Staying the Course

The operation of the stability control systems found on late-model Subaru vehicles is fascinating and complex.

Here's a look at how they work.

A few years ago, vehicle dynamics stability systems were only found on high-priced luxury European vehicles. Subaru now offers these safety-enhancing systems on certain of its newer models. These complicated — and often misunderstood — systems require a little education as to how they function.

The National Highway Traffic Safety Administration (NHTSA) recently issued a mandate for all automobile manufacturers to incorporate anti-rollover ESC (Electronic Stability Control) in all passenger cars, light trucks and sport utility vehicles by 2012. Many manufacturers have already begun to move in that direction, feeling that the safety aspect of ESC is desired by consumers and is a selling point for their vehicles. Over the next six years, all technicians will need to become very familiar with ESC systems because of this development.

While known generally in the automotive industry as ESC, the system is labeled with various names by each vehicle manufacturer because it has been customized and tailored to the needs of that company's vehicles.

The purpose of ESC is to help avoid dangerous situations that could lead to an out-of-control condition and result in fishtailing or vehicle rollovers. Basically, the safety system works by analyzing the input data from several sensors and determining if the vehicle has strayed from the driver's intended path. To help maintain the vehicle's stability, the system temporarily reduces the engine power, engages traction controls and selectively applies the brakes. The best and safest scenario for vehicle stability is to incorporate ESC, ABS and a Traction Control System (TCS) with a top-notch All Wheel Drive (AWD) System. Subaru, of course, falls into this category.

Subaru Vehicle Dynamics Control

The Subaru Vehicle Dynamics Control (VDC) System is designed to ensure the safest reaction to detrimental and adverse driving conditions. The system enhances directional stability by utilizing the Anti-lock Brake System (ABS) and Traction Control System (TCS) functions to assist the driver in accident avoidance and help maintain vehicle control when driving on wet, slippery or loose surfaces.

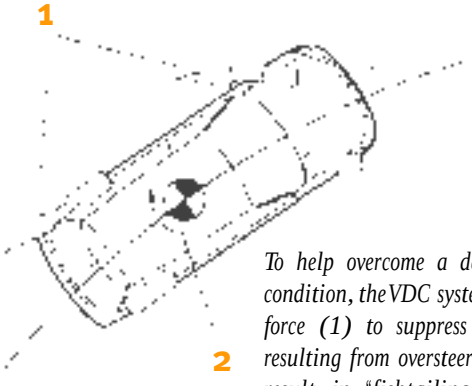
First, let's take a look at what the VDC system does and how it achieves that result. Basically, the stability system controls and/or corrects the speed and the direction of the vehicle by controlling the engine power and selectively applying the brakes. The system works in conjunction with the ABS, TCS and engine control module.

The direction of the vehicle is controlled to resist oversteer and understeer in turning – conditions that could lead to dangerous loss of driver control and result in spinning or rolling the vehicle.

Oversteer Suppression

When a vehicle starts to spin during cornering, the VDC control module (VDCCM) determines the direction line the driver was intending to follow and actuates the brakes on the front and rear outer wheels to suppress the oversteer condition and stabilize the vehicle.

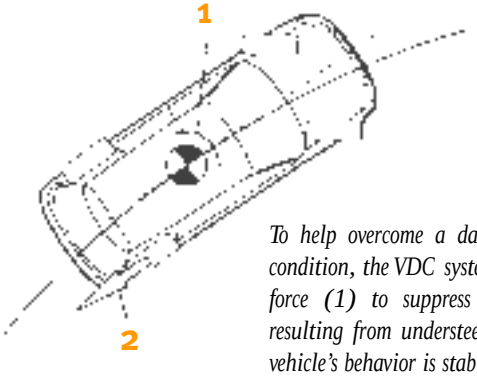
The system is alerted by the "yaw," or vertical axis variance away from the intended path. Readings from many input sensors incorporated into the system are analyzed. A "yaw moment" is generated in the system and it responds to correct the speed and direction of the vehicle. To understand this concept, try to think of a yaw moment as an emergency alert that the VDC system counteracts with a plan of defense. The graphic below illustrates how the VDC system is designed to suppress the oversteer condition.



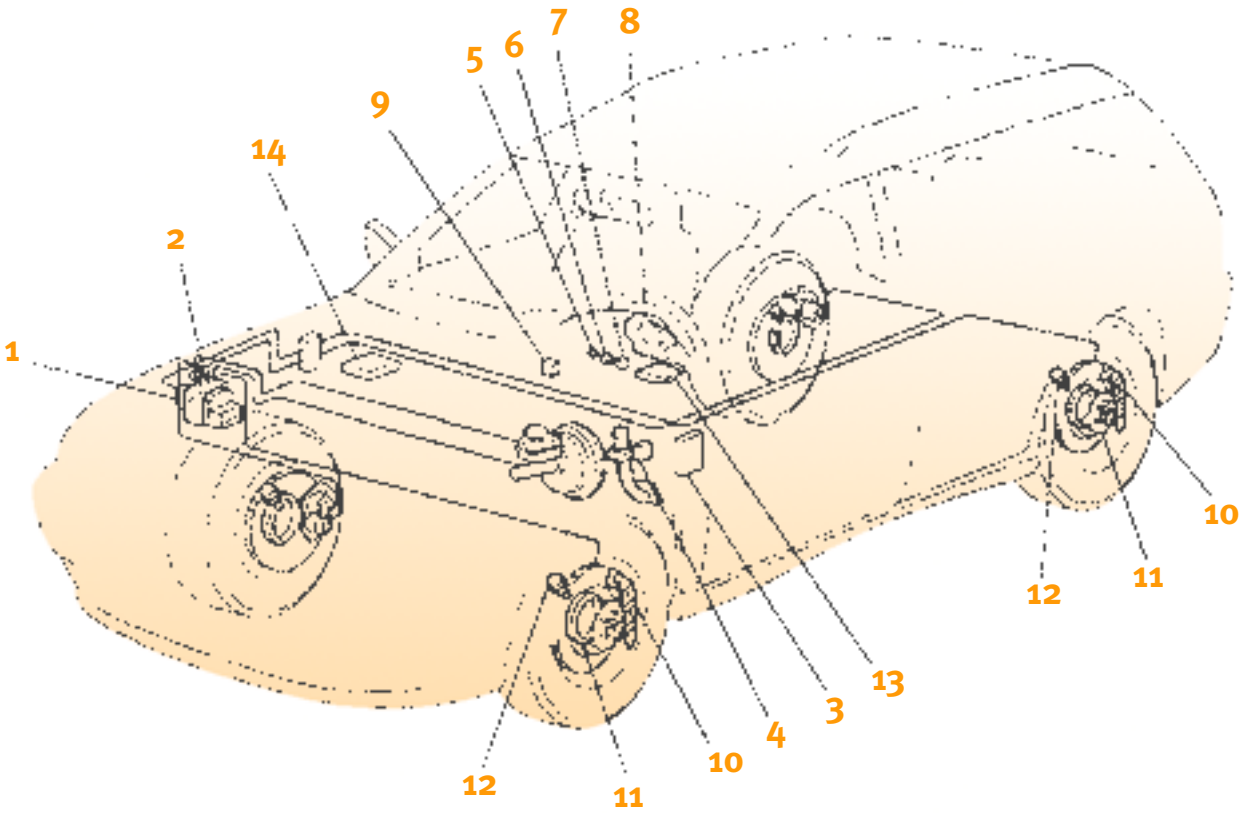
To help overcome a dangerous oversteer condition, the VDC system applies braking force (1) to suppress the yaw moment resulting from oversteer (2), which could result in "fishtailing." The vehicle is brought back into the proper line.

Understeer Suppression

When the vehicle begins to drift outward during cornering, the VDC reacts to correct the understeer condition and return the vehicle to the safe intended line through the turn. The graphic below illustrates how the VDC system is designed to suppress the understeer condition.



To help overcome a dangerous understeer condition, the VDC system applies braking force (1) to suppress the yaw moment resulting from understeer (2), so that the vehicle's behavior is stabilized.



To understand how the complex system operates, we must look at the many components that are integrated into the Subaru Vehicle Dynamics Control (VDC) System. The graphic below shows all the integrated components and their locations.

1. Vehicle dynamics control (VDC) control module
2. Pressure sensor
3. Automatic transmission control module
4. Stop light switch
5. ABS warning light
6. Vehicle dynamics control (VDC) indicator light
7. Vehicle dynamics control (VDC) warning light and vehicle dynamics control (VDC) OFF indicator light
8. Steering angle sensor
9. Vehicle dynamics control (VDC) OFF switch
10. Wheel cylinder
11. Magnetic encoder
12. ABS wheel speed sensor
13. Yaw-rate and lateral G sensor
14. Engine control module

The heart – or brain, really – of the Subaru VDC system is the VDC control module (VDCCM), which is located in the passenger side of the engine compartment. It is constantly monitoring input from several components and sensors to calculate the best plan for reacting to any *potential* out-of-control situations. If any such a dangerous incidents occur, the VDCCM sends messages to:

- The Engine Control Module (ECM) to cut power appropriately.
- The Traction Control System (TCM) to distribute the correct drive power to the wheels.
- The Anti-lock Brake System (ABS) to selectively apply braking to the proper wheels.

The VDC control module (VDCCM) is located on the passenger side of the engine compartment.

Here is a chart listing the stability components of VDC and their contribution to the operation.

VDCCM	• Determines the vehicle's running condition from various sensor signals and, based on the result, controls the vehicle dynamics control (VDC) hydraulic unit, ABS and TCS as required. • Performs CAN communication with the engine control module, automatic transmission control module and the steering angle sensor. • Causes the system to stop and the warning light to illuminate if a fault occurs in a circuit of the electrical system. Stores the code that indicates the location of the fault.
Vehicles dynamics control (VDC) hydraulic unit (VDCH/U)	Actuates the pump motor in response to a command from the VDCCM and changes fluid passages using solenoid valves to control the hydraulic pressures applied to the wheel cylinders.
Steering angle sensor	Detects the steering direction and angle when the steering wheel is operated by the driver, and outputs signals. On 2005 and up models, these go to the CAN.
Yaw-rate and lateral G sensor	Detects the yaw-rate and lateral G of the vehicle and outputs it to the VDCCM.
Pressure sensor	Detects the hydraulic pressure resulting from driver's brake pedal operation and outputs it to the VDC-CM.
ABS wheel speed sensor	Detects the speed of each wheel and outputs it to the VDCCM.
Engine control module (ECM)	Controls the engine output in response to commands from the VDCCM. Further, it transmits current engine output and engine speed signals etc. to the VDCCM.
Automatic transmission control module	Controls the transfer clutch in response to commands from the VDCCM during vehicle dynamics control (VDC) control, ABS control or TCS control so that torque is distributed optimally between the front and rear axles.
ABS warning light	Alerts driver to an ABS fault.

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Vehicle dynamics control (VDC) warning light and vehicle dynamics control (VDC) OFF indicator light	• Alerts the driver to a vehicle dynamics control (VDC) or TCS fault. • Illuminates to tell the driver that the vehicle dynamics control (VDC) and TCS are inactive (when system is not failed).
Brake warning light	Alerts the driver to an EBD fault. This warning light is also used for parking brake warning and brake fluid warning level.
Vehicle dynamics control (VDC) operation indicator light	Blinks when the vehicle dynamics control (VDC) is operating or lights steadily when the TCS is operating.
Vehicle dynamics control (VDC) OFF switch	• Allows the driver to temporarily disengage the vehicle dynamics control (VDC) • In "temporarily disengaged" status, the vehicle dynamics control (VDC) OFF indicator light illuminates.

Note: CAN (Controller Area Network) communication refers to the bidirectional multiplex high-speed communication.

The three main areas of function in stability are: the Vehicle Dynamics Control (VDC), the Traction Control System (TCS) and the Anti-lock Braking System (ABS). The interaction and function of each is illustrated below.

Vehicle dynamics control (VDC) function

The vehicle dynamics control (VDC) determines the driver's intention from the data provided by the steering angle sensor, braking pressure sensor, engine-related sensors and other relevant sources and recognizes the result as the target vehicle behavior. At the same time, it determines the vehicles actual behavior from the data provided by the yaw-rate sensor, lateral G sensor, ABS wheel speed sensor and other relevant sources. Then, the module compares the target and actual vehicle behaviors to estimate how the vehicle is running (whether it understeers, oversteers, slips or is in other condition), and based on the result, performs braking control of individual wheels, engine output control and AWD control as necessary to correct the vehicle's running condition.

TCS function

The TCS constantly receives signals from the relevant sensors to monitor the vehicle speed. When the running wheels' slip exceeds a certain limit, it performs braking control of individual wheels, engine output control and AWD control as required to maintain optimal traction and adequate side force.

ABS function

The ABS function constantly receives signals from the relevant sensors to monitor the vehicle speed. When the slip of wheels during braking exceeds a certain limit, it performs braking control of individual wheels and AWD control as required to maintain optimal traction and adequate side force.

NOTE: "Braking control" is effected by the VDCCM as follows: The VDCCM calculates the required braking force for each wheel and sends signals to the VDC hydraulic unit. The hydraulic unit's motor pump is then operated to generate the required hydraulic pressure. Further, it controls the hydraulic unit's solenoid valves to increase, maintain or decrease the the hydraulic pressure applied to the brake wheel cylinder as required. When the brakes are applied by the driver, however, the braking force is controlled by the hydraulic pressure resulting from the driver's action.

"Engine output control" is effected by the VDCCM as follows: The VDCCM calculates the target engine output for each condition, and sends commands to the engine control module. The engine control module compares the target engine output with the current engine output. Based on the comparison, the throttle opening or fuel injection is controlled. The targeted engine output is then achieved.

"AWD control" is effected by the VDCCM as follows: When necessary, the VDCCM sends a command to the automatic transmission control module. According to the command, the transmission control module controls the transfer clutch so that the torque is distributed between the front and rear axles optimally.

VDC System OFF Switch

A switch allows the driver to temporarily disengage the Vehicle Dynamic Control system. The switch is located on a panel at the lower left side of the steering wheel. On some occasions, better driving results may be obtained by disengaging the VDC to allow the drive wheels to slip for a certain amount when starting the vehicle on icy or unpaved, steep uphill roads, or for escaping when the wheels are mired in heavy mud or snow.

When the VDC OFF switch is momentarily pressed while the engine is running, the VDC OFF indicator light in the combination meter illuminates to show that the VDC system is disengaged. When the VDC OFF switch is momentarily pressed again, the VDC OFF indicator light turns off and the system returns to "engaged" status. If the VDC OFF switch is pressed and held for more than 10 seconds, the VDC OFF indicator light turns off. The system will not allow further operation until the next time the engine is started.

The VDC OFF switch allows the driver to temporarily disengage the stability system.

Although Subaru VDC systems function similarly, they may vary slightly from model to model. Full service information for each specific model can be found on the Subaru Technical Information System website at http://techinfo.subaru.com.

The VDC OFF indicator light illuminates to inform the driver that the stability system is disengaged.

VDC Diagnostic Trouble Codes

Vehicles equipped with the Subaru Vehicle Dynamics Control (VDC) System may display unique diagnostic trouble codes (DTCs). The table to the right shows some of the generic DTCs for the VDC system, the detailed code, the display and the content of the diagnosis. Always refer to the correct information for the model and year of the vehicle you are repairing.

Also, because VDC system incorporates and utilizes the ABS system, some DTCs may appear as ABS codes. Examples are:

- DTC C0021 Front Right ABS Sensor Open Circuit
- DTC C0023 Front Left ABS Sensor Open Circuit
- DTC C0025 Rear Right ABS Sensor Open Circuit
- DTC C0027 Rear Left ABS Sensor Open Circuit

DTC	Detailed Code	Display	Content of Diagnosis
C0072	4721	Yaw rate sensor signal	Yaw rate sensor signal malfunction
	4722	Inside yaw rate sensor	Yaw rate sensor internal problem malfunction
	C723	Yaw rate sensor comunication	Yaw rate sensor comunication malfunction
	4724	Yaw rate sensor oscillation	Yaw rate sensor oscillation malfunction
C0074	4741	Pressure sensor open line	Pressure sensor open circuit
	4742	Pressure sensor signal seizure	Pressure sensor signal freeze
	4743	Pressure sensor 0 point	Pressure sensor 0 point
	4744	Pressure sensor noise	Pressure sensor noise
	4745	Pressure sensor output rise	Pressure sensor output rise