

FACT SHEET XXL

48 VOLT

SCHAEFFLER

New dynamism in the car

More dynamic and more economical

Schaeffler reveals the advantages
of 48-volt systems



Hybrid concepts

One idea –
many possibilities

p. **4**



Recuperation

Environmentally
friendly and efficient

p. **8**

Editorial



Matthias Zink
Member of Executive
Board of Schaeffler AG,
Co-CEO Automotive

Welcome to the subject of 48 volts! Schaeffler was pioneer of this automobile technology in 2013 and consequently paves the way in mobility for tomorrow. In the meantime, a broad spectrum of ideas can be realized with 48 volts: it starts with hybridization and

stretches to handling dynamics and comfort features. The automobile becomes more economical and more dynamic at the same time – and this at very competitive prices. Read and find out for yourself just what is possible with 48 volts.

Contact

Schaeffler Technologies AG & Co. KG

Jörg Walz

Communications and Marketing

Schaeffler Automotive

Industriestr. 1–3

91074 Herzogenaurach

presse@schaeffler.com

www.schaeffler.com

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48

It's not actually that easy to explain the jump from 12 to 48 volts. However, efficient mild hybrid 48-volt drivetrains are a decisive step in order to make the combustion engine fit for tomorrow's mobility

Do you remember? You know, the good old Beetle had a 6-volt power supply system, before 12-volt vehicle electric systems finally established themselves industry-wide in the 1960s. Now, automobile technology faces its next hurdle: Schaeffler has, as first company, shown in demonstration models and with individual technologies what is possible with 48 volts. The background is the ever-increasing energy demands made by modern cars. It was only around two decades ago that the era of modern driving assistance systems and multimedia systems began. In addition, comfort – such as electric heating or adjustment technologies – and safety place increasingly higher demands on the systems. The laws of physics sets 12-volt systems limits in the process. Ohm's Law states that voltage is the product

Electric boosts sport feeling Schaeffler's 48-volt system not only increases the efficiency, but also the dynamism through additional power



volts

why?

of resistance and current. The more electric consumers there are in a car, the higher the resistance. If you now quadruple the voltage from 12 to 48 volts, greater power (see info box) can be realized for reduced cable cross sections, which in turn boosts efficiency.

48-volt systems: lighter and more cost-effective to handle

One advantage is evident: owing to the higher voltage, the wire cross-section remains low despite ever-new consumers – approximately 75 per cent smaller than if using 12-volt systems. As a result, the wiring loom remains light, compact and inexpensive. Furthermore, 48 volts is a low-voltage system and thus within a harmless range for humans. So, there are no separate safety requirements as there are for high-voltage systems in full hybrid models. From installation to maintenance, 48 volt systems are significantly easier and cheaper to manage at all stages of the value chain.

Nonetheless, they also offer huge potential: 48-volt models can be elegantly hybridized as Schaeffler demonstrates. Start-Stop systems are characterized by improved starting comfort and rapid response. A mild hybrid with 48 volts is sufficient to pull away, to roll along electrically in a traffic jam or to actively coast. A 48-volt hybrid module sinks consumption by over 15 per cent compared to conventional power units. As a result, CO₂ emissions are clearly reduced at modest costs. The higher system voltage also simultaneously guarantees greater generator power – this helps during regenerative braking.

Many recuperation areas in the New European Driving Cycle (NEDC) are even completely covered. Which other ideas become reality with a 48-volt system are revealed on the following pages. ■

Thinner cables, more power

Cable thickness

12 V

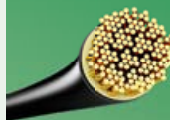


Max. power

3 kW



48 V

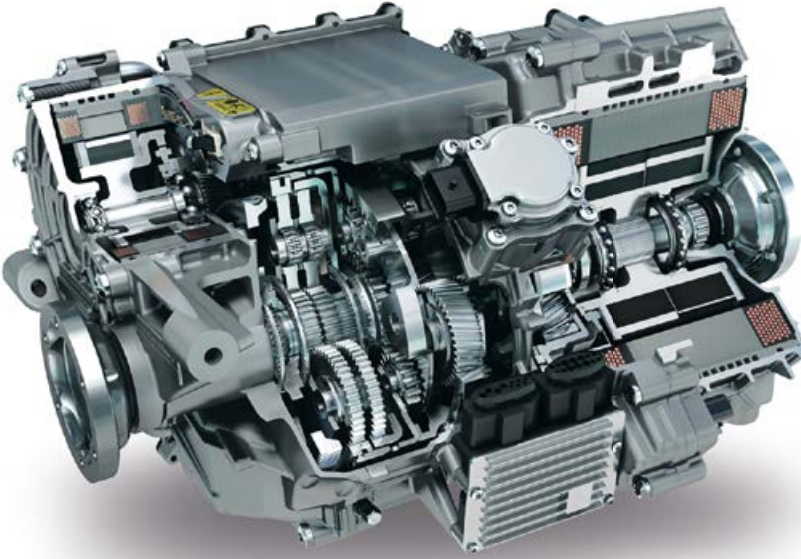


12 kW



Increasing the voltage to 48 V not only makes it possible to raise the power limit to a total of 12 kW (i. e. a fourfold increase), it also allows the conductor cross-section to be reduced by 75% at the same time. This has a positive effect on the weight, cost, and design envelope of the cable harness.

All-purpose solution With the electric axle, Schaeffler offers a highly interesting product family. The drive component is of modular design and thus adaptable to suit specific customer requirements



One idea – many solutions

48-volt systems provide technicians with a broad range of possibilities. Innovative electromobility architectures opens up new freedoms on drivetrains. Schaeffler supplies the appropriate answers

With mild hybridization there are no less than five different installation positions conceivable:

P0 E-motor features conventional belt drive. Aligned with the transmission, this system is installed in front of the engine. Affordable entry level in 48-volt hybridization. Specific advantages when restarting, but also when boosting.

P1 This configuration combines the E-unit, starter and generator and reduces installation space. Advantage: simple and cost-effective solution. Disadvantage: combustion engine and transmission cannot be decoupled. Recuperation is thus not very efficient, pure electric operation not viable.

P2 Here, the E-Motor is placed between the combustion engine (can be decoupled) and transmission. Inexpensive, compact. Easily integrated in vehicle concepts. Driving modes “boost” and “coasting” as well as pure electric running are possible. Consumption and emissions significantly reduced.

P3 E-Motor in transmission or on transmission output. Increased space requirements. Can be decoupled (e.g. via Schaeffler’s E-Clutch). Subject to configuration also pure electric crawling or parking possible (2-speed version).

P4 Separate E-axle not connected to the combustion engine. Allows upgrade to all-wheel drive.

Schaeffler’s many inventions

The Schaeffler engineers have system solutions for several architectures and variants on offer. To position the efficient, belt

driven starter generator in front of the engine in P0 configuration, Schaeffler products like the belt tensioner, idlers and tensioners or the water pump bearings are indispensable. In addition, Schaeffler has developed a pulley featuring integrated de-coupling module. The functional advantages of the system, which is bolted directly to the crankshaft, and operates according to the bow spring principle are reduced resonances, irregularities as well as dynamic forces, and thanks to lower belt tension the frictional losses are significantly reduced. This has a positive effect on consumption and CO₂ emissions. The pulley decoupler (PYD) is suited for conventional as well as belt start-stop systems and in this case also supports the boost and recuperation functions in hybrid configurations. The robust solution is designed for over 1,000,000 starts. Schaeffler also offers a switchable PYD. This solution allows decoupling from the crankshaft. In this way, a mechanical AC compressor can be

P0 configuration E-machine (1) and AC compressor (2) are connected to the engine via a pulley decoupler (3)



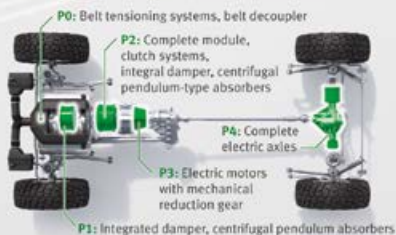
Efficient hybrid solutions

Schaeffler has a **wide range of products** for efficient electrification of the powertrain. For the American market, Schaeffler has brought together its expertise in torque converters and advanced hybrid modules. Its recently developed **P2 high voltage hybrid module with an integrated torque converter** will be available for the first time in 2020 in North America.



A question of positioning

The installation position of hybrid modules and electric motors in the powertrain determines the function and overall performance. There are five different variants - **P0 to P4**. The **P2 hybrid module** - positioned between the internal combustion engine and the transmission - enables particularly efficient electrification of the powertrain. A selection of **suitable solutions** from Schaeffler for all other integration variants are:



P2 hybrid module

The combination of the hybrid module and torque converter provides high efficiency levels. The module has a compact design due to the integrated converter which requires significantly less space than the conventional P2 module architecture.

powered electrically when the combustion engine is switched off.

For the P2 configuration, Schaeffler has developed two solutions – a disc-shaped construction as well as a coupling via belt drive. The disc-shaped P2 hybrid module fits elegantly in the installation space between engine and transmission. It integrates an E-machine with a disconnect clutch and one-way clutch. Customers are pleased about the many advantages: the system can recuperate energy when braking and facilitates pure electric drive under certain conditions, such as for E-creeping. This means when creeping along in slow-moving traffic. The driver can also park and maneuver using pure electric power. Furthermore, Schaeffler's P2 hybrid module supports the so-called "coasting" and "boosting" (more rapid acceleration with E-motor support). Simultaneously, the engine, which is deactivated and decoupled from the transmission, saves fuel thanks to the start-stop function. A Schaeffler integrated automatic clutch ensures greater convenience when restarting the engine. It helps the engine to rev up immediately after starting – the car pulls rapidly away without power loss. The car's transmission remains unchanged with this architecture. This is a significant cost benefit. In this case, an additional engine start system is unnecessary. Without great expense and without electrical safety measures like those required for high-voltage systems the P2 module is thus an elegant solution at reasonable cost.

Inexpensive hybridization

The P4 configuration ultimately opens entirely new possibilities. If the combustion engine drives the front wheels, as is the case in many cars, the electric drivetrain in this case can be integrated as dedicated drive for the rear wheels. The 48-volt motor permits E-creeping as well as stop-and-go driving, turning, parking, boosting to support the combustion engine and also coasting and

recuperation during braking. Thanks to ingenious transmission technology, torque vectoring can also be realized on the rear wheels: if for example the outside wheel in the corner is fed more torque, the car seems more eager to turn into corners and handles better – it supports the driver's chosen steering direction. If it's a question of ultimate traction, the customer can even use all-wheel drive with P4 configuration. With this inexpensive form of hybridization, more than 15 per cent of emissions can be avoided.

New force

Just which potential harbors in the 48-volt technology pursued primarily by Schaeffler is also reflected in this value: with this system, Schaeffler currently tests power of 20 kW – more than the first VW Beetle's combustion engine produced, but also more than the high-voltage E-cars transferred to the road two decades ago. ■

P2 module The compact module connects E-drivetrain and clutch to the transmission



Minimal outlay – *significant revenue*

Schaeffler Chief Technology Officer and Deputy CEO Prof. Peter Gutzmer reveals the many advantages of 48 volts in the car of the future

Why is Schaeffler backing 48-volt technology?

The 48-volt technology is ideal to make automobiles with combustion engines significantly more efficient. It can produce exactly that what combustion engines are not capable of doing: energy recuperation and therefore putting it to productive use again. There are different possibilities how we reemploy this energy. Our 48-volt concept shows just how dynamism and efficiency can be integrated with moderate effort and in many ways into an interesting concept. In comparison to high volt models, our concept vehicle requires very low voltage in order to sink the consumption significantly.

What other milestones do you see on the development route that you demonstrate?

When we presented our technology at the IAA 2013, we were the initiator and pioneer of this idea. In the meantime, the industry recognizes just how beneficial it can be. With the 48-volt hybrid drive, we are now testing 20 kW output, so 27 HP. In addition, we have long since integrated other systems like the active roll control into the architecture. It prevents excessive lateral roll in corners and requires less energy in the process than a hydraulic system. Other electromechanical systems should also benefit in the future from the 48-volt architecture.

Dynamism also repeatedly plays a role in your concepts. What contribution can 48-volt technology make in this respect?

We have presented different configurations. A 48-volt system can be integrated in quite different ways. With the so-called P4 configuration, we focus on a pure electrically powered axle. It permits all-wheel drive as well as active torque distribution meaning torque vectoring. In this way, the driving dynamics improve dramatically and the customer's enthusiasm grows. Momentum can develop from this – mild hybrid powertrains do not mean making sacrifices, but in fact represent a plus on driving fun and efficiency. ■

Prof. Peter Gutzmer
Deputy CEO and
Chief Technology
Officer

“Mild hybrid powertrains do not mean making sacrifices, but in fact represent a plus on driving fun and efficiency”



New free in the entire car

The E-clutch permits a particularly cost-effective start in mild hybridization with 48 and 12 volts. Thanks to a combination of electronics and mechanics, Schaeffler automates the classic mechanically or hydraulically operated

clutch. The big advantage: the module builds on many existing elements and supports driving strategies that reduce fuel consumption. For example, the engine can be turned off when rolling. A manual transmission is still as

CLUTCH BY WIRE – AUTOMATED CLUTCH

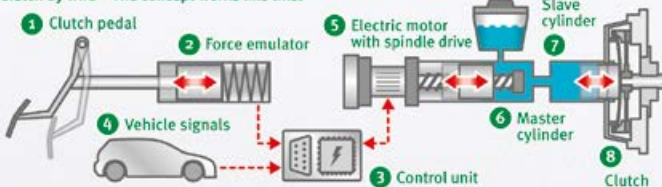
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Clutch by wire is a conventional manual transmission as far as the driver is concerned – but as the name "by wire" indicates, there is no direct hydraulic or mechanical connection between the clutch and the clutch pedal. The clutch is actually operated by modern actuators from Schaeffler. The system can therefore take control at any time to increase driving comfort, safety and efficiency using stored driving strategies.



Graphics: www.josekdesign.de

Clutch by wire – The concept works like this:



When the clutch pedal is actuated (1), the position of the pedal is detected by a force emulator (2) and interpreted together with additional data such as vehicle signals (4) by the control unit (3). This data is used to derive the clutch target moment, which is set by the electric motor (5) using the spindle drive and is transmitted to the clutch (8) by the movement of the spindle drive via the master cylinder (6) and slave cylinder (7).

Comparison of electric clutch systems

Electrification & efficiency



48 V hybrid capability

Comfort & safety



No pedal

Automatic functions



Clutch protection



Start-stop assistance



Optimum pedal force



Automatic parking

ECM

Clutch by wire

MTplus



Sailing

dom

Recuperation, automatic clutch operation, and electromechanical roll stabilizer – a car’s drivetrain is just one area that can benefit from 48-volt architecture. With diverse systems and components, Schaeffler demonstrates which newfound freedoms arise

before the most common version in emerging economies, but also up to and including the mid-range model segment in Europe.

Three possibilities for the clutch

Schaeffler offers three grades of automation for conventional manual transmissions, in order to facilitate coasting and in turn to sink consumption: the variant MTplus continues to use hydraulic activation. Thanks to the additional actuator in the pressure line, the engine and transmission can be decoupled automatically at constant speed by automatic disengagement and the engine temporarily switched off. Between two and six percent fuel can be saved in this way, in urban traffic even eight percent is possible.

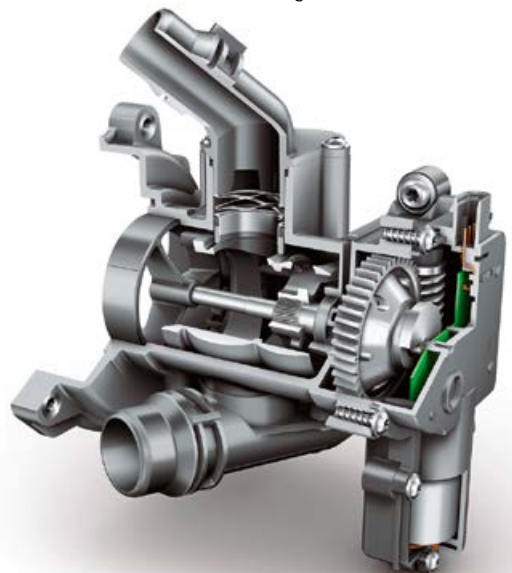
The second version called clutch by wire with an electric actuator and pedal force adjuster replaces the mechanical or hydraulic connection. The system is even more efficient and dynamic than MTplus. In the concept vehicle “Gasoline Technology Car” from Schaeffler, Ford and Continental, this clutch makes an enormous contribution to reducing consumption by 17 percent.

The third variant, the electronic clutch management EKM, functions completely without a clutch pedal. A sensor activates the clutch when the driver prepares to shift gear. This high level of automation is ideally suited for cars featuring 48-volt mild hybridization, which run fully electrically when parking or in stop-and-go traffic.

The mild hybrid drivetrain is really gaining momentum, not least due to the diverse array of Schaeffler innovations from eMobility Systems division. The combustion engine can remain idle more often in the future. However, this means that it warms up slower than when running constantly – and this in turn is not ideal.

Nevertheless, to bring the engine into the ideal temperature range as quickly as possible and therefore to achieve the lowest possible

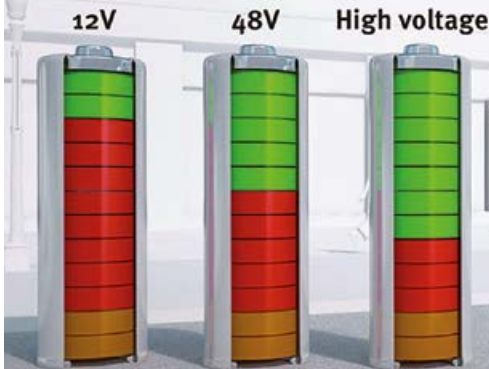
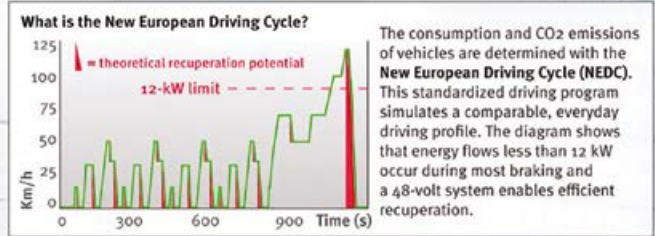
Always at the perfect temperature The thermal management module regulates the coolant flow



RECOVERY OF BRAKING ENERGY

SCHAEFFLER

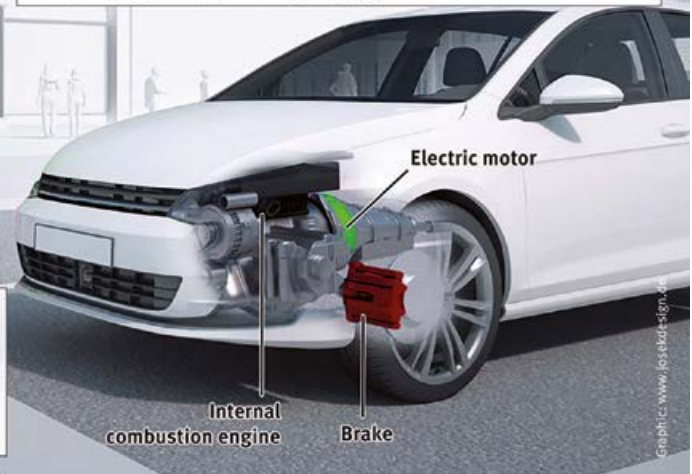
Up to now, braking energy was lost in the form of heat. Modern hybrid components enable the recovery of braking energy (recuperation). The performance of the components in electrified drive trains is a decisive factor. A low-voltage power system with 48 volts allows energy flows in the order of up to 12 kW – and is sufficient for significant, fuel consumption-reducing energy recovery.



Recuperation capacity depending on voltage of electric system

An increase in voltage from 12 V to 48 V significantly increases the recuperation capacity. Slightly more braking energy can only be converted into electrical energy with a high-voltage system.

- Energy recovery
- Unused braking energy due to losses
- Road resistance



frictional losses, Schaeffler has a thermo management module available. It can divert the coolant downstream from the cooler. In this way, the operating temperature is achieved more swiftly and thanks to sensor control more exactly.

Advantages also when steering

Among the other systems benefiting from the higher voltage is for example the electromechanical steering with ball and screw drive. With 48-volts, the engineers can implement greater track rod forces and make higher torques possible. For the driver, this means that the steering feels dynamic and gives excellent feedback, but does not get heavier. It has high efficiency and requires less energy than a conventional hydraulic servo steering.

More suspension comfort

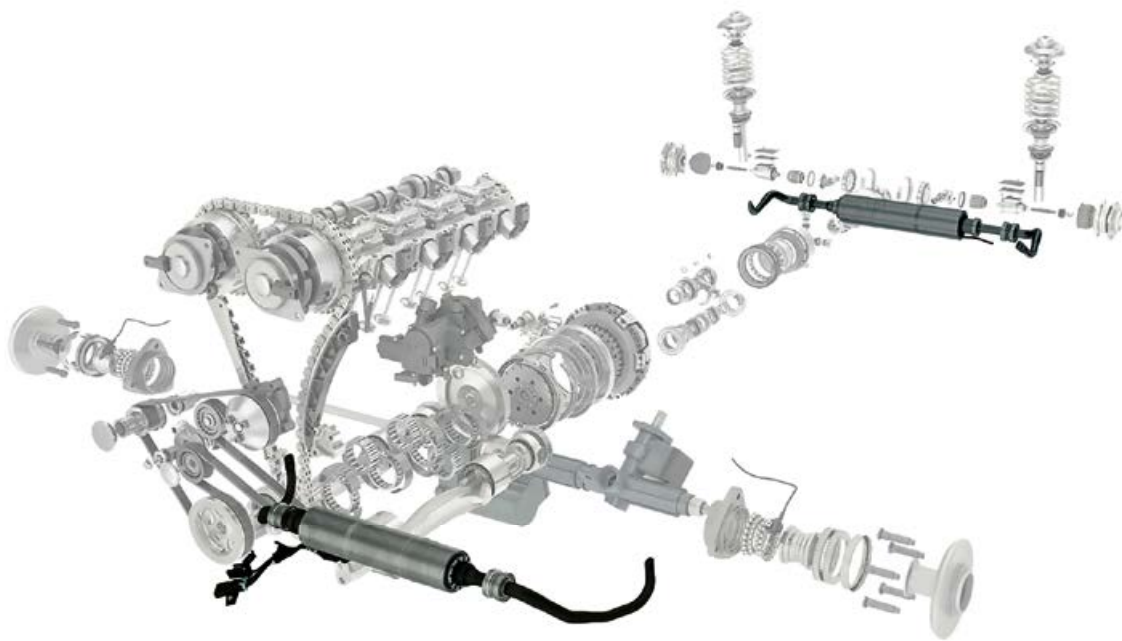
In the meantime, another Schaeffler idea is now in high-volume production – electro-

mechanical active roll control. It overcomes a conflict of objectives that arise specifically with SUVs and dynamic upper-class limousines with their high centers of gravity: maximum comfort demands a softer stabilizer. The greatest possible dynamic safety when cornering or when making evasive maneuvers require less low body roll – and, as a result, a stiffer lateral connection. Unlike a conventional, passive anti-roll bar, the active roll control includes an electric motor, a control unit, a multi-stage planetary transmission and a torque sensor. This system can differentiate between different states and offers opportunities in the era of digitalization and connectivity: if a road irregularity causes single wheel suspension movement then this displacement is absorbed correspondingly softly by the system. Alternatively, if lateral body roll arises then the system acts against this tendency by rotating the stabilizer halves against each

other – the car rolls less. If the roll stabilizer is a part of a 48-volt electrical system, the electric currents reduce and there are less power losses. In contrast to hydraulic systems, the newly designed assemblies only need oriented or co-called “power on demand”. As a result, the electric system requires less energy than a hydraulic system. Schaeffler received the “German Innovations Prize 2016” in April 2016 for its invention.

Regardless of which system is best suited for which vehicle concept: thanks to 48-volt technology, the customers can look forward to the tangible advantages of low-voltage hybridization. Motoring becomes even more dynamic and more emotional. At the same time, the costs for such a system remain acceptable. ■

Among the other systems that benefit from higher voltage are, for example, electromechanical components like steering and roll stabilizers



Innovation Sixty Schaeffler components on average are used in every new car. One of the latest innovations is the electromechanical active roll control for front and rear axles. It overcomes a conflict of objectives between maximum comfort and agile handling that arises specifically in SUVs and dynamic luxury class limousines

High *Five*

As pioneer of 48-volt technology Schaeffler has set the pace and to this day has now unveiled five concepts. They demonstrate in everyday scenarios what the new electrics makes possible



2014 Gasoline Technology Car

In 2014, Schaeffler and Continental in cooperation with Ford presented the first “Gasoline Technology Car”. At the Vienna Engine Symposium, guests see a Ford Focus that perfectly combines different efficiency technologies. In the New European Driving Cycle (NEDC), the model consumes 17 per cent less fuel than the comparative basis. As a result, it emits only 95 grams carbon dioxide per kilometer. The one-liter three-cylinder gasoline engine is equipped with a 48-volt eco drive system in P0 configuration. The E-machine is coupled via a modified belt drive to the combustion engine and supports this at low rpm via an E-Boost function. This means: combustion engine and electric drive accelerate the car together. Consequently, the turbo lag disappears, and ignition timing can be selected that helps to save fuel – and all this at an extra cost of only around 950 Euro.



2014 System 48 V

Schaeffler reveals at its four-yearly colloquium the “Schaeffler System 48 V” model. In contrast to the “Gasoline Technology Cars”, this technology demonstrator is equipped with electrified components on the combustion engine as well as the rear axle. The gasoline engine is coupled to a belt starter generator, and an E-axle is used at the rear. The motorist can choose between the driving modes “Eco” and “Sport”. In the first case, the combustion engine is dormant as often as possible. Be it pulling away, low speeds or maneuvering – the concept vehicle operates electrically. If the combustion engine is required, the belt starter generator speedily and silently starts it again. In sport mode, the combustion engine is always running. The torque generated by the electric motor can be distributed selectively between each rear wheel – the car is more agile to drive.



2015 Efficient Future Mobility North America

Schaeffler unveils its first SUV concept vehicle featuring 48-volt technology in January 2015 at the North American International Auto Show (NAIAS). The test vehicle "Efficient Future Mobility North America", which was unveiled two years previously in Detroit, acts as base. This modified Ford Kuga featuring four-wheel drive and automatic transmission already saves as much as 15 per cent fuel through Schaeffler's inexpensive technologies including all-wheel drive decoupler, thermal management module, permanently engaged starter generator with start-stop function that also works as starter motor, to accelerate and as generator. Schaeffler equipped the SUV 2015 concept additionally with the new TDA system (Transmission Driven Accessories) in order to demonstrate how the more stringent fleet consumption standards (Corporate Average Fuel Economy or CAFE) targeted for 2025 in North America can be achieved. The system powers the ancillary units on the combustion engine – without support of the engine itself – using a 48-volt E-machine. By omitting the conventional belt drive, innovative driving modes such as boosting or coasting can be realized with the TDA system. This also helps to make significant savings regarding consumption and CO₂ emissions.

2016 Gasoline Technology Car II

Two years after the first "Gasoline Technology Car" comes the second generation. It demonstrates: a fuel saving of up to 25 per cent compared to the base model. The car is equipped with a 48-volt hybrid module featuring P2 architecture. The E-machine is no longer located in front of the engine, but installed with a belt drive between combustion engine and transmission. The main advantage: the combustion engine can be completely decoupled and switched off; nevertheless, the car continues to run using pure electric power. The efficiency climbs significantly owing to many intelligent interactions between the electrified components and classic combustion engine.



2016 High Performance 48 V

The latest technology demonstrator is the most powerful. The model "Schaeffler High Performance 48 V" represents cost-effective hybridization coupled with maximum dynamism. It retains the fundamental architecture of the "System 48 V" model. The biggest difference: the high-performance variant permanently supplies 20 kW of electric power transmitted to both rear wheels and supplements the combustion engine, which is connected to a 48-volt belt starter generator. The powerful E-motor generates starting torque of up to 2,000 Newton meters. As a result, the car runs solely on electric power at speeds of up to 35 km/h. Active coasting at a constant speed of more than 70 km/h is even possible. In addition, the E-motor can support the combustion engine – the car accelerates even more rapidly.



Silent running

Which scenarios await us in our everyday lives with 48 volts? A journey into the not too distant future reveals a raft of comforts in traffic – starting with maneuvering out of your garage at home

Whoever has already driven a full hybrid model or electric powered vehicle knows the spectacle – the vehicle pulls silently away, an action previously connected with the unavoidable revving of a combustion engine. An entire car moves silently away as if by magic. What the eyes and ears previously perceived simultaneously are now a mismatch. Either the car must remain stationary or it must make a noise – or not? Nowadays not, because in the electric day and age both fit together. Pedestrians are still irritated, while the drivers in the cockpits make themselves comfortable: gliding silently to their destination is simply relaxing. For themselves and for their environment.

Electric when it makes sense

Schaeffler proves, to this end, that expensive high-voltage technology only – in full hybrid or electric cars – is unnecessary. The 48-volt architecture offers the potential to drive electrically in a series of everyday situations, when it makes sense – and to save fuel and preserve the environment in the process. For example when pulling away. Who really likes to wake up the neighborhood in the quiet side streets if for once the journey must start so early in the morning? Driving home to the peaceful suburbs in the evening and coasting electrically to stop also relaxes the neighbors considerably more than the combustion engine.

Another aspect arises in parking garages: even with good ventilation, the smell of exhaust

fumes usually lingers. Who would object if in the future maneuvering was carried out exclusively using electric power and the air remains unpolluted? The Schaeffler systems producing up to 2,000 Newton meters starting torque on the E-axle have another completely different advantage: a car has never reacted so dynamically when pushing the throttle. In stop-and-go traffic at the traffic lights or in the rush hour the E-drivetrain is perfect. And the fuel gauge doesn't move a millimeter since the combustion engine can take a well-earned rest.

Even at faster speeds, the efficient E-drivetrains installed in 48-volt models are now sufficient. Those wishing to go with the flow at a constant pace require very little propulsion. The 20 Kilowatts produced by the E-axle of the Schaeffler High Performance 48 V car are perfect, even at 70 km/h, to prevent being left trailing behind. Experts call this state active coasting. Every time a driver has to brake the E-machines become generators and recuperate energy. This flows as electricity back into the lithium ion battery.

A multitude of drive configurations

However, 48-volt powertrains are not just fun when it comes to savings. If the worst comes to the worst and two driven wheels no



into the future



Upstream
Schaeffler's various
concept vehicles
demonstrate the
pleasant effect of
48 volts

longer suffice in snow, an all-wheel drive mode can even be realized thanks to the E-axle: the combustion engine conventionally powers one axle, the other two wheels are propelled with electric power. Those wishing to use the entire system power under acceleration – such as on a motorway slip road or while overtaking – is, thanks to 48 volts, also a step ahead compared to those with a conventional drivetrain. The E-drivetrain briefly supports the classic engine in this moment. And when the winding

road lures drivers into sporting tarmac carving, Schaeffler offers another option. The E-axle can variably distribute the torque via superimposing transmissions. If the system systematically directs more torque to the outside wheel in the corner, the drivetrain supports the dynamic corner stability. The car turns more willingly into the corner, assists the driver as a result and is more agile – thanks to E-drivetrain. Fun and savings: thanks to 48 volts both is possible, and this for an acceptable price. ■

The drive modes possible with 48 volts



Electric coasting



Start-Stop assistance



Torque vectoring



Electric parking



Boosting and recuperation



Electrified all-wheel drive

1,100 NM

difference torque between the right and left wheels via torque vectoring with electric axle

0.3 L

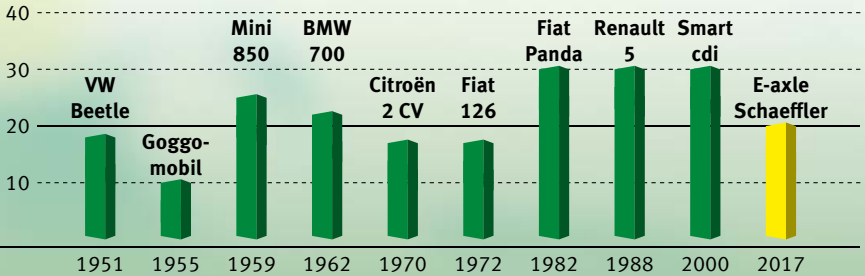
of fuel is saved by the electromechanical roll control compared to a hydraulic solution

An electric compressor (E-Booster) absorbs a maximum power of

6 kW

Schaeffler: facts and figures

Schaeffler's 48 V E-axle generating 20 kW is today just as powerful as some standard automobile engines from the last seven decades



Choice of standard engines (in kW)

post 1945

Schaeffler designed the bow springs of its pulley decoupler for

1,000,000

starts

A modern air-conditioning compressor requires a peak power of

5 kW

The E-axle generates

2,000 NM

starting torque

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- ~ 87,000 employees worldwide
- 13.3 billion Euro turnover in 2016
- > 2,300 registered patents in 2016
- 170 locations in 50 countries



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Communications and Marketing Schaeffler Automotive

presse@schaeffler.com