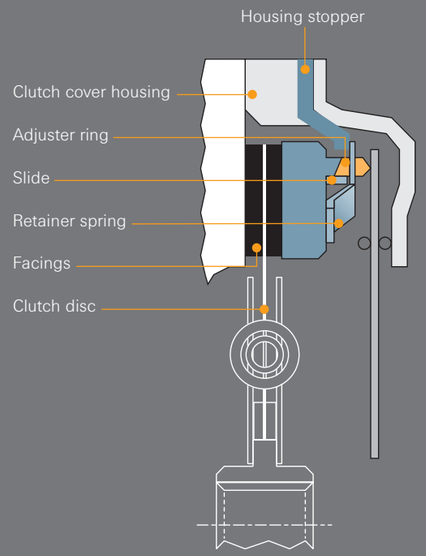
The task:
Although clutch facings have undergone substantial improvement in terms of quality and service life, they are still subject to normal wear, even if the vehicle is operated with care. Reduced facing thickness considerably influences the forces within the clutch system. Release and clamp loads rise, and thus the necessary pedal forces as well. XTend® is the ideal solution to counter wear and the associated negative effects on the powertrain. XTend® clutch covers are suitable for all vehicles with high mileage and clutch loads.

The technology:
XTend®, the clutch cover with automatic wear compensation, decouples facing wear from the movement of the diaphragm spring. The compensation mechanism constantly registers the reduction in facing thickness, and securely offsets this distance by rotating an adjustment ring. This keeps the force ratios constant, and extends the service life because the facings can accommodate additional wear. Another advantage of XTend® lies in its design: It reduces the axial dimensions of the clutch system needed to accommodate normal facing wear.

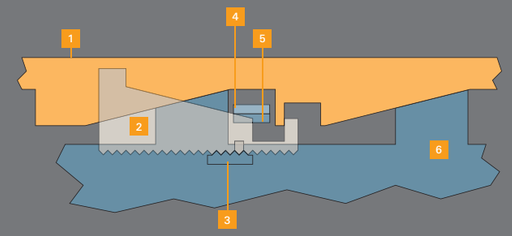
XTend® clutch cover

Benefits
- Constant pedal forces throughout the entire service life
- Flexible adjustment to individual vehicle requirements
- Resistance to extreme temperatures, dirt, and aging
- Smaller axial dimensions
- Easy to install and service

Clutch in new condition



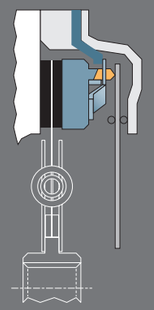
Principle of wear compensation



1 Adjuster ring
2 Toothed slide
3 Toothed disc
4 Retainer spring
5 Stopper
6 Pressure plate

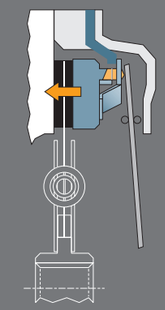
Clearance adjustment during clutch action

1



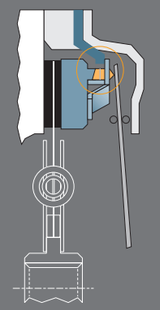
Clutch in new condition

2



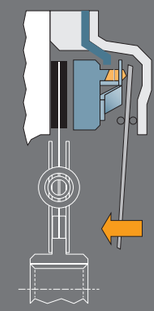
When wear occurs, the clutch cover moves toward the flywheel.

3



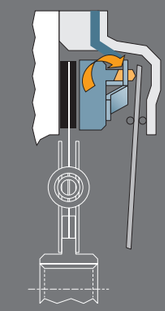
The stopper raises the retainer spring from the adjuster rings, the slide fills the gap.

4



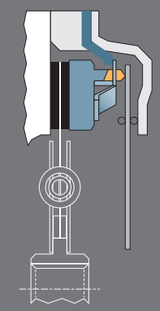
When the clutch is released ...

5



... the adjuster ring compensates for the wear.

6

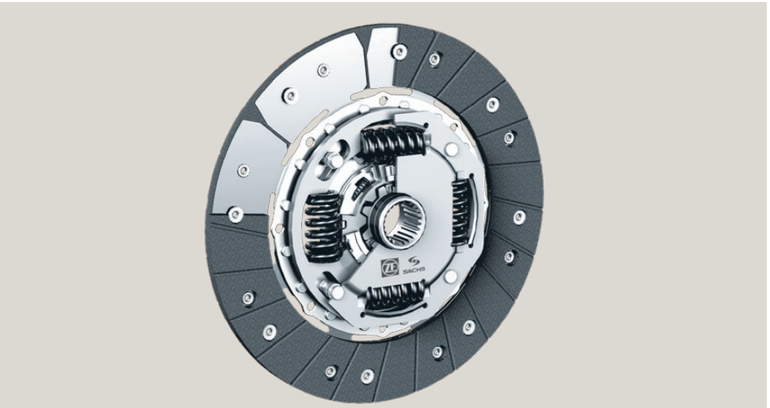


The clutch has compensated for the wear and the system is reset to its initial force and path settings.

Clutch Disc with Torsional Damper – Peace and Quiet in the Powertrain

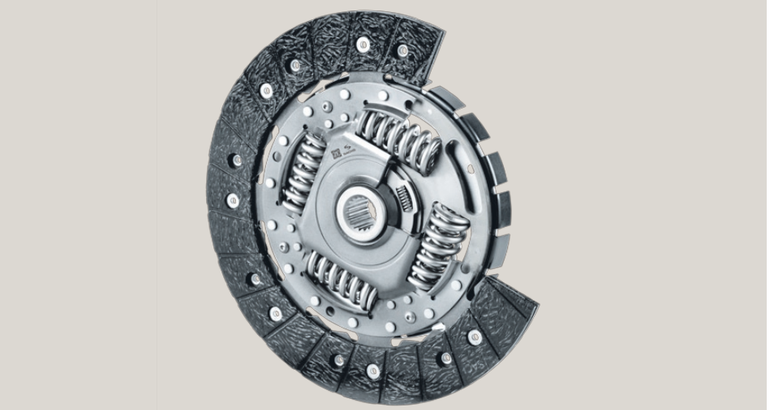
The task:
Ignition-induced irregularities in rotational speed and rapid load alterations generate vibrations in the powertrain, which in turn cause disturbing noises in the vehicle body and unpleasant rattling in the transmission. Modern engines are featuring smaller displacements and super-charging (down-sizing) in order to reduce fuel consumption. These engines generate high levels of torque at low rpm levels (down-speeding). This constellation of engine characteristics leads to an increase in torsional vibrations. Yet drivers continue to demand higher performance from their damping systems.

The technology:
The torsional damper integrated in the clutch disc is the main element for adjusting torsional rotation properties throughout the powertrain, from the combustion engine to the wheels. This effective vibrational damping system consists of a friction unit and spring sets for both driving and idling. Coil springs positioned in windows allow a limited degree of rotation between the crankshaft and the transmission input shaft. Torsional dampers are individually tuned because each engine/transmission aggregate has its own characteristics. The resulting superior spring and damping characteristics generate outstanding decoupling qualities.



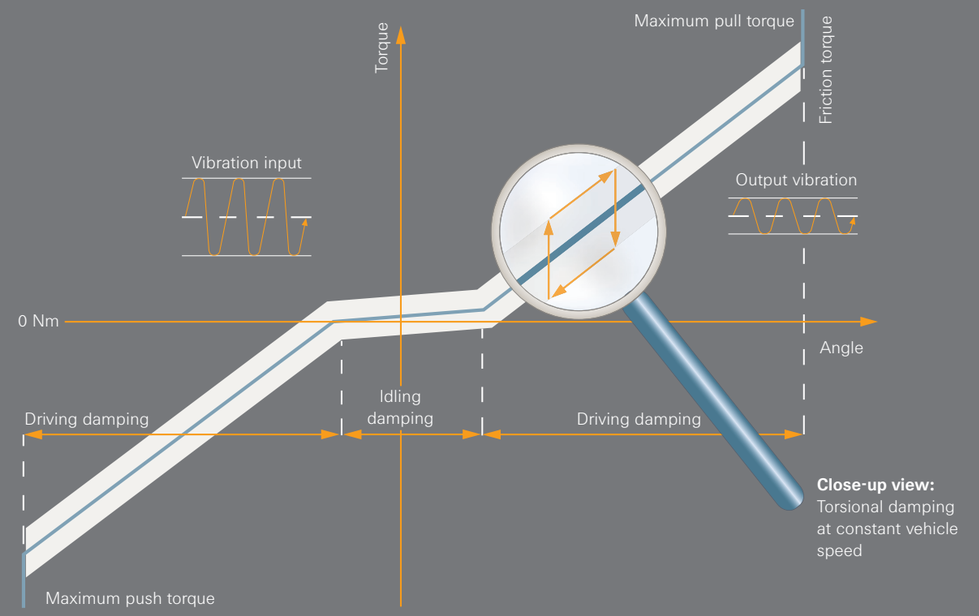
Benefits
- Complex individual characteristics
- Compact construction
- Low inertia
- Modular design

Clutch disc with torsional damper
The torsional dampers are tuned for the characteristics of each vehicle model. Thanks to multistage main dampers and extra preliminary dampers, engine vibrations are effectively minimized both when idling and driving.



Clutch disc with torsional damper and centrifugal force-dependent friction
The clutch disc changes the damping behavior as a function of engine speed. This property enables pronounced torsional vibrational activity to be decoupled from two and three-cylinder engines.

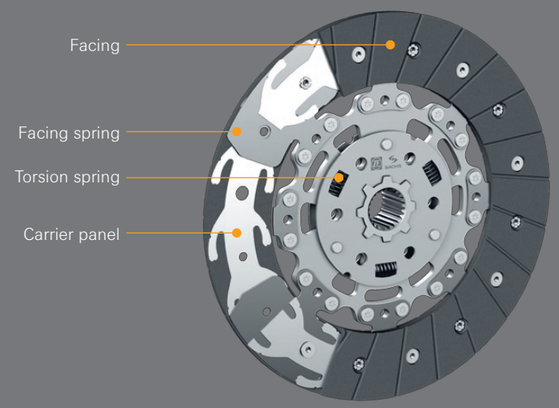
Vibrational damping in a torsional damper – torque and angular travel



Clutch facings: Long-lasting and environmentally friendly

By enabling carefully calibrated slippage in the launch phase, the friction facings and cushion springs allow precision torque calibration and are therefore responsible for the gentle clutch engagement needed to start vehicles smoothly. Clutch facings are made of a number of carefully matched materials: glass or aramide fiber together with copper or brass wire, embedded in a mixture of resin, rubber, and fillers. Especially when launching under tough conditions, but also under normal driving operations, the facings are subjected to high friction speeds, strong clamp loads, and extremely high temperatures. During all these types of conditions, drivers still expect full performance. Clutch facings from ZF contain no lead and are manufactured via environmentally friendly processes and comply with EU vehicle recycling regulations.

S-Tec
The thin facings on the clutch disc feature very high burst resistance, constant engagement performance over the entire service life, higher wear volume, better heat storage capacity, and lower space requirements.



Clutch Actuation – Pressure Under Control

The task:
The hydraulic clutch actuation system transfers the force exerted by the driver's foot on the pedal to the clutch, in order to disengage it. It has to ensure absolute reliability, ergonomic operation, and a high level of comfort throughout its entire service life.

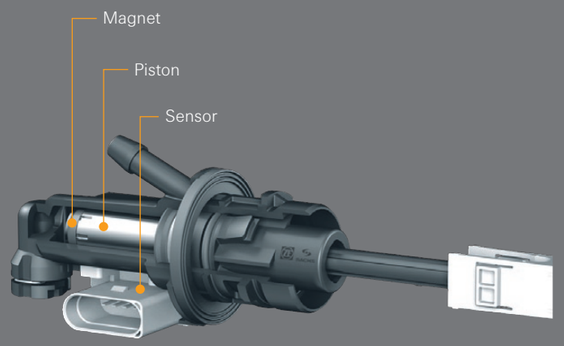
It is important for the driver to get a good, subjective "feeling" for the pressure point. ZF offers the entire system from a single source. Thanks to comprehensive expertise in this system and its interfaces, the individual actuation components can be ideally adjusted to the vehicle design.

The technology:
The hydraulic clutch actuation system consists of a hydraulic and a mechanical subsystem. The hydraulic subsystem comprises the master cylinder and its connection to the brake fluid reservoir, the pressure line, and the slave cylinder mounted to the transmission housing. The mechanical subsystem is located inside the clutch housing.

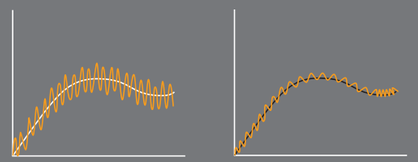
When the driver pushes down on the clutch pedal, the stroke is transferred to the clutch via the hydraulic subsystem with the help of the release lever. An improved over-center spring system in the pedal mechanism can reduce pedal forces and thus relieve stress on the clutch actuation. Additional components such as the pedal vibration damping device and the peak torque limiter can be integrated to enhance comfort and functional properties. Together with an electromechanical parking brake, an integrated sensor system prevents vehicles from rolling backwards even when the clutch is not engaged.

Slave cylinder
The slave cylinder actuates the releaser lever. An integrated compression spring ensures that the releaser is preloaded to the diaphragm spring.

Master cylinder
The master cylinder with displacement sensor prevents the engine from starting when the clutch is engaged, and switches off the cruise control as soon as the clutch is released.

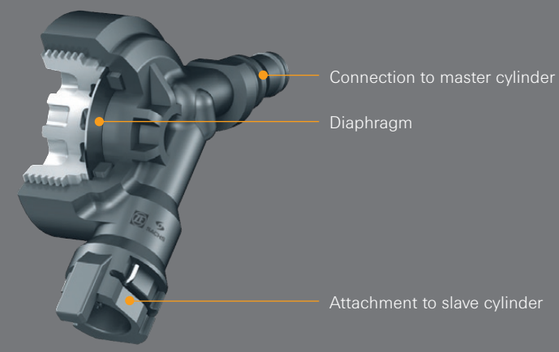


Pedal vibration damping device
The pedal vibration damping device suppresses axial crankshaft vibrations by having two diaphragms compensate for pressure. Multiple fluid redirectional processes take place inside the filter.

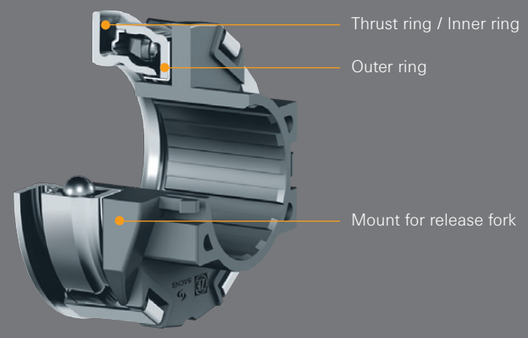


Pressure pulsation without damping device

Pressure pulsation with damping device



Ausrücklager
Das Ausrücklager ist das Übertragungsglied zwischen der rotierenden Kupplung und dem ruhenden Betätigungssystem.



Multi-Disc Clutches – Handling Extreme Loads

The task:
Powerful car engines and sports-oriented driving styles place high demands on transmission reliability and thermal capacities.

The technology:
Multiplying the number of friction surfaces increases the torque and thermal capacity while making the best use of installation volume. Thus, minimizing the inertia for clutch disks preserves the transmission synchronization and makes shifting more dynamic. In its regulation of torque flow, the intermediate plate control provides a reassuring level of comfort.

The MF2/228 multi-disc clutch for high-end standard series production handles high friction levels thanks to its large heat-absorbing surface, and can transmit torque levels of up to 800 Nm; load control for the intermediate plate ensures comfort and reliable functioning.

Benefits
- Excellent transmission reliability
- Optimum use of installation space
- Lower actuation forces
- Flat characteristic force curve
- Low moment of inertia
- Short length for clutch disc hub

Hybrid Clutch – Integration Expertise

The task:
For many hybrid drives it is necessary to install an additional separable clutch in addition to the electric motor in the existing installation space. This clutch enables all conceivable hybrid functions such as electric driving, especially for electric motors of parallel hybrid drivelines in cars. Hybrid clutches have to be adapted to typical hybrid requirements.

The technology:
As a systems provider, ZF can supply hybrid modules which have the clutch completely integrated into the electric motor. For these systems, the electric motor components perform additional clutch functions, and vice versa, in order to meet installation space requirements. Hybrid clutches are adapted in the best possible way to meet concrete requirements. They build on standard-series production of manual transmissions, but also provide additional functions.

With the dynamic starter clutch, the rotating electric motor propels the stationary combustion engine to its operating speed by engaging the clutch in less than 0.3 second, without undesirable side effects. This clutch can also transmit extremely high torque levels.

Benefits
- Dramatic reduction in fuel consumption and emissions
- Very fast and quiet engine start and therefore comfortable start-stop operation
- Recuperation of electric energy from braking
- Improved driving dynamics thanks to power boost for combustion engine during acceleration
- Purely electric operation (no emissions) by separating the combustion engine from the driveline

Automated Manual Transmission – Intelligent Gear Shifting

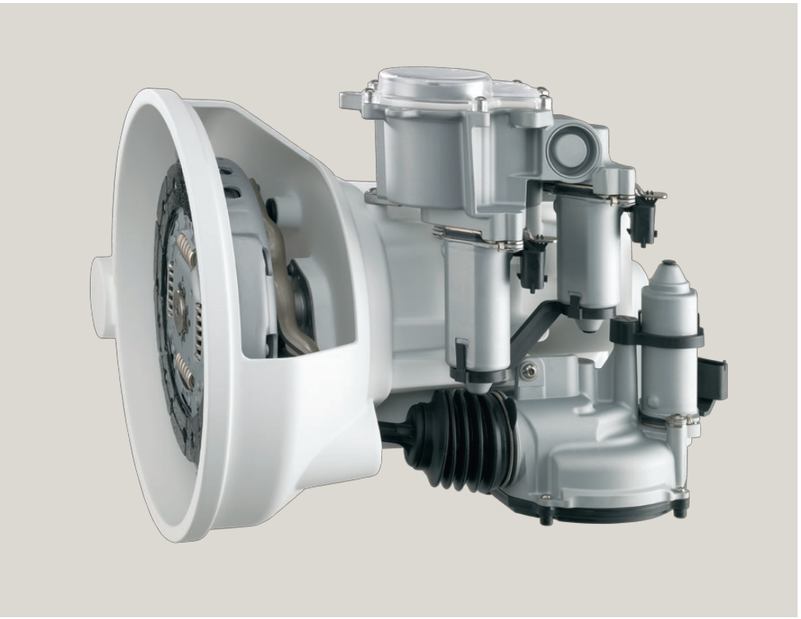
The task:
To best meet demands on the part of drivers, the automobile industry, and legislators for lower fuel consumption and emissions, it is essential to raise the level of efficiency in the powertrain. Moreover, components from ZF can also be used to automate manual transmissions and thus improve comfort in vehicle categories that cannot have automatic transmissions for reasons of weight, installation space, or cost.

ZF provides the overall system with actuators, TCU, software and shifters from a single source, and can thus assume leadership of the system development process. Complete expertise with the system and its interfaces means that the individual actuation components can be adapted optimally to vehicle designs.

The technology:
In automated manual transmissions, electromechanical or hydraulic actuators take over the clutch and shift actions. In either case, individual driving pleasure is not diminished because drivers can decide whether they want to use the automatic mode or shift manually using switches or levers.

With their optimized shift strategies, automated manual transmissions reduce torque interruption to a minimum. Sensors register and convey all the relevant information to the control system. Using this data, the system calculates the shift points and controls the shift and clutch processes automatically. The technology even intervenes in driving operations to improve safety – such as automatically interrupting the torque flow briefly to counter the risk of skidding. Automation components can also be used in start-stop as well as hybrid applications. Buyers of standard cars are already enjoying greater comfort thanks to ZF components for automated manual transmissions.

Automated manual transmission

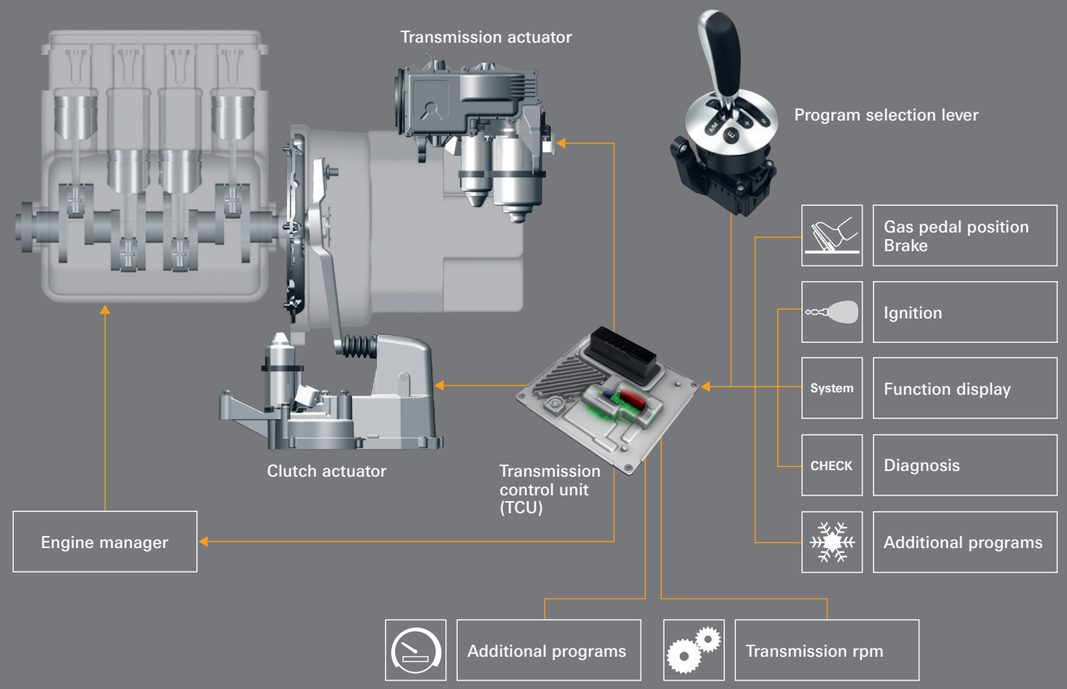


Benefits
- Full driving comfort – no clutch actuation, no shifting
- Prevents error during shifting
- Lower cost and weight, smaller space claim than automatic transmissions
- Allows manual shifting and thus individual driving styles
- Separate programs for sportive driving, bad weather conditions or slippery or icy road conditions and trailer use
- Reduced fuel consumption due to electronically optimized shift points and high mechanical efficiency

MT/AMT comparison

Parameters	MT	AMT	Comment
Fuel consumption	+/-	++	Fuel consumption reduced by shifting to automatic mode at the optimum point in time
Emissions	+/-	++	CO_2 emissions lowered by shifting to automatic mode at the optimum point in time
Costs	++	+	Favorably priced automation alternative compared to other common systems (dual clutch, automatic transmissions)
Driving comfort	+	++	Driver and passenger comfort markedly increased by shifting to automatic mode at the optimum point in time

Schematic diagram of an electromechanical automation system



Dual Mass Flywheel DMF – Multi-Stage Vibrational Damping

The task:
Passenger car engines with optimized fuel-consumption levels are becoming ever more powerful despite smaller displacements and fewer cylinders. To drive on less fuel, the engine's useable rpm range has been shifted toward the idling range. This has led to a marked rise in rotational irregularities in the combustion engine. To continue to provide rumble-free driving and to protect the powertrain from harmful vibrations, effective vibrational damping is needed.

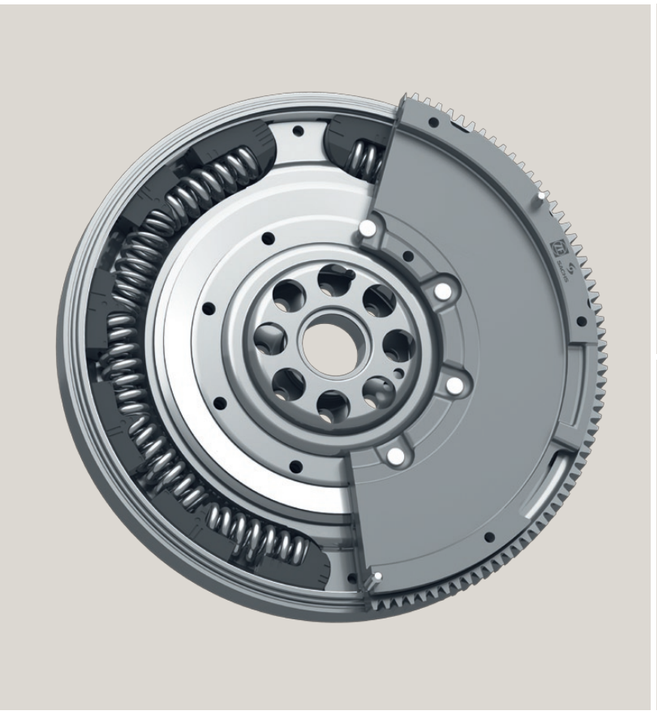
The highly effective DMF models from ZF provide optimum torsional damping.

The technology:
The dual mass flywheel is installed between the engine and the transmission along with the clutch cover and clutch disc. The DMF and the MTD both consist of a primary and a secondary mass, which are connected by a lubricated spring set. The primary mass is bolted to the crankshaft and carries the starter ring gear. The primary and secondary masses are mounted such that they can rotate independently. The spring set has a modular design, which allows characteristic curves to be varied and optimized. It consists of compression springs as well as compression spring guide elements which are made of high-strength plastic. The properties of the polyamide plastics are selected by application-specific compounding.

All DMFs from ZF have multi-stage torsional characteristic curves. This is achieved by combining different quantities of compression springs with different rigidities. The soft initial stage ensures excellent engine starting and stopping behavior. Subsequent harder stages provide effective torsional vibration decoupling and sufficient overload protection at normal driving speeds.

A further improvement in torsional vibration damping is achieved by a DMF with a double-row spring set. The second spring set is located radially within and downstream from the first, which substantially decreases the DMF's torsional rigidity. The inner damper's compression springs operate with low friction at both high engine rpm and torque levels. A DMF with an rpm-adaptable damper provides excellent torsional vibration decoupling. The rpm-adaptable damper operates on the DMF's secondary mass and is located within the outer spring set. The rpm-adaptable damper vibrates inversely to the rotational irregularity remaining from the DMF spring set, which nearly eliminates residual rotary vibration amplitudes. This additional vibrational damping enables vehicles to be driven at high loads without annoying noises from idling speeds on up.

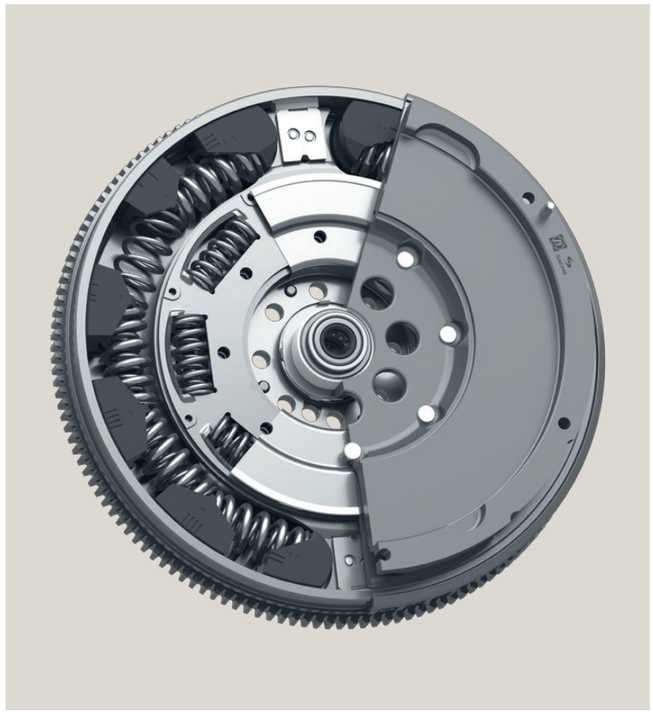
Single-row DMF
For engines with low and medium torque ranges up to 400 Nm.
Straight compression springs. Multi-stage characteristic curve.

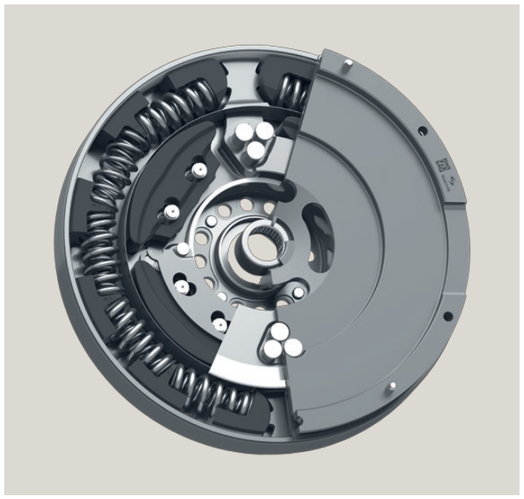


Mechanical Torsion Damper
For engines with low and medium torque ranges up to 350 Nm. Additional friction unit with speed-dependent effect.

DMF TD with direct output.
Application for CVT, dual clutch, and hybrid transmissions.

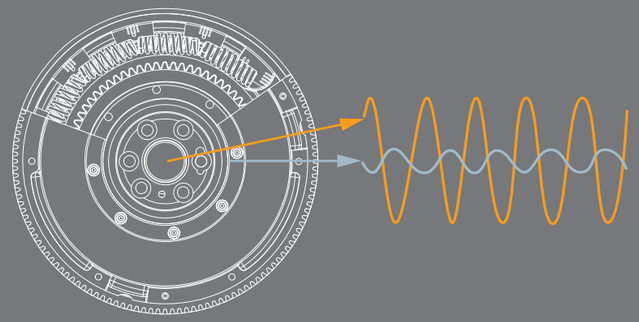
Double-row DMF
For engines with medium and high torque ranges > 350 Nm.
Additional inner damper for high driving comfort.





DMF with rpm-adaptable damper
Swing-mounted flyweights for vibrational damping.
Application for highest comfort requirements.

DMF at a Glance

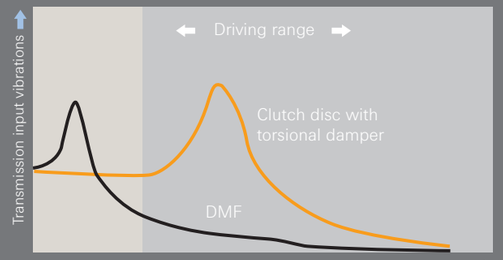


Benefits

- Less noise
- Easier to shift gears
- Outstanding vibration damping throughout the entire rpm range
- Easily adjusted to vehicle designs
- Smooth start/stop performance
- Long service life
- Smaller dimensions
- Pull and push-type clutches possible
- Reduced fuel consumption because vehicles can be operated at lower rpm levels

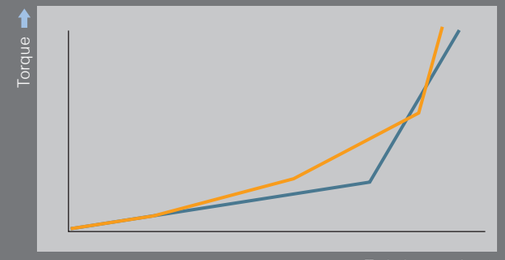
The flywheel is divided into a primary and a secondary mass. Together with the spring set, it effectively isolates torsional vibrations.

Comparison of clutch disc vs. DMF



For a torsional damper in the clutch disc, the resonance rpm lies in the lower engine speed range, but for a dual mass flywheel it lies well below the engine idling speed.

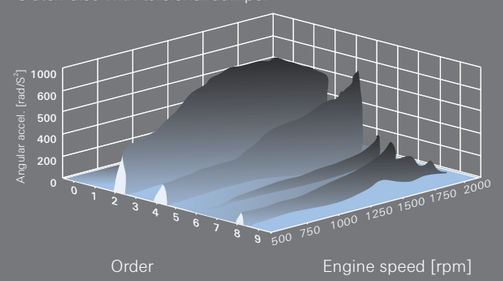
Two and three-stage DMF characteristic curves



A typical DMF characteristic curve. It starts with a soft initial stage, followed by considerably harder stages. The first stage features a minimum degree of stiffness in order to keep the DMF natural frequency low.

Comparison of vibration damping

Clutch disc with torsional damper



Dual mass flywheel