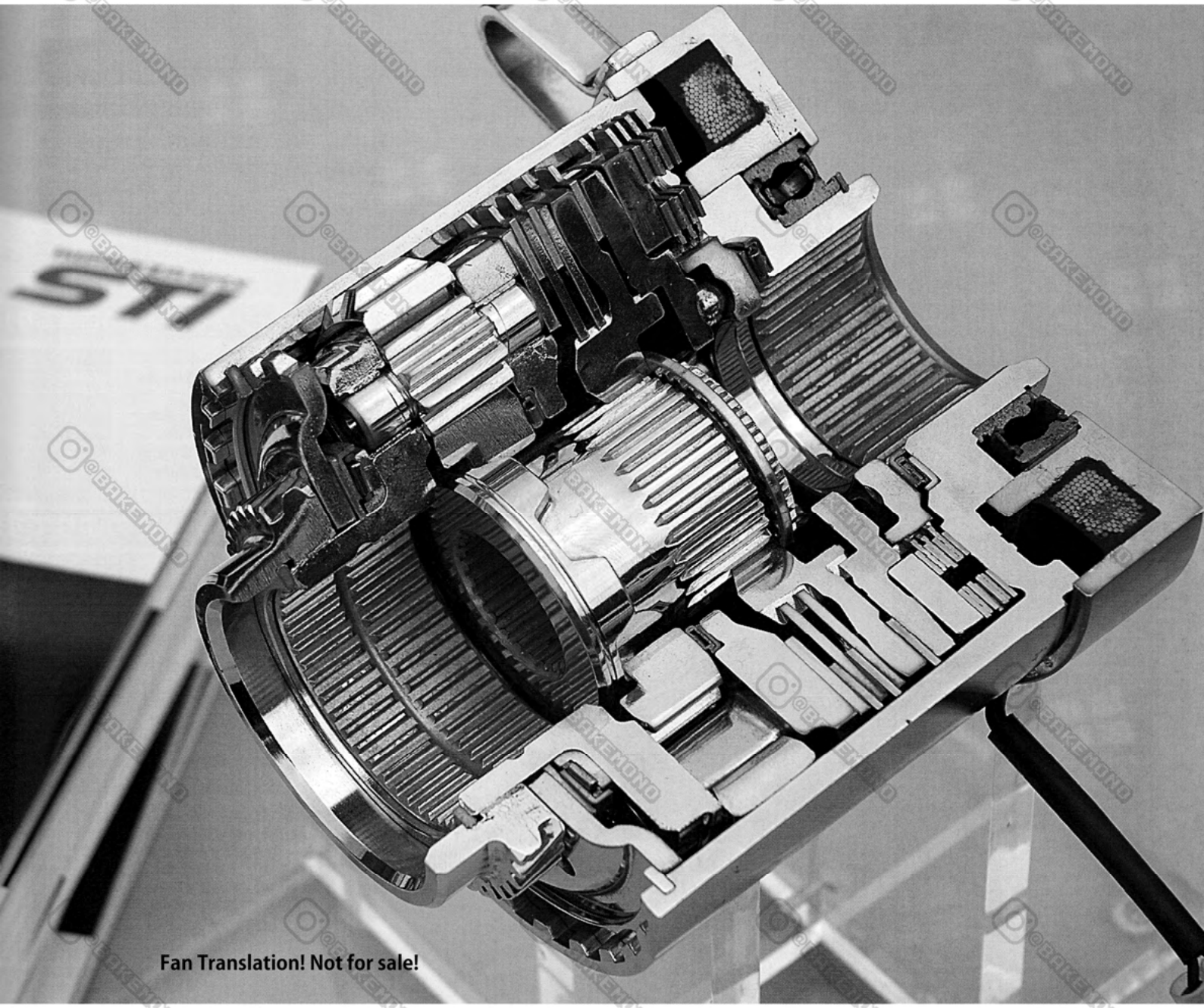
Electronic control devices are no longer circuit-only items!

DCCD Street Usage Manual

DCCD is an effective function on the circuit, but if you don't think it would change anything on the street, wait a minute! On the street, where the road surface situation frequently changes, DCCD lends itself well to allow you to run safely and comfortably. In this article, we explain the basic function of DCCD, and how it operates in different situations. We'll also cover how to effectively use DCCD in an effort to master it.

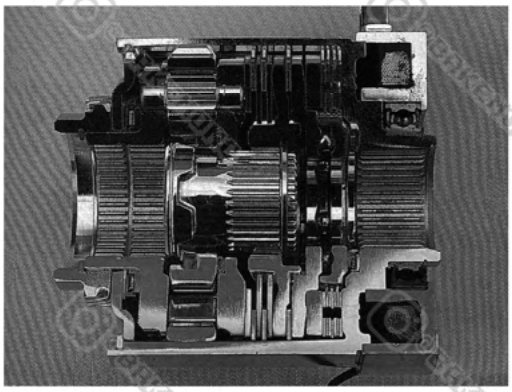


Scans taken from Impreza Magazine #41, Published 2009

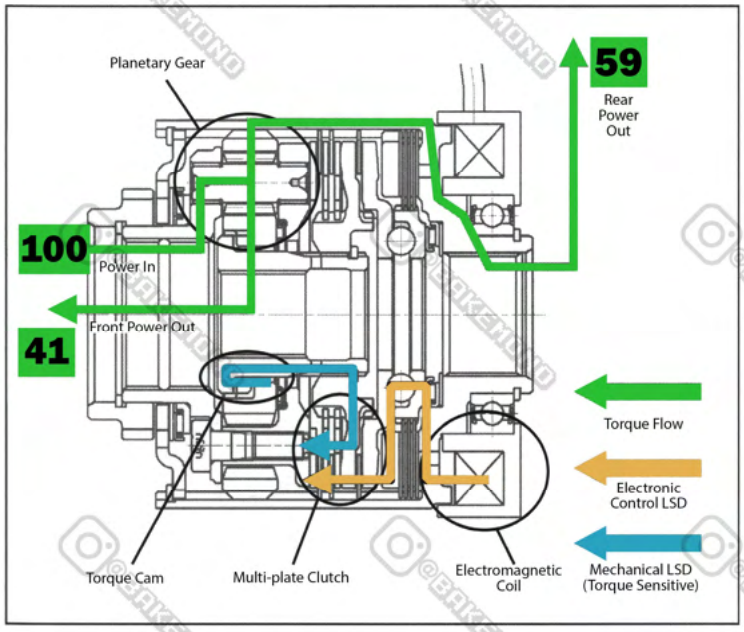
Understand the DCCD Mechanism and Know its Merits

LESSON 1

The center diff senses all conditions and distrbutes optimal torque to front and rear



DCCD (for GDBF type and later) employs a complicated mechanism that incorporates a mechanical LSD in addition to an electronic clutch. Looking at the diagram below, the torque is divided betwen the front and rear the the front/rear distribution is changed according to the conditions of the corners.



4WD vehicles, including the Impreza, always have a center diferential. THe force that explodes in the combustion chamber rotates the crankshaft and travels to the wheels through the flywheel, clutch and transmission. If it is FR, the drive wil be sent directly to the rear diff, but a 4WD vehicle must also turn the front wheels. In other words, the center differential is a mechanism to assign power to the front and back. It is built into the transmission so there are not many opportunities to see it...Let's move onto the DCCD. The official name is "Driver Control Center Differential," and literally translated, is a center diferential that the driver can control arbitrarily. It seems to have been named like this due to the ability to change settings via a dial. Before getting into the detailed explanation of the DCCD, let us first delve into the an explanation on the standard mechanical center differential.

Common mechanical center differentials distribute power equally with 50 at the front and 50 at the rear. Al models without DCCDs will be distributed evenly. The advantage of this mechanical center diff is the tremendous traction performance of 4WD. If you remove the viscous LSD and replacec it with a mechanical LSD< the traction performance will be further improved. The disadvantage is that the "foot performance" decreases. The power to move forward is too great and the power to turn is lost. This phenomenon is known as "push under," is more likely to occur when the force to move forward exceeds the force to turn. DCCD was designed to counteract such a disadvantage which not sacrificing traction performance. In brief, when entering a corner, the center differential function is weakened with an emphasis on turning performance, and when exiting a corner the diferential is strangthened to obtain traction performance. It is the DCCD that electronicaly controls this.

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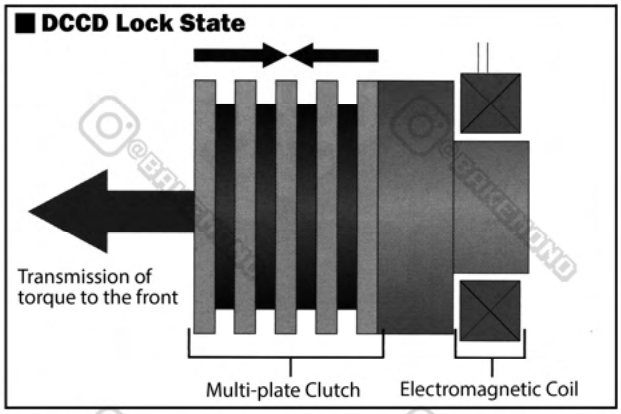
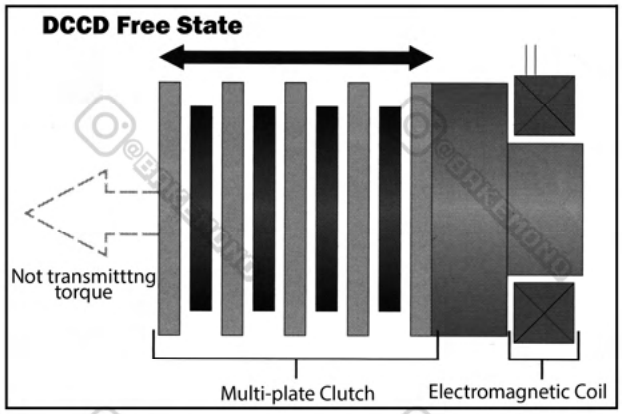
The electromagnetic clutch is the same as the clutch that transmits the motion from the engine. In the DCCD Locked state, the multi-plate clutch is crimped and the torque is also transmitted to the front side. On the other hand, DCCD Fre adjusts the amount of torque sent to the front by sliding the clutch plate in the same way as in the half-clutch state. This is adjusted by the coltage sent to the electromagnetic coil.





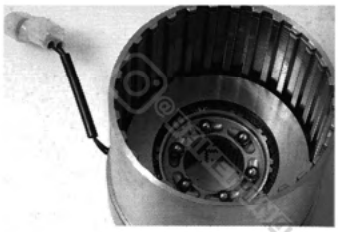
Although the size is completely different, the DCCD has the same structure as a multi-plate clutch. The amount of torque distributed to th front an rear is adjusted depending on whether or not the clutch plates are engaged. To increase durability a special material is used on the face.

In order to make the differential case as light as possible, the part that does not receive force is remove to save weight.

A mechanical LSD was incorporated into the DCCD from the GDBF type. At that time, Subaru had more than 20 patents. This is a relatively complicated mechanism.

As you can see fromthe comparison with a 500 yen coin, it is packed with a number o extremely small gears. Great care is taken in regards tothe accuracy and durability of the gears.

Wiring connector extending from the differential case. Electricity is sent through here and the current reaches the electromagnetic coil inside



I want you to think of the mechanism of a clutch in your head. If you step on the clutch, with your left foot to the floor, the car should not move forward. This is the "free" state of the DCCD. On the other hand, when the clutch is engaged, the car moves forward. This is the "locked" state. In the half-clutch state when the clutch is slightly disengaged at the end, the way the car advances differs depending on how much the clutch is engaged. Its easy to think of this as an intermediate state between "free" and "lock."

Understand that in the case of a clutch, the operation is performed with the left foot, but in the case of DCCD, the left foot is substituted with electricity. By changing the voltage sent to the center differential, the half-clutch state is increased or decreased. Looking at it this way, its not that complicated. The diagram at the top of the page should make further understandin easy.

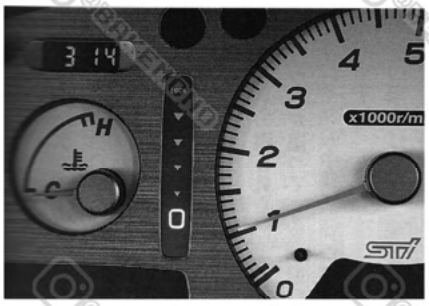
Although it shares many components with a standard clutch, the shape is slightly different. If you look closely, it looks like a mechanial LSD. In the mechanical LSD the plates press against each other and the amount sent to the left and right tires is adjusted. However if there is a slight difference in the number of revolutions of the left and right tires, it is a mechanism that just connects the left and right. However, the DCCD determines what the condition of the car is in, from the steering angle, lateral G, vehicle speed sensor, and so on. Based on this information, the optimum cohesive force of the center differential is adjusted.

Why does the center diff torque split vary by Impreza model?

LESSON 2

If you check the front/rear torque distribution of each successive model, you will see that the distribution ratio changes for each model. What are the advantages and disadvantages of changing the distribution between the front and the rear? First, let's start with the case of the rear. With a heavier rear distribution, when entering a corner the driving force of the front tires is weak so the nose turns toward the inside. However, near the corner exit, it does not pull because the driving force of the tire is weak. Since the force that pushes out becomes stronger, it means that the exit is under. In other words, it is a setting that emphasizes turning performance.

On the other hand, a front bias setting is focused on traction. When entering a corner, the driving force of the front tire interferes with corner entry, but while pulling at the corner exit, the rear tire does not push out , so you can accelerate sharply. Let's try running with the DCCD in manual mode, locked, and free. To be honest, it is difficut to determine which torque distribution is better. However, due to the transition of successive models, I feel that front side is better than the rear side. By the way, the rival Mitsubishi Lancer Evolution is set to 50/50 for all successive models, and have never changed this setting. I think this is because if the torque distribution is set to either one, the balance will be lost due to the feeling that acceleration is good but deceleration is not good.



When the dial is turned upwards, it is locked, and when it is turned downward, it changes to FR-like characteristics. Since there is no problem turning the dial while driving, it was possible to return two steps from lock at the corner and free on the straight.

The front/rear torque distribution was changed according to the front/rear balance of the vehicle body to seek more optimal handling.

GC

Front/Rear Torque Split

36:64

DCCD is adopted from STi Version II!
Ground-breaking system that changes turning characteristics according to running stage and driver.

DCCD, which was developed for rally and other competition cars was a very ground-breaking system at the time. The torque distribution was 36:64, emphasizig the rear considerably. Why? The answer was in the Impreza's drive layout. The center of gravity of the engine is low and the engine is relatively light. Weight distribution was symmetrically balanced left to right. They wanted the car to have the honest turning characteristics of an FR car. The GC front/rear torque distribution remained unchanged until the introduction of the GD chassis in 2000.

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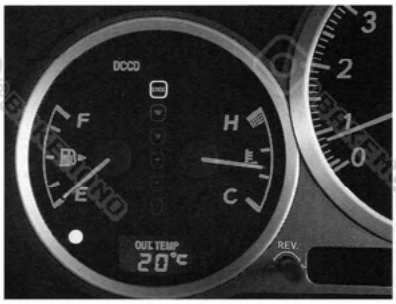
GD

Front/Rear Torque Split

45:55 (A&B Type)
35:65 (C-E Type)
41:59 (F - G Type)

The GD platform changed the torque distribution 3 times From the C-type "auto mode" function was added, and development of electronic control devices was actively promoted

With the full model change of GDB, the Impreza moved from a "small size passenger vehicle" to a "normal size passenger vehicle" class. The front/rear torque changed to a more front-biased 45:55. The body of the Impreza changed drastically. While the drive system is not changed, the body became heavier to comply with collision safety rules, and weight balance shifted to the front, placing a larger burden on front tires, resulting in a vehicle that understeered. In response to the impression that the Impreza is weak at cornering, the torque split changed to 35:65, giving it an FR characteristic. The hawk eye model changed this again to 41:59, also incorporating a mechanical LSD. Since it changed 3 times, its easy to imagine Subaru searching for that magic balance.



Various people evaluated the bugeye Impreza as a car that could not turn. Subaru responded quickly with a secret weapon: DCCD auto. Until now, DCCD control was manual only, distributing the torque distribution arbitrarily.

GR

Front/Rear Torque Split

41:59

In addition to the manual and auto mode, "plus" and "minus" have been added, referring to the 'clamping force' of the diff. Three tyes of settings have been added to auto-mode only.

A new function called "VDC" has been added! Armed with an electronically controlled device, The ride quality keeps its "Impreza-ness."

WIth the GRB model change, a new chassis was adopted with an evolve double wishbone rear suspension.It was thought that the torque distribution would change significantly but it was 41:59, same as the GDB. However, DCCD, which used to only have a manual and auto mode, has a wider range of settings with the addition of Auto Mode (plus) and (minus) functions. One mode enhances traction performance while one emphasizes turning performance. Another major change was the multi-mode VDC (vehicle dynamics control) which linked the electronically controlled throttle and brake control.

What is the function of the Evo's ACD & AYC electronic control?

LESSON 3

The center diff control is similar to the Impreza

ACD

The impreza has 6 adjustment settings with the dial, but the Lan Evo has a total of 3 settings. "Snow" has the strongest center diff engagement, "Gravel" is a middle settings, and "Tarmac" has the weakest engagement, can be changed by pressing a button.

The ECU map that determines the control of ACD can be rewritten. ACD computers are used in various competitions such as rallies, Gymkhana, and Super Taikyu.

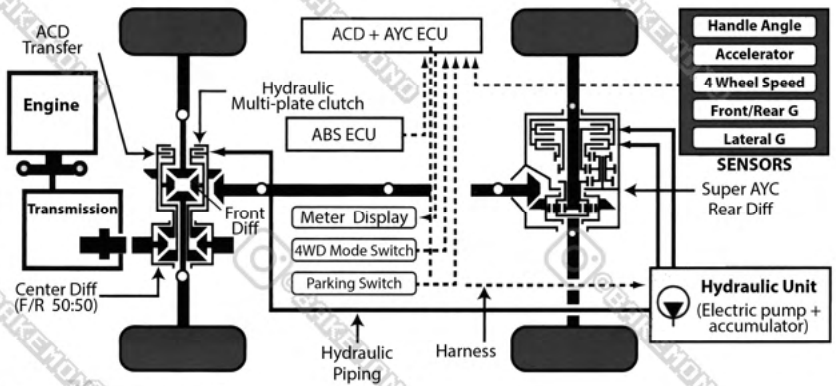
First installed on the Lancer Evolution VII, the ACD (Active Center Differential) has grown into a useful technology on rally stages, circuit time attack, and gymkhana. It can be thought of as a mechanism similar to the Impreza's DCCD, such as the internal mechanism, torque distribution to the front and rear, and the fact that the distribution rate can be changed with a button. However, the way that the torque is transmitted back and forth is different. On a previous page, we explained that the Impreza finely adjusts the amount of torque sent by levels of clutch engagement when sending torque to the front. However, the Lancer Evolution's ACD changes the torque distribution of front and rear by shifting the timing, even though it sends torque the same way. Impreza= amount to send. Evo= time to send.

ACD is said to be an electronically controlled device that mainly affects traction performance but it also plays a role in stabilizing the vehicle body during breaking.

When you enterthe corner vigorously, the rear tire rises and you are in a state of 'swinging your hips' (The car by this time has ABS so i am talking about it as an exteme example). In such acase, ACD enchances the cohesiveness of the center differential and contributes to the stability of the car.

In this way, at the entrance of the corner, the cener differential is used to secure a sense of stability, and when the steering is started, the cohesive force is weakened to support turning performance, and stengthened again at the exit.

ACD is installed next to the engine because it is FF based. Like the Impreza the effectiveness of the ACD is adjusted from throttle position, lateral G and wheel speed.



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A device that improves turning performance by changing the amount of torque sent to the left and right rear tires

AYC

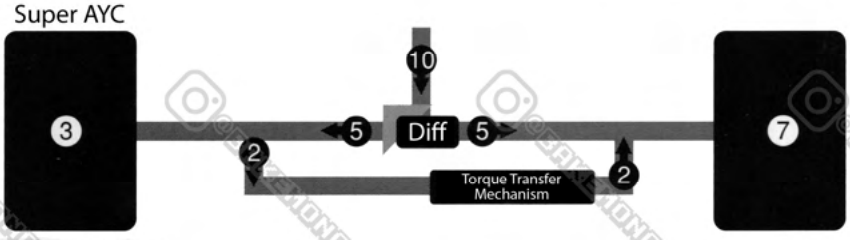
Even with the same 2.0L turbo, the drive layout is completely different. Compared to the Impreza, it is front heavy and the left-right balance is heavier on the right.

In Super Taikyu, it is becoming mainstream to install both ACD and AYC. In rallies, there are still many users who use only ACD.

AYC (Active Yaw Control) is a mechanism installed in the rear differential that can distribute torque to the left and right. Simply put, the torque distribution can shift to the left or right on the situation, such as 80% for the right tire and 20% for the left tire. The excavator caterpillar can rotate 360 degrees on the spot by applying power to the left or right. The theory is the same here. If the tires on the left side turn more than the tires on the right side, which direction is the car facing? The answer is "right." AYC is a mechanism that transfers torque to the outer tire and generates a yaw moment when it decides that it wants to change the direction of the car while cornering.

Unfortunately, the Impreza's rear differential is an old mechanical LSD, Suretrack LSD, or Torsen LSD (depending on model and grade). I can't say anything more than this because personal taste greatly influences one's opinion, but the Impreza considers electronic control as a support device for the car chassis. On the other hand, the Lancer Evolution has utilized an electronically controlled device to manage the imbalance of the car body. When you ride each car here, phrases like "natural ride" and "unnatrual turning" come to mind.

The illustration on the right portrays what is happening while turning in a left corner. By applying more torque to the right tire, a yaw moment is generated in the car body, increasing turning performance.



Comparison of performance and turning radius between DCCD "locked" state and "free" state

LESSON 4

The feeling transmitted to the handling is completely different. Small turns in "lock" mode are difficult

There should be many Impreza owners asking, "Its usually in a free state. I wonder if its possible to switch to manual mode several times a year." Certainly, there is no particular problem usnig the auto mode, because the car always distributes the optimum torque through the center diff to the front and rear tires on any road surface.

So why didn't Subaru just use the auto mode only? "Because I want you to make use of the manual mode as well."

So, first of all, as a simple test, I went to a large parking lot and tested the diferent modes of DCCD. The car acts completely diferent in manual mode "lock" and "free."

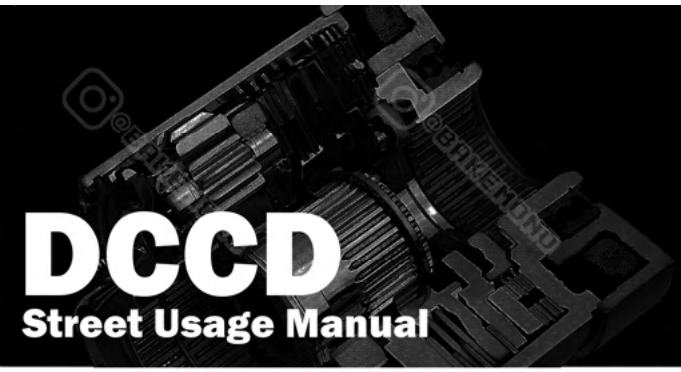
When the DCCD is in "Lock" state, the torque is transmitted to the front tires. If there is a rotational difference between the front and rear tires, the car is quite jerky because it tries to suppress it somehow. You can clearly see that the turning performance has degraded.

On the other hand, if you make the DCCD "free," the resistance is reduced because the torque transmission to the front tires are reduced. Even if you release the accelerator, if you don't step on the brake, you can feel the car moving forward. Its the same car, but just by messing with the DCCD dial, the car changes drastically and it feels like a complete different car. Its a function that changes the characteristics of the car so much that it would be a waste not to master it.

Test #1 DCCD Free Mode

It's easy to turn in the garage and at intersections! The drive of the front tire does not interfere, so it can rotate smoothly.

The first thing I tested was the case where the DCCD was "free." From a starting postion, the steering wheel was rotated and the car was gradually started. The test condition was to keep the vehicle speed as constant as possible (about 30km/h). There is little recoil tramsmitted from the front tires to the steering, and there is no need to be particularly nervous. I can hear and feel that the rear differential is working but it is not at the point of causing the vehicle to stall due to resistance. Next, I tested it in auto mode. I didn't post the photo because the result was nearly the same. The feel of the steering, distance traveled and the radius did not change. Perhaps auto mode in this scenario was almost free. What happens if you lock the DCCD?



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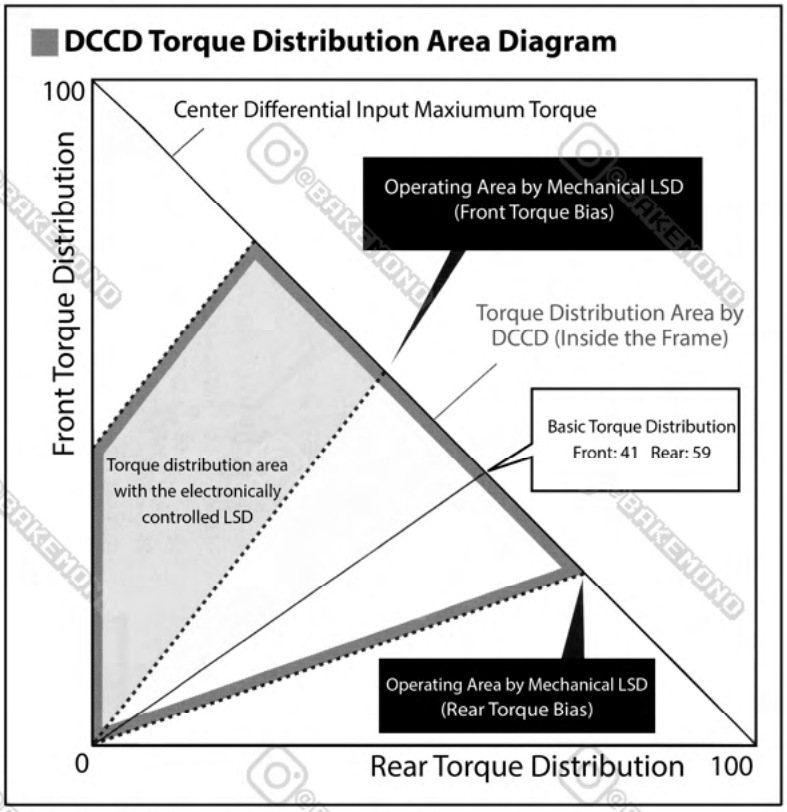
How durable is DCCD? What should I do for maintenance?

There are reported troubles using the GC DCCD for competition, which are unheard of with the GDB

DCCD's have been installed since the STi Version II. There have been many reports of low durability and failure with DCCD's manufactured in the early stages. However, these issues were quickly addressed and the major troubles disappeared. Early DCCD's had issues running hard on a good road surface with high grip tires (like Gymkhana), which put a heavy burden on the center differential, and caused clutch plate slippage. This is not reported on the GDB. As long as you change the gear oil regularly, the DCCD will not be damaged.



If you look at this chart, you can see from the position of the Basic Torque Distribution line, the range of torque set to the rear side by the DCCD is small, and the range of torque for the front is relatively large. In other words, DCCD determines whether or not the front wheels are driven.

Test #2 DCCD Full Lock

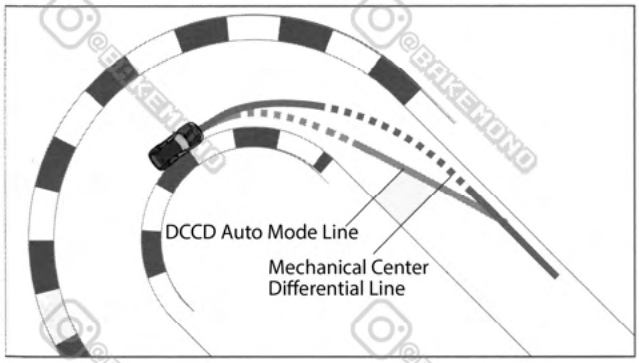
Its clearly different from the moment you engage the clutch. You can feel the magnitude of resistance transmitted to the steering wheel.

If you try to start the DCCD in lock mode, the moment you engage the clutch, you will likely stall if you are not careful due to the high resistance. It is difficultto keep the steering in a certain position from there and if you try to stop by releasing the accelerator, the car will behave erratically.
You can see the difference in the test results by taking a closer look at the pictures. The distance to the car facing completely front is completely different between free and lock... about a half car of difference. If it continues to rotate 360 degres as it is, the radius of the lock mode will gradually increase. Wouldn't the test results be significantly different when the vehicle speed is increased?

DCCD mode impacts the movement of the car changes drastically. Let's compare Auto and Manual Mode

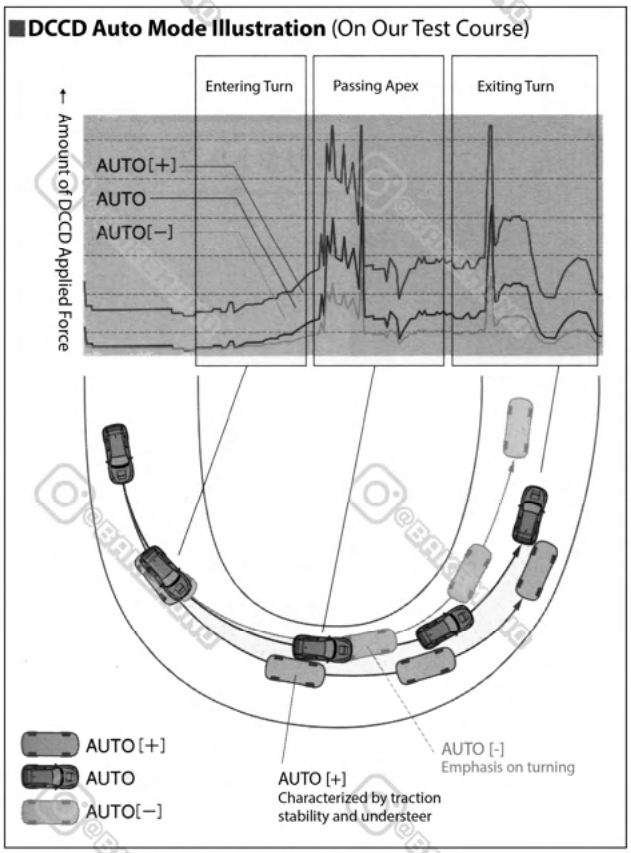
LESSON 5

When you step on the accelerator near the apex, DCCD Auto accelerates so that it cuts inward. On the other hand, with a normal helical LSD, the car body will inevitably flow to the outside. If this happens there is no other choice but to release the accelerator.



DCCD AUTO

Various information is collected from the whole car, such as stering angle, vehicle speed sensor, horizontal G, throttle position, and at that time the computer determines whether the car wants to turn, brake, or accelerate. It changes the torque distribution of the center differential to the optimal setting. For example, as shown in the illustration on the left, when going through a tight hairpin, torque is not distributed to the front tires because it is turning. When it is judged that the turn is almost finished, the torque is gradually distributed to the front to improve the traction performance. Since everything is automatic, this is the easiest for the driver. If this was a mechanical differential, it must be handled with driving skills, such as decelerating firmly, leaving a load on the front tire, and controlling the accelerator so that the rear tires do not slip. With all models, the Impreza moves naturally, so you won't be dissatisfied driving in the city.



Compared to the normal auto mode, there is a [-] mode that allows you to cut into the inside corner, and a [+] mode that provides excellent traction but swells to the outside in a turn The center diff engagement near the apex is very different.

DCCD AUTO +&− MODE

A new feature adopted by the GRB is "Auto Mode Select." There are two types: Auto [+] with improved traction performance and Auto [-] with an emphasis on turning performance. Since it is basically automatic, the engagement (and torque distribution) of the center differential changes depending on the situation. Compared to standard mode, [+] is set to have a stronger engagement, causing a tendency to understeer. Auto [-] has a weaker engagement. If you check the line graph in the illustration on the left, you can see that the engagement is nearly the same from the entrance of the turn to the apex. However there is a gradual difference in engagement from the point where the apex of the turn is passed. Auto mode exits the turn on a regular line, but Auto [-] exits on the inside from an early stage. On the other hand, Auto [+] clearly has a high engagement force as a whole, and the difference (as seen on the graph on the left) is about double, especially at the apex of the turn. If its a winding road with tight corners, use Auto or Auto [-]. If its a wide, predictable road, use Auto [+]. Lets try various things in diferent situations and feel the difference.

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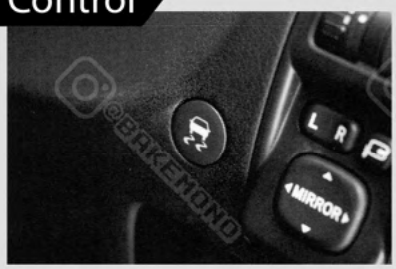
Cars without DCCD can set up their turning performance through their selection of mechnical LSD on the front and rear. However ou can't do this at the touch of a button. This is the big difference between mechanical and electronic control.

You can change from a 50:50 locked state to a 41:59 (GDB-F or later) by turning the DCCD dial. This adjustment method is easy.

DCCD MANUAL

It depends on the model, but if you look at the tachometer, you will find a long vertical indicator. The top is "locked" and the lower you go, the more center differential engagement is released, until it is "free" on the bottom setting. There are a total of 6 states, which can be set more finely that the Evo equipped with a similar device. As with the damping adjustment of the harmonic drive, there is no exact name for the middle settings . Therefore, it is common to refer to the settings as steps from "full lock" or from "free." One useful application of Manual Mode is in suspension setup. In Auto-mode it is difficult to tune suspension because you do not know to which degree the DCCD is affecting turning performance. When establishing a baseline for suspension settings, using manual mode you can keep DCCD fixed and say "when setting up it is 'locked' or 'three steps from locked.'" Once a baseline is established, you can find the best mode depending on the stage you are on. In our example here, since there are many high-speed corners, we have it set to high engagement. Running like this allows a better understanding of Impreza handling characteristics.

Vehicle Dynamic Control



VDC
What kind of feature is the GRB's newly installed multi- mode VDC?

Multi-Mode VDC is a fail-safe feature that avoids danger through throttle and brake intervention

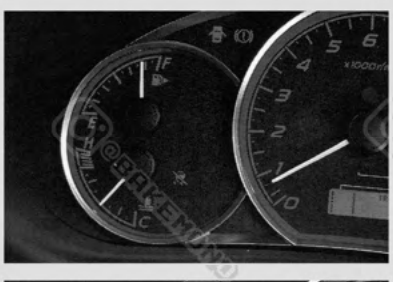
There are times when the road surface becomes wet and unpredictable. In such a dangerous situation that comes suddenly, nothing can be done anymore. In such a case, if it is a GRB's multi-mode VDC, the vehicle will detect the danger and guide the position of the car to a stable direction.

The computer controls the throttle position and ABS intervention timing. When VDC is on, it actively intervenes, so it can be a reassuring ally on unkown circuits, winding roads with few escape zones, and rainy or snowy days. In off mode, all functions except ABS are cancelled. Finally the traction mode alows you to enjoy sports driving while VDC intervenes at the very end.

When used in combination with DCCD, you can enjoy sports driving with a peace of mind. However please note that just having VDC does not make the car 100% safe.

Traction Mode

Press and hold the VDC button for more than 2 seconds and the display will turn green. The system intervention is slower than normal so it is recommended for people who are a little worried about "off mode." Throttle control is released.



Off Mode

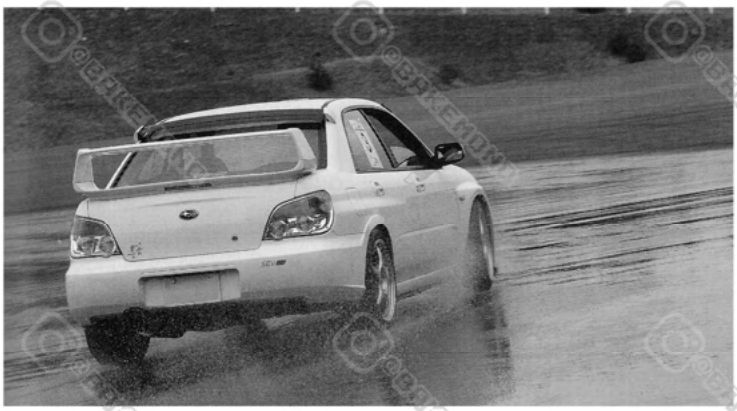
Press the VDC button once and the yellow mark will light up. All functions except ABS will be cancelled, so this mode is recommended for those who are confident in their settings and skils.

Let's actively change the DCCD mode according to the location and road surface condition!

LESSON 6

Streets where the road surface conditions and weather change are ideal for mastering DCCD to get both speed and safety!

DCCD Usage Scenario 1 Wet Road Surface



In the rain the mode that emphasizes traction is best You can run stably, even on rough roads

On rainy days, I want to choose a mode that emphasizes traction as much as possible. Especially if there is a lot of loose pavement on the road surface and the steering is likely to be taken to the left or right, it should be in lock mode or one step back from lock. There is no problem in free mode if it is in heavy traffic, but if it is an open road where there is some speed, I like to let the front tires take on some work. In particular, the sense of security when braking is best in lock mode. If you have the opportunity on a rainy day, experience the difference between DCCD free and lock settings in a parking lot, and you won't panic in an emergency. If your car is a GRB, I would make use of multi-mode VDC (on) and DCCD in Auto [+]. The car should settle itself at a surprising level even in a hydro situation.

DCCD Usage Scenario 2 Driving on the Highway

Free mode if your concern is fuel economy Auto [+] if you enjoy stable cruising

If torque is distributed to the front side in "lock" mode, the rolling resistance of the front tires will increase, resulting in poor fuel economy. If you commite to work or run a long distance slowly, try running in free mode to improve fuel economy. On the other hand, if you want to drive at a spirited pace, considering the responsiveness of the front tires, it is recommended to go back two steps from Auto [+] or "lock." The sense of security when changing lanes is completely different. Finally, when driving on the highway on a rainy day. The scariest thing about wet roads is when you change lanes. If you feel heavy wet, don't hesitate to switch to lock mode. The second you lock it the traction of the front tires wil increase and the steering wil feel a bit heavy, but it will increase the stabilty of the car and be much less scary than in Auto mode.

DCCD
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DCCD Usage Scenario **3**

Driving on Tight, Winding Roads

For the first tight pass, choose Auto Mode for safety

The scariest thing about winding roads is that you don't know the way and can't read the corner at all. There are few escape zones, and even a small mistake can quickly damage the car. Therefore, we recommend Auto Mode which can handle any situation easily.

"This is a tight winding area, so its a mode that emphasizes turning performance." Often unexpected troubles are waiting for you, such as ice patches or loose gravel, causing you to spin the car. I want to fully demonstrate the Impreza functions for safety and fun on windy roads. If you are familiar with the road and its conditions, chose Auto [-] or 3 steps from lock. From here, find a mode where the front nose enters the curve comfortably. If you enter the turn at the same speed and steering angle, and only change DCCD settings, there may be new discoveries.

DCCD Usage Scenario **4**

Driving in the Snow

For snowy roads, choose lock! Use Auto Mode for safe city driving

In the case of snowy roads, you can sacrifice some turning performance here, and emphasize traction. In Auto Mode and Free, the tires will turn but the feeling to the front tires is vague, and there is a high possibility the car body will sway.

The scariest thing about snowy roads is that you can't stop where you want to. If you panic, you will step on the brakes and cause a spin. For that reason, lock mode is recommended.

Lock mode is also recommended if you want to drive like the picture on the left. Even if you know that lock mode generally causes understeer, if you force the steering, the car will go in the direction being turned and will be mysteriously stable while continuing to press on the accelerator.

DCCD Usage Scenario **5**

Driving on the Circuit

Auto [+] for big circuits Try Auto Mode for Tracks with Tight Continuous Corners

"Circuit" may be too broad, as there are big courses like Fuji Speedway and small, tight courses like Honjo Circuit. Try running in Auto Mode first and determine if the car is under or oversteering.

Generally, if it is a tight mini circuit, we recommend the mode that emphasizes turning performance. In manual mode, its about one level higher than free or free. A shortcut to find the best setting is by changing the dial while running gradually. For GRB, use the Auto Mode and try running with [-] first. Depending on how you feel with this, you will have to adjust gradually.

In the case of a large circuit, it is often safer to emphasize front tire traction in high-speed corners even if the understeer is a bit strong. Rather than full lock, try it first with 2 steps from lock.