Audi quattro with ultra-technology

With quattro permanent all-wheel drive, Audi has extended its lead over a period of more than three decades. Now it’s time for the next big step: quattro in combination with ultra technology.

The development goal of quattro with ultra technology is an all-wheel drive system optimized for efficiency with no discernible differences to permanent systems with respect to traction and driving dynamics. The system should set benchmarks in its class for fuel consumption and CO_2 emissions, particularly under everyday conditions. With correspondingly equipped test vehicles, Audi developers used on average 0.3 liters/100 kilometers less fuel than with conventional all-wheel drive. The tests were conducted on a route throughout the Ingolstadt area and in normal traffic.

At first glance, these requirements hardly appear to be reconcilable. But through the interaction of the newly developed all-wheel drive components and a sophisticated operating strategy, the Audi developers were able to achieve this goal. The results: The all-wheel drive system’s intelligent control works predictively, always looking ahead by means of a comprehensive array of sensors and the continuous analysis of the driving dynamics, road condition and driver behavior data collected. Consequently, the quattro all-wheel drive system is always ready when needed. During standard operation at low loads without the risk of wheel slip, the new quattro taps into all the advantages of front-wheel drive.

All-wheel drive is always deactivated when it is not needed, but remains permanently available, significantly reducing the potential fuel consumption difference between front-wheel drive and permanent all-wheel drive.

The strategy
The all-wheel drive system is activated before the driver needs it. In fact, all activations and deactivations follow a highly differentiated strategy.

The quattro electronics are networked with a number of other control units. Every ten milliseconds, the system acquires and analyzes a wide variety of data, such as steering angle, lateral and longitudinal acceleration and engine torque to name just a few. Activation of the all-wheel drive system follows a three-stage strategy: proactive, predictive, i.e. forward-looking, and reactive.

On the proactive level, the focus is on the data delivered by the networked systems in the

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car. The control unit uses these data to, for example, compute the point when the inside front tire will reach the limit of grip during fast cornering. The calculation is completed roughly 0.5 seconds prior. If the wheel approaches the limit of grip to within a defined threshold, the all-wheel drive system is activated.

With predictive activation, the quattro control unit orients primarily on the driver's style, the status of the ESC and the mode selected in drive select, and on the trailer detection system.

With reactive activation, which rarely occurs in practice, the system reacts to sudden changes in the coefficient of friction. These occur, for example, when the wheels go from dry asphalt to a sheet of ice.

quattro all-wheel drive is more frequently active in winter than in summer because the coefficients of friction are lower then. The need for all-wheel drive is generally higher at low and moderate speeds with acceleration phases than when driving fast at a constant speed. Use of quattro all-wheel drive is therefore lower on the highway, in particular.

However, the car can also be driven safely on a snow-covered road with just front-wheel drive if the road is straight and speed remains constant. On the other hand, if the car is being driven dynamically on a winding road, all-wheel drive remains active at all times, even on dry, grippy asphalt.

The optimal distribution of power between the front and rear axles is computed continuously when the system is active. The control strategy considers ESC data, ambient conditions, the driving situation and the wishes of the driver. The power can be optimally distributed between the two axles at all times as a function of these factors.

There is generally sufficient time available for deactivation of the all-wheel drive system. In contrast, operational requirements determine the speed at which the clutches close to activate the system. In certain driving situations, this has to occur in just fractions of a second.

By networking quattro drive with Audi drive select, the driver can adjust the all-wheel-drive properties to suit his or her individual requirements. The auto mode in drive select provides the best possible traction and balanced driving dynamics. In dynamic mode, power is sent to the rear axle sooner and to a larger degree, improving the driving dynamics particularly at low coefficients of friction. Wheel-selective torque control – a software function of the ESC – smooths out the handling as needed by minimally braking the inside wheels.

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Two clutches – the technology
The enhanced efficiency is made possible by two clutches in the drivetrain. When the system changes to front-wheel drive, the front clutch – a multi-plate clutch at the transmission takeoff – disconnects the propshaft. An integrated decoupler in the rear-axle differential also opens, shutting down the primary cause of drag losses in the rear section of the drivetrain. At the same time, the quattro drivetrain is nearly four kilograms *(8.8 lb)* lighter than the previous system despite the new technical components. That, too, saves fuel and benefits handling.

The multi-plate clutch
The all-wheel drive clutch is located at the rear end of the transmission. An electric motor integrated into the quattro control unit powers a spindle drive that actuates the multi-plate clutch. Depending on the model, the clutch comprises a package of five or seven pairs of plates that rotate in an oil bath. The friction rings are arranged behind one another in pairs. The first is permanently meshed with the clutch basket, which rotates with the input shaft. The next ring is meshed with the output shaft to the rear axle differential. When the plates are pressed together, the all-wheel drive system is activated. The contact pressure of the plates is used to distribute the drive torque variably and dynamically between the axles.

The integrated decoupler
The decoupler integrated into the rear-axle differential works according to a different principle. The shaft to the right rear wheel is divided into two parts beyond the point where it exits the differential. The left sub-shaft with the axle bevel gear in the differential and the right sub-shaft are each connected to a claw element. Both can be positively coupled.

The claw clutch is opened electromechanically and closed via pretensioned springs. If both the all-wheel drive clutch and the decoupler are open, the large components in the rear-axle differential relevant for friction and drag losses as well as the propshaft stop. Only the axle bevel gear and the compensating gears in the differential, which compensate for differences in the speed of rotation of the vehicle’s drive wheels during cornering, continue to rotate under zero load. However, they cause only very slight drag losses.

To activate the all-wheel drive system, the stationary components are accelerated in fractions of a second via the controlled multi-plate clutch. The claw clutch closes as soon as the propshaft and thus the differential housing are rotating at the necessary speed. An electromagnetically actuated metal pin then disengages the locking lever. The springs relax and the claw clutch closes.

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The use of pretensioned springs when closing the claw clutch allows for very short shift times.

quattro with ultra technology – the transmission
The key to achieving a significant efficiency gain in single-axle operation is a directly driven axle with optimal efficiency. The new generation of manual and S tronic transmissions ideally fulfill all the prerequisites, as efficiency was also a primary focus during their development.

Status: 2/2016

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