Worldwide News

Subaru Technology Overview

Oct 6 . 2008 [Canada]

What makes Subaru Symmetrical full-time All-Wheel Drive better than other AWD or 4WD systems?

The goal of any all-wheel drive (AWD) or four-wheel drive (4WD) system is to improve traction. Good traction is vital for stable acceleration, cornering, and stopping.

Subaru's Symmetrical full-time All-Wheel Drive continuously powers all four wheels, doubling the traction. Contrast this with 4WD systems that must use two-wheel drive (2WD) mode on-road, where SUVs actually spend most of their time. Or part-time AWD systems that only switch from 2WD mode after detecting wheel slippage and only at low speeds.

In addition, bolting AWD components to an existing 2WD system can help take advantage of available traction, but also adds weight and reduces stability.

Achieving stability through balance

Symmetry means balance and balance is crucial to stability. Subaru designed its Symmetrical full-time All-Wheel Drive as a complete system. Every component helps to ensure stable, balanced performance.

- The flat profile of the horizontally-opposed Subaru Boxer engine keeps the vehicle's centre of gravity low. This means better stability and less chance of rollover. The "torquey" boxer is also well suited to the kind of driving conditions where AWD shines.
- The Subaru Boxer is compact and lightweight as well as rugged, and uses a compact, lightweight transmission and a compact, lightweight centre differential. Among other advantages, this helps reduce fuel consumption.
- The engine and transmission balance over the front axle, so a Subaru is less nose-heavy. This reduces both dive under heavy braking (which decreases rear traction when the back end lifts) and yaw (the tendency of an unbalanced vehicle to spin when unbalanced laterally).
- Subaru mounts the engine, transmission and centre differential in a straight line from front to rear. This provides exceptional left/right balance and driveline efficiency. It also allows for equal-length axle shafts in front and rear, reducing torque steer (the tendency of front-wheel drive vehicles to pull slightly to one side).

The centred driveline and equal-length axles permit Subaru's signature long-travel suspension. This allows the tires to stay in contact with the driving surface (essential for good traction) in a wide variety of conditions and surfaces.

Why the balanced, stable performance of All-Wheel Drive is important

Traction improves when all four wheels share the work of moving the vehicle. This is particularly important under driving conditions that challenge stability.

- Powering both ends of the vehicle reduces the instability that occurs when weight transfers to the front when traveling downhill or coming to a stop. Power at all four corners also increases the effectiveness of engine braking.
- When all four wheels provide power and traction, the front wheels have more available traction for steering, reducing the potential for understeer and oversteer.
- When driving on roads with uneven traction—such as loose sand or gravel, patches of wet leaves, or blowing snow—All-Wheel Drive doubles the amount of available traction to keep the vehicle moving safely in the right direction.

All this adds up to an extra measure of safety in poor conditions, and an extra measure of performance in good conditions.

No system can create traction where it doesn't exist. Under many driving conditions, however, Subaru's Symmetrical full-time All-Wheel Drive system helps keep vehicles balanced, stable, and with all four wheels on the road where they belong.

All this in a package that has the size, weight, performance, maneuverability, and fuel consumption benefits of a sedan or wagon.

Subaru Technology: Symmetrical AWD and A Lot More

After more than 30 years of designing and refining its Symmetrical full-time All-Wheel Drive systems, Subaru has a well-deserved reputation for engineering excellence.

Subaru turns this expertise to every part of every Subaru vehicle, from the exceptional occupant protection of its unique Ring-shaped Reinforcement Frame safety structure to the aerodynamic body design that improves performance, stability and fuel efficiency.

When it comes to enhancing driving and safety performance, Subaru equips its vehicles with some of the most advanced technology available.

Vehicle Dynamics Control-stability control "plus"

Most traction control systems combat slipping wheels by slowing the vehicle down. In some conditions, however, such as climbing a slippery hill or merging into highway traffic, the loss of momentum creates a new set of problems.

To help drivers maintain direction and momentum, Subaru uses Vehicle Dynamics Control as the first line of defence against directional instability.

If the system detects understeer or oversteer, VDC first tells the AWD system to adjust the front/rear torque split to balance the available traction, rather than applying brake force. If the total traction is still not enough for stability and wheels continue to spin, the system will then use braking and reduced engine power to reduce momentum and help regain control.

Multi-mode VDC: Subaru took VDC to the next level when it introduced Multi-mode VDC on the 2008 WRX STI. Previously, the VDC button simply turned the stability control system on and off. Multi-mode VDC offers drivers three different combinations of stability control, traction control and ABS performance to suit any driving condition or driving style.

Normal mode delivers VDC's full capabilities for maximum safety in everyday conditions.

Off mode allows some wheel spin to enable throttle steering in corners, and wheel spin on ice or in deep snow.

Traction mode minimizes the intrusiveness of VDC (traction and stability control).

SI-DRIVE—performance and fuel efficiency

It's like having three engines in one vehicle. Subaru Intelligent Drive (SI-DRIVE) balances performance with fuel economy in three effective combinations and puts the choice in the hands of the driver.

That's because, from a dial on the centre console, drivers can choose from three different engine settings, each with its own unique characteristics.

Intelligent Mode for smooth, efficient performance. In Intelligent mode, the engine lowers the idle speed and relaxes throttle response, using up to 10 percent less fuel than the more aggressive Sport mode. It's ideal for driving conditions that burn a lot of fuel, such as stop-and-go traffic and residential neighbourhoods. Intelligent mode also delivers smooth response at low speeds and enhanced control when the road is slippery. On Subaru models equipped with a manual transmission, an indicator on the tachometer alerts the driver to the best shift point; automatic transmissions switch to fuel-efficient shifting in Intelligent mode.

<u>Sport Mode for all-around performance.</u> In Sport mode, quick throttle response, full engine power, and strong, linear acceleration at all speeds produce smooth acceleration and create the feel of a larger-displacement engine. This setting is right for the challenges of highway driving and steep climbs. While fuel economy is not the first objective, an Eco-gauge on the fuel indicator gives the driver a real-time fuel consumption reading.

<u>Sport Sharp Mode for maximum performance.</u> In Sport Sharp mode, the vehicle's throttle becomes more responsive across the engine speed range. This is ideal for twisting roads as well as confident merging and overtaking on highways. Automatic transmissions are set for high-rpm shifting to deliver exciting engine performance and control.

Blipping Control-smoothes engine braking during downshifts

Automatic transmissions with sequential shifters, such as Subaru's SPORTSHIFT, offer the convenience of an automatic plus the interactive driving experience of a manual transmission. Traditionally, however, these transmissions caused unwanted engine compression (engine braking) when downshifting, because vehicle speed is greater than engine speed.

To overcome this problem, Subaru's Blipping Control uses the Engine Control Unit (ECU), Transmission Control Unit (TCU), and Electronic Throttle Control Unit (ETC) to quickly match the speed of the engine and transmission. As the driver shifts down, the ETC opens the throttle to increase engine speed while the TCU changes from a higher to a lower gear. The engine and transmission reconnect seamlessly as soon as the transmission is in the lower gear and the engine speed matches.

More Power to the Pistons

In all internal combustion engines, air is taken into the cylinders through air intake valves, mixed with fuel, ignited, and the exhaust gases removed through exhaust valves.

One way to make engines more powerful and efficient is to pump more air into the cylinder and mix it with more fuel for a stronger burn. There are several ways of achieving this:

- opening the valves more (valve lift) to allow more air into the cylinder
- varying the valve timing
- turbocharging—to increase the density of the air, allowing a richer burn

Active Valve Control System

Subaru's Active Valve Control System (AVCS) is a variable valve timing system.

Normally, when intake valves are open, exhaust valves are closed. AVCS, however, controls the valve timing so that there is some overlap in the open/closed cycle—the exhaust valve is open for part of the time the intake valve is open. This creates an effect similar to opening windows at opposite ends of a house to encourage better ventilation. When you open one window you get a breeze; when you open a second window you get a much stronger breeze because the air moves through with less obstruction.

On Subaru models equipped with AVCS, the Engine Control Module receives input signals from the airflow sensors, coolant temperature sensors, throttle position sensor and camshaft position sensors. The system then adjusts the air intake camshaft timing as the revs increase so that the intake and exhaust valves are both open just long enough to provide stronger air intake and stronger exhaust venting.

This system has nearly infinite adjustment (within a maximum range of 35 degrees from the crankshaft) on a continuous basis for best performance and efficiency:

- at low revs, there is no overlap for smooth idling
- at medium speed, there is a slight overlap for better fuel efficiency and lower emissions
- at high revs, the overlap is increased for more top end power for passing and merging into fast traffic

The flexibility of AVCS increases engine power and torque output but also lessens fuel consumption and emissions.

Subaru employs two different valve lift systems. In either case, the principle is the same—the wider open the valve, the more air gets in. This allows more fuel to be injected into the cylinder for a more powerful and efficient burn at higher revs.

i-Active Valve Lift (i-AVL)

The i-AVL system uses rocker arms that adjust at high revs to allow greater air intake only—the exhaust valve remains unaffected. This is a simple on/off system.

Subaru equips normally aspirated H4 engines with i-AVL to increase power at higher revs for enhanced passing and merging power.

Active Valve Lift (AVL)

The Active Valve Lift system has the same function as i-AVL—to increase valve lift as the revs go up—but it uses pneumatics to allow variable adjustment through the full rev range.

AVL is used on Subaru's normally aspirated H6 3.0L engines in tandem with Subaru's Active Valve Control System to improve the performance of these highly refined engines.

More Power to the Wheels

Because one size does not fit all, Subaru uses a variety of advanced drivetrain components, each carefully designed and engineered to meet the specific needs of each package.

Viscous-coupling Limited-slip Centre Differential

Subaru uses a viscous limited-slip or "self-locking" differential as a centre differential on manual transmission (MT) models to balance torque between the vehicle's front and rear axles. A synthetic viscous fluid is sealed in a housing with two sets of plates, one from each output shaft. Under normal driving conditions, both sets of plates and the viscous fluid spin at the same speed, but if one output shaft begins to move more quickly than the other (as would happen if one set of wheels began to lose traction), its set of plates begin to spin faster. This generates heat, causing the fluid to thicken, strengthening the adhesion between the two plates. The fluid tries to keep up with the faster plates, dragging the slower ones along with it. This balances the torque to both outputs, effectively "locking" both driveshafts at the same speed.

This simple, reliable mechanism maintains a constant 50/50 balance of power between the two axles.

With over 30 years of AWD expertise, Subaru's viscous limited-slip differential is extremely compact, allowing it to be attached directly to the transmission for a more efficient power transfer. Subaru also employs it as a rear differential on some performance models for stability under powerful acceleration and on some crossover models for more balanced driving and traction on inconsistent surfaces.

Electronically-controlled Multi-Plate Transfer Clutch

Subaru uses a Multi-plate Transfer Clutch System (MPT) on many of its automatic-equipped models for a combination of optimum traction and fuel economy. The system uses an electro-mechanical centre differential. Its control unit constantly monitors input from the Throttle Position Sensor (TPS), the Engine Control Module (ECM), the Transmission Control Module (TCM) and wheel speed sensors to provide the most effective front/rear balance of torque.

In good traction, the MPT's predetermined logic splits torque 60/40 front/rear for enhanced fuel economy. In poor traction situations or under hard acceleration it can vary the balance up to a full 50/50 for maximum traction.

Variable Torque Distribution

Variable Torque Distribution (VTD) is a highly sophisticated system for automatic transmissions that combines an electro-mechanical centre differential with the advanced capabilities of a planetary gear set. The difference between VTD and MPT is significant—while MPT can vary torque between 60/40 and 50/50 front/rear, VTD provides the kind of performance experience usually associated with rear-wheel drive vehicles. In most conditions, the split is 45 percent front, 55 percent rear for an enhanced performance feel. In poor traction conditions, VTD can dynamically adjust up to a full 50/50 front/rear split.

When used with Subaru's advanced Vehicle Dynamics Control (VDC), VTD has the flexibility to open the centre differential fully and direct engine torque to a single wheel. The VDC-equipped system works in tandem with the AWD system, Traction Control and ABS to provide outstanding stability control.

Helical-Type Limited-slip Front Differential

A viscous differential is not suitable for use on a front axle because it maintains a 50/50 balance of torque between the left and right wheels. It would be useful in situations where there is a major difference in traction between left and right wheels—such as in the snow—but would be disastrous in turns where left and right wheels must move at different speeds.

The "helical-type" front differential, which made its debut on the 2005 WRX STI, overcomes this problem by using a planetary gear set to vary the torque delivered to the left and right axle shafts, depending on traction and engine load. Instead of locking the output shafts so that they rotate at the same speed, this differential sends more torque to the wheel with more grip. In addition, it makes a gradual adjustment for a more fluid response.

Mechanical Limited-slip Rear Differential

Like the helical differential, the mechanical limited-slip differential provides a quicker, stronger and more dynamic response than the viscous system. Unlike the helical differential, it can come to a full 50/50 lock, making it inappropriate for front-end applications but ideal for ensuring that maximum torque is shared between both the left and right side rear wheels.

Driver Controlled Centre Differential

Subaru developed its Driver Controlled Centre Differential (DCCD) to meet the performance requirements of the WRX STI. DCCD uses a cam-type mechanical limited-slip centre differential to vary front/rear torque from 41/59 to 50/50 depending on drive surface, traction, torque load and lateral g-load.

What makes DCCD unique is that it has two modes, Automatic and Manual.

Auto mode is the default setting on engine start-up. This mode is an all-round control mode appropriate for the majority of driving conditions. It automatically adjusts front/rear torque split to accommodate variations in traction, individual wheel speed, and yaw.

Auto (+) mode biases front/rear torque toward a 50/50 setting but does fluctuate slightly for flexibility on clear patches. This near-neutral setting is ideal for rough roads and slippery conditions or situations when safety through traction is of the utmost concern.

Auto (-) mode biases front/rear torque distribution toward 41/59, increasing steering response for quick and agile driving due to the near-consistent rear-wheel bias.

Manual mode offers drivers a precise choice in torque split to exactly suit driving conditions and their individual driving preferences by pressing the Auto/Manual button and toggling forward (+) or backward (-) to adjust front/rear torque split. Only the real experts will get the most from this feature as it puts total decision-making in the hands of the driver.

A bar graph located in the gauge group shows approximate front/rear torque split when in Manual mode.

While Vehicle Dynamics Control maximizes stability, DCCD takes advantage of all available traction for the ultimate in a true performance driving experience.

Combining multi-mode technologies

By combining the SI-DRIVE, Multi-mode DCCD and Multi-mode VDC settings, drivers can fine-tune the WRX STI's engine power, throttle response, traction and stability control characteristics and front/rear torque distribution for ideal performance in any driving condition or driving style.

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