

ZF gets in gear with hybrids

ZF is not only the world's leading vehicle transmission builder it also produces a whole raft of other vehicle componentry from axles and suspensions to sophisticated electronics. Ahead of the IAA Exhibition in Hanover in September the Friedrichshafen, Germany, based company held a press conference to announce some of its new equipment which will be on show.

By any stretch of the imagination ZF is a mighty player. Sales in 2009, despite the recession which hit the World's vehicle manufacturing industry, were €9.371bn. The company employs over 60,000 people worldwide, over 30,000 of them are involved with production and operate from 123 centres. In addition there are research and development centres and service and parts centres across the world.

Despite the recession, ZF has maintained its emphasis on research and development. Innovation has always been a hallmark of the company and a major reason why its products are so widely regarded and used by the world's vehicle manufacturers.

Even in the face of the worst recession to hit the industry in living memory, ZF continued to invest in innovation, research and development.



The ZF Hybrid battery pack produces 60kW. It is totally enclosed in a water cooling jacket to prolong battery life.

2009 saw the company spend €516m on capital expenditure and €663m on research and development. The company has five R&D centres in Germany at Friedrichshafen; Dielingen; Schweinfurt; Passau and Schwabisch Gmund; one in the Czech Republic at Pilsen; one in North America at Northville and one in Shanghai in China. Worldwide it employs 5,300 R&D engineers and on average the company files 700 patents a year, making it one of the top ten innovative companies in Germany.

Getting into gear with hybrids

ZF merged a few years back with the giant electronics company Sachs and since then has been developing hybrid systems. It has now come out (or rather it will at Hanover) with a complete package of offerings to suit all types of applica-



The Mercedes-Benz Citaro G Bluetec Hybrid uses the ZF AVE 130 portal axle system with hub mounted DynaStart motors. (Inset) It also uses ZF battery packs, control system and inverters. A production batch of 50 will go in to trial service in early 2011.

tions.

I've experienced most of the current offerings from manufacturers seeking to solve the hybrid question but I think the ZF approach could well be the one that really sees demand for hybrids lift off

because it is essentially very simple, using tried and tested systems integrated with known components. The systems are also designed for volume production which will see economies of scale and therefore reduction in initial costs.

ZF are offering four different types of hybrid package depending on usage. Some are particularly suited to stop start work such as city buses or delivery vans; others are designed for longer distance running. All share a common theme in that they can be integrated easily with existing

drivelines meaning manufacturers do not have to carry out radical re-designs of their products to take advantage of the hybrid technology.

The four systems being offered by ZF are EcoLife; eTronic; HyTronic and Fully Electric Drive AV 130. Incidentally ZF believes that ultimately all vehicles will eventually become electrically powered though it doubts that state will be achieved until around 2030.

Unlike most other manufacturers, ZF is not

plumping for one system i.e. either serial

or parallel, preferring to select which system is best for which duty. 'It isn't a case of one size fits all,' said Wolfgang Schilha, Senior Vice President Bus Driveline Technology, 'to achieve maximum advantage you need to select the system which best suits the type of operation. In some cases the parallel system offers distinct advantages, in others the serial system is the most preferable. We have both so can choose the right one for the job.'

EcoLife Hybrid

The EcoLife Hybrid is a complete system from ZF comprising the e-motor, power electronics and the energy storage system. The heart of the

system is the e-motor developed by ZF Sachs. It is a permanent magnetic synchronous motor with high power density, high efficiency at low speed and with common parts technology with existing ZF transmission systems. The basic motor design has been used on the Mercedes S class saloon since 2009 and is also used on

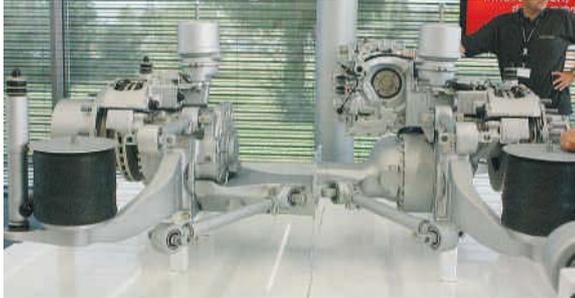
BMW 7 series saloons.

The beauty of the system is that the electric drive fits into the existing EcoLife transmission housing replacing the normal torque converter. Thus the package size for the hybrid drive is



The control unit is common to all the different types of ZF hybrid.

exactly the same as for the standard EcoLife automatic transmission. This gives the vehicle a full scope of hybrid functionality and, perhaps more importantly, a driving performance that matches the non-hybrid version. The electric drive alone develops up to 120kW.



This strange looking portal axle shows the difference between the conventional diesel powered AV 132 and the new electric drive AVE 130. The AV 132 is on the right and the AVE 130 on the left. Note that the AVE 130 is slimmer than the AV 132 allowing an even lower flat floor at the rear of a bus.

The vehicle has the ability to be driven using purely the electric drive or a combination of the diesel engine and the electric motor. Regenerative power is developed during deceleration and braking to restore battery condition.

The other key elements in the system are the HyControl inverter and control unit which combine high efficiency with robust design and compact dimensions. Typical of ZF attention to detail is that the same units are used right across the board whether the unit is for use in a bus or a truck. That is important because it means that components can be produced in volume and therefore prices can be kept as low as possible.

Energy storage (batteries) are lithium Ion and have a 60kW capacity. These are provided in a completely sealed unit with a cooling water jacket. This ensures they maintain peak operating performance for much longer than uncooled battery packs. They can be coupled together to cater for high power output requirements.

Wolfgang Schilha says that batteries still remain one of the biggest stumbling blocks to the widespread introduction of hybrid buses. 'Development just has not matched the timescale we were all led to believe would be achieved. We were being told ten years ago that, by now, battery life, weight and cost would have improved substantially, but progress is still far too slow. We have to get to the stage where batteries will operate for the life of the vehicle. Changing batteries part way through a vehicle's life will simply make them not cost-effective.'

Adopting the EcoLife Hybrid system does mean that a smaller diesel engine can be fitted to the vehicle, thus substantially reducing the fuel consumption.

The first complete prototype is nearing completion but extensive bench testing has convinced the ZF and Sachs engineers that the system is a winner and ZF plan to move to production with the system very swiftly. I hope one of the UK suppliers get their hands on one quickly because it would be interesting to see how it performs alongside the hybrids already operating in the UK.



This Mercedes-Benz Citaro is fitted with the new EcoLife hybrid drive. It was also equipped to demonstrate the new OpenMatics platform system for handling on-board ancillaries like GPS, real time information, diagnostics etc.

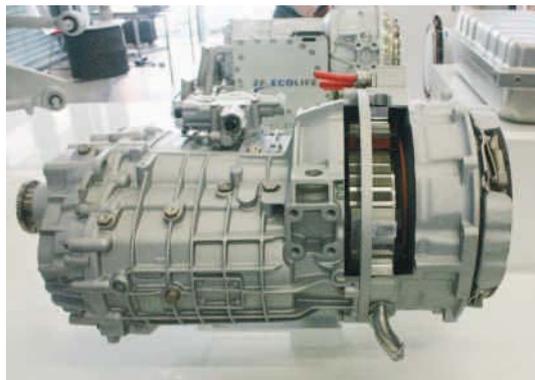
e-Tronic hybrid

The e-Tronic Hybrid is designed primarily for use in delivery vehicles. It is an electro mechanical system whereby the electric drive unit is integrated into the driveline. A

separating clutch decouples the electric motor and the transmission from the combustion engine and, consequently, enables purely electric driving. The electric motor is also used as a power source in generator operation. The braking effect caused during generator operation is integrated into the brake management system and extends the life of the service brakes. The hybrid transmission offers all of the functions of a full hybrid system and has been optimised for use in light commercial vehicles in delivery traffic. The purely electromechanical solution allows for maximum fuel savings and low system costs at the same time.

HyTronic

The HyTronic is aimed at distribution truck and light bus applications and is again integrated into



A standard EcoLife six speed automatic transmission with the torque converter unit replaced with the new hybrid drive unit within the same casing.

the existing driveline. The overall system consists of transmission, 60 kW electric motor, inverter, high-voltage battery, power routing, and energy management. Thus, it can assume all functions of a full hybrid system: the start/stop function, regeneration of braking energy, support during acceleration, electric starting, and purely electric driving.

The additional system weight due to wiring, battery, and cooling system is moderate and almost compensated for by savings of similar scale (by downsizing the combustion engine, omission



A range of the new ZF hybrid drive units designed to be incorporated in or used in conjunction with their existing transmissions.

of 24V battery and starter). As the electric motor is also available as a power source for additional power consuming systems during generator operation, this hybrid transmission system is also attractive for municipal vehicles. So far, their PTOs have permanently required fuel because they are mechanically connected to the combustion engine. The powerful generator and the hybrid battery on the other hand allow for the use of electric PTOs which consume fuel on demand only.

Electric Drive AVE 130

Now this really is a hybrid system to make you sit up and notice. Why? Because it is essentially very simple and it works.

The system uses the same batteries, inverter and control unit as mentioned on the EcoLife Hybrid but the real difference comes in why the system operates. The diesel engine is used purely for power generation and not powering the vehicle. The vehicle is powered by individual DynaStart hub mounted electric motors. These are mounted in the hubs of the ZF AVE 130 portal drive axle. Hub mounted motors aren't new, they have been tried by a number of companies including VDL, the difference is that these are very small. Despite their size they generate high performance, are designed for high service life, have zero wear and are designed to be used for both mild and full hybrid systems. They can be integrated into existing driveline concepts offering high economy of procurement and operation. They are highly integrated controllable solutions with torsional vibration damping, starting and shifting components able to be accommodated in limited installation space. Indeed, looking at the hubs, it is difficult to realise that they are actually electric motors and not just hub reduction hubs.

Many readers will be familiar with the ZF AV 132 portal axle because it is widely used on low floor buses to accommodate the rear drive and give a low floor at the rear. The AVE 130 is directly developed from the AV 132 and indeed contains much of the same componentry, including exactly the same Knorr Bremse braking

system. The axle is actually slightly less bulky than the AV 132 and thus achieves an even better low floor condition. Each motor drives independently and has its own 60kW power supply. The system incorporates regenerative braking to boost power supply.

The system is already being used by Mercedes-



This is the new ZF RL55 EC independent suspension for midi buses and coaches.

Benz in its Citaro G Bluetec Hybrid which is on trial in Hamburg and Stuttgart. In a joint ZF/Mercedes programme a further batch of 50 similar vehicles are due to be built later this year and will be trialled in city bus operations across Europe. I hope that includes London because again it would be interesting to see it compared with those systems already operating in London.

At the conference ZF had one of the Mercedes-Benz Bluetec G Hybrids on test. The vehicles are artic and they have an AVE 130 portal axle as the drive axle on the main section and also on the self steering trailing axle. Each wheel motor has its own 60kW power pack giving a total of 240kW (322bhp). The total battery pack weighs just 350kg.

Instead of the usual OM457 diesel delivering up to 260kW (349bhp) that would be fitted to a Citaro artic the bus is fitted with a much smaller 4.8 litre 160kW (215bhp) engine as used in the Atego range.

I experienced the Citaro with the ZF system on the test track at Friedrichshafen. This bus drives like no other hybrid I've been on, though in fairness I have not driven the ADL yet. It is smooth and quiet and goes a long way before the diesel engine cuts in. Indeed the ZF engineers told me that the vehicle will operate in the region of 10km



The eTronic hybrid system is primarily designed for use in delivery vehicles requiring high levels of stop start operation.

on pure electric power. Performance was excellent in terms of acceleration, top speed, hill climbing and braking. It brought back memories of the sort of smooth acceleration I used to experience on a

630 trolleybus in London going to school. Incidentally the system also lends itself to being built as a trolleybus or having the diesel replaced in the future by a fuel cell.

The vehicle I tried was a prototype and there was a fair amount of noise from the hub motor drives but the ZF engineers said the bulk of this was not from the motors but due to the profile of the reduction gears and that these had already been re-profiled so that those going on the next batch of 50 will be significantly quieter.

Mercedes engineers explained that they were able to slot the system straight into a standard Citaro G artic. Very little adaptation was needed. In fact the vehicle was actually carrying a certain amount of excess structure at the rear end that would be needed if it had the normal OM457 engine and the smaller engine and AVE 130 axle. So weight appears to be a positive rather than a negative issue.

Hybrids in coaches

I asked Wolfgang Schilha about the prospect of hybrids in coaches. He believes it to be eminently feasible and hinted that ZF were already advanced with developments. I would not be surprised to hear some announcement about this development during 2011.

Other ZF developments

It wasn't all about hybrids at the ZF conference. They also announced a number of other new products or variants applicable to the bus industry.

EcoLife with TopoDyn

The EcoLife six-speed automatic transmission for buses which is already used by Mercedes in the Citaro and Tourismo; Volvo with the B9TL, ADL in the Enviro 400 and MAN in its bus range now comes with the TopoDyn software as part of the package. This controls operation of the transmission to ensure that it is always operating in the optimum gear to produce not only the necessary performance but also the maximum noise and fuel consumption reductions.

The EcoLife transmission can now accept maximum torque up to 2000Nm and the actual torque converter has been optimised for weight. It has also had the hydrodynamic features adjusted to the engine characteristics to improve acceleration and low speed performance. The lock-up clutch closes earlier giving reliable

transmission even at high engine torques. A torsional vibration damper ensures high comfort even at low engine speeds. Overall the changes give a fuel consumption reduction of 5%.

RL55EC independent suspension

ZF displayed examples of its new RL55EC independent suspension for midi sized vehicles with 19.5in wheels. A direct development of the popular IFS for 22.5in wheels, the new system gives outstanding active safety and reduced turning radius because of the large steering angle. This gives the vehicle improved handling and higher comfort due to the reduction in unsprung masses from de-coupling the wheels.

Steering

ZF's steering systems are almost universal in the modern bus world but that doesn't stop it developing improvements. New are the Varioserv adjustable vane-cell pump, which uses less power, reduces oil temperature whilst the Servocom system benefits from a pressure increase to 185bar, which results in a 6% reduction in energy consumption. There is also a new steering shaft which is 30% lighter thanks to optimised shaping technology which has allowed mass reduction.

New EcoShift transmission

Although manual transmissions are now rare in the UK on new big coaches, they remain popular



This unit shows the standard 22.5in diameter wheel ZF IFS on the left and the new RL55 19.5in diameter wheel ZF IFS on the right.

on the Continent and in other parts of the World. ZF will introduce a new six-speed transmission, the EcoShift, at Hanover.

The EcoShift transmission is a platform for a new product range of modern six-speed transmissions that are based on the EcoShift basic transmission. The goal of the innovation was to create a new, state-of-the-art series of manual bus transmissions that would satisfy future market demands. The selection made was in favour of a manual basic transmission that is based on an extensible modular design principle and which, as a platform, is the basis for additional transmission variants.

And finally Openmatics

Something very different from ZF - Openmatics. This is a development between ZF and intel. One of the problems with modern vehicles, as they become fitted with more and more complex electronic equipment, is that often the various systems cannot be integrated and manufacturers, dealers and operators are left with fitting a number of different systems to vehicles. Often these systems conflict or overlap in the job that they do. For example on a coach you may

have telematics, diagnostics, real time information, CCTV etc all from different sources. The aim of OpenMatics is to provide a single universal unit into which all other systems can be connected.

In a strategic alliance with Intel, ZF will create a hard- and software platform which is available for telematics applications. The platform can be used in city buses from all manufacturers, for example. The system, available in 2011, is made up of an on-board unit for the vehicles and a web-based software portal for evaluation purposes. The open structure of Openmatics equally provides for several advantages: The system can integrate future, third-party software developments; in other words, programmes which make the system even more versatile and attractive for its users. Moreover, Openmatics takes a major step towards standardising and integrating several individual telematics solutions - something that transportation companies are already requesting today.

Telematics services are spreading quickly; until now, however, mainly as stand-alone solutions. Be it the debiting of road charges, emergency call functions, or just city bus fleet management in general, and often, the systems act independently of one another, fleet owners and transportation companies have to install each unit in the vehicle separately, screw on antennas for radio communication, and conclude service contracts.

The strategic alliance between ZF and Intel is now embarking on a different path with Openmatics. The open, powerful system will meet all requirements for telematics services and is to further standardise the market in the future. The system platform Openmatics consists of a hardware box and, in its core, the powerful Intel Atom processor. In terms of features and interfaces, the box is therefore ready to fulfil all present and many future telematics services for city buses - including multimedia applications. It sends the data to a web portal in real time via 3G,

GPRS, and WLAN. Software applications on the web portal are in charge of the specific evaluation and processing of data. Depending on the application, different authorised target user

groups can access these results, from the service technician who receives information about possible malfunctions in the vehicle's technology up to the fleet manager who can monitor the expected arrival times of his vehicles.

'The system architecture has been designed to be as open and independent as possible', says Dr. Michael Paul, Executive Vice

President for Technology at ZF. This makes telematics services particularly attractive to major bus fleet operators who benefit from a standard connection point. Instead of installing a variety of hardware boxes and antennas on their vehicles and integrating these in the CAN bus data traffic, Openmatics can provide a platform for all solutions.

Intel's expertise plays a role both in the Atom chip and in the system architecture, and ZF contributes its knowledge regarding vehicle drivelines, the web portal, and business applications. By way of example, planning of transmission servicing and diagnosis can take place via Openmatics if a city bus has a ZF transmission on board; previously, ZF had a system of its own for this purpose.

However, Openmatics is also open for the applications of vehicle manufacturers and third-party providers. ZF is already contacting renowned fleet management system providers in order to make the Openmatics platform compatible with all common software solutions in this field. Another feature is that additional applications, also known as 'Apps', can be developed by vehicle manufacturers or third parties and sold to new user groups via the platform. A universal offer thus makes it even more attractive for the users.

The co-operation between Intel and ZF is independent of vehicle manufacturers and as both are leaders in their fields, them coming together is

logical. Apart from hardware and software knowledge, Intel contributes its expertise in standardising open IT solutions, and ZF is a driveline expert which can also contribute its worldwide service network, which is also available when installing or retrofitting Openmatics.

After concluding the development in 2010, the schedule provides for prototype and preliminary tests at key customers' as well as the set-up of the web portal. As from 2011, an AppStore will be set up, where customers can order the range offered by third parties. Production start-up is scheduled for the beginning of 2011.

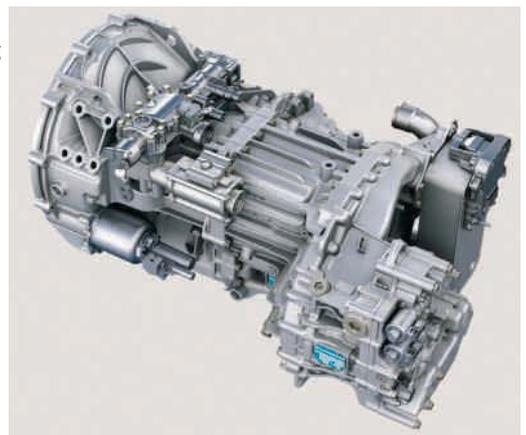
ZF and Intel demonstrated the system fitted to Mercedes Citaro and I have to say it was very impressive.

Conclusion

I've visited ZF on a number of occasions over the years and I have never been disappointed yet. They always come up with some new highly practical innovations. One might have expected, with the global recession, that the pace of development at ZF would have slowed but nothing could be further from the case. ZF and its partner companies have obviously been forging ahead despite the recession.



The ZF Hytronic is a hybrid drive for vehicles up to 7.5tonnes GVW. It utilises the existing ZF AS-Tronic Lite transmission with a hybrid drive added. The AS-Tronic Lite is the automated transmission used in the Iveco Daily amongst other vehicles.



The ZF EcoShift is a new six speed manual transmission.

Many of the developments, particularly the approach to hybrids and the development with Intel of the Openmatics platform, will, I think, have great relevance to the way vehicles are designed, built and operated in the future.

You can see all the developments on the ZF stand at the IAA in Hanover, Germany in September.

By Rob Orchard



ZF had arranged a wide range of vehicles for test including vehicles fitted with the EcoLife automatic transmission with TopoDyn control and the AS-Tronic automated box.