BMW Motorrad Active Cruise Control.
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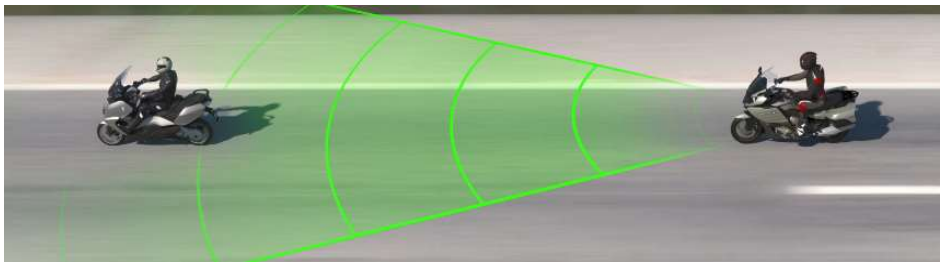
1 The new Active Cruise Control (ACC). (Short version)



The new BMW Motorrad Active Cruise Control (ACC). Cruise control with distance control for maximum comfort and best possible safety when riding a motorcycle.
Relaxed cruising with active cruise control, without having to manually adapt to the driving speed of the vehicle in front – already available in cars now for many years, but not the standard in motorcycles to date. However, with the Active Cruise Control (ACC), BMW Motorrad will soon offer this type of rider assistance system, thus providing motorcyclists with a completely new, comfortable riding experience.

ACC is a novel rider assistance system that was developed in cooperation with the partner, Bosch. The many years of experience with passenger car driver assistance systems of both companies could be applied selectively here and used for motorcycle applications. The new ACC provides maximum comfort for the demanding touring motorcyclist by automatically regulating the speed set by the rider and the distance to the vehicle driving in front. The system automatically regulates the vehicle speed when the distance to the vehicle in front is reduced and keeps the distance defined by the rider. This distance can be varied in three stages. Both the riding speed as well as the distance to the vehicle in front can be set conveniently using a button. The individual settings are displayed on the TFT instrument cluster. The new BMW Motorrad ACC has two selectable control characteristics: comfortable or dynamic, in which the acceleration and deceleration behaviour is changed accordingly. The distance control can also be deactivated in order to be able to use the Dynamic Cruise Control (DCC).

When cornering, the speed is automatically reduced by the ACC if required and a comfortable lean angle is aimed at. With an increasing lean angle, however, the braking and acceleration dynamics are limited in order to maintain a stable rideability and not to unsettle the rider by abrupt braking or acceleration. The BMW Motorrad ACC is a rider assistance system that leaves the responsibility with the rider and allows him to intervene at all times. That is also because the new ACC only responds to moving vehicles.

Stationary vehicles – like at the end of a traffic jam or at traffic lights – are are not considered. In such cases, the rider has to do the braking.

2 Rider assistance systems by BMW Motorrad.

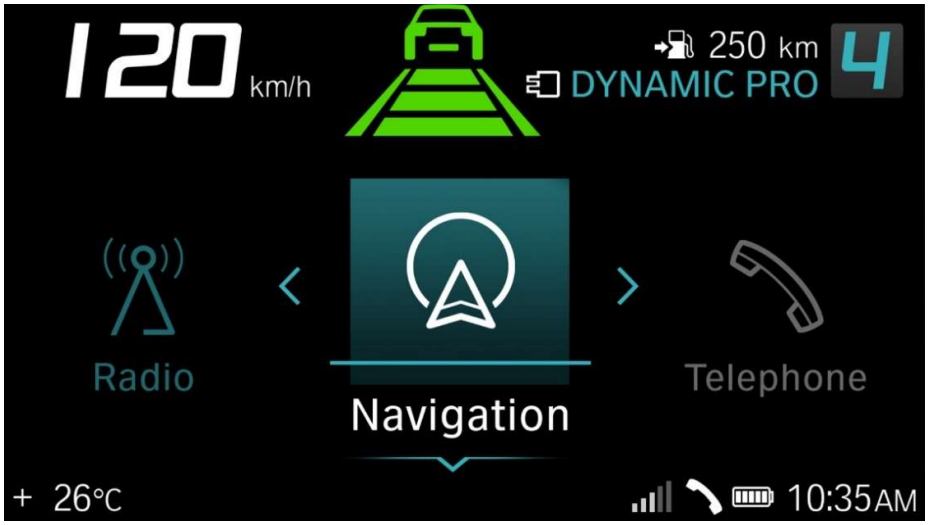
Rider assistance systems by BMW Motorrad as part of a comprehensive solution: Safety meets riding pleasure.
BMW Motorrad has been a pioneer for decades regarding motorcycle safety. With its innovative power, BMW Motorrad established itself as a trendsetter in this context at a very early stage. That resulted in a comprehensive understanding of safety that covers all areas of safety when riding a motorcycle: The safety technology at the vehicle itself, as well as the vehicle equipment and rider training.

BMW Motorrad rider assistance systems relieve the rider when driving, provide additional comfort and, last but not least, increase safety. But above all, they keep your head clear for carefree motorcycle riding pleasure.

Today, the topic of safety – along with a high degree of convenience – takes the highest priority in motorcycling. BMW Motorrad is aware of this and therefore in the past, new and further developments resulted in order to make motorcycling even safer and more enjoyable.

What began in 1988 with the first BMW Motorrad ABS, today turns out to be an ABS that works perfectly in almost all conditions; even at high lean angles. Traction control was also perfected as well, which initially debuted as Automatic Stability Control (ASC) and today, in the form of Dynamic Traction Control (DTC), leaves virtually nothing to be desired in terms of control and thus safety when accelerating. Since the autumn of 2019, engine drag torque control, available initially in the BMW S 1000 XR, represents an excellent addition to ABS and traction control. Electronically controlled, engine drag torque control prevents the rear wheel slipping caused by abruptly releasing the throttle or shifting down gears. In short: These selected examples show that BMW Motorrad is continuously striving to further develop existing rider assistance systems with the aim of achieving even greater safety when riding a motorcycle and to supplement them with new systems such as Active Cruise Control (ACC).

3 ACC technology in detail.



The new BMW Motorrad Active Cruise Control (ACC): Cruise control combined with distance control.
The new BMW Motorrad Active Cruise Control (ACC) is an innovative cruise control with distance control. It allows the rider to specify a set speed and a set distance to the vehicle in front. This speed is automatically maintained as long as the distance to road users in front is not less than the distance preselected by the rider. If this distance is fallen short of, the speed is reduced until the set distance is restored. The distance to the vehicle in front is determined for this by a radar sensor installed in the front of the motorcycle.

The new ACC is a rider assistance system in which the rider retains responsibility at all times and must be able to intervene independently. That is also because the ACC only reacts to moving vehicles. Stationary vehicles are ignored. This means, for example, that no distance is controlled for vehicles the end of a traffic jam or waiting at traffic lights and the rider is responsible for braking in these situations. The desired speed and distance values can be set by the rider using the operating elements.

ACC with high degree of control unit networking.
The ACC functionality is distributed across several control units. Objects driving in front are detected by the **radar sensor** at the front of the motorcycle. At the same time, the radar sensor uses the yaw rate and the vehicle speed to determine the so-called vehicle path, i.e. the corridor in which the motorcycle will move the next some 100 m. If an object is detected in the vehicle path, the system responds and the speed is adjusted to ensure the set distance to the object. This **distance controller** in the radar sensor sends a target acceleration (negative for deceleration, positive for acceleration) via the CAN bus

connection. This target acceleration is received by the ABS and taken into account in the cruise control. The ABS determines the necessary acceleration and requests a drive torque from the engine and, if required, a braking torque from the brake system to accelerate or decelerate the motorcycle.

Three control functions: Speed control, distance control and cornering control.
The new ACC features three control functions. The **cruise control** (Dynamic Cruise Control DCC) is used to apply the set speed selected by the rider.

The **distance control** (Active Cruise Control ACC) applies the set speed selected by the rider considering the preselected distance to vehicles ahead.

The **curve speed control** (only available with ACC) is used during cornering. If necessary the vehicle speed is reduced to reach a comfortable curve speed with limited lean angle (e.g. 20°). In addition, the braking and acceleration dynamics are limited with an increasing lean angle in order not to surprise the rider by abrupt braking or acceleration manoeuvres. The curve speed control prevents any unexpected acceleration, for example, if the object is lost (the radars capability of detecting objects is limited in cornering situations).

Simple, intuitive operation, two control characteristics, “comfortable” and “dynamic” as well as three distances.
By using the switch unit located on the left handlebar ACC and DCC can be operated. Moving the switch for the cruise control to the right into the ON position switches on the ACC/DCC function. The distance control can be deactivated by the rider, so that only cruise control (DCC) takes place. The set speed is then always maintained, regardless of the distance to the vehicle in front. DCC is also able to control the brake system for cruise control, e.g. for downhill driving.

The ACC/DCC features two **control characteristics**: **“comfortable”** and **“dynamic”**. They affect the acceleration and deceleration behaviour of the motorcycle during control by ACC/DCC. Configuration of ACC and DCC is done in the Assist menu of the TFT instrument cluster. The set speed, the distance to the vehicle in front and the control status of ACC/DCC are indicated on a display.

In the cruise control menu the characteristic of ACC/DCC can be chosen by the rider: “comfortable” or “dynamic”. With the “comfortable” characteristic, well-balanced acceleration and deceleration of the vehicle are achieved in ACC/DCC mode. With the “dynamic” characteristic, ACC/DCC has a

noticeably stronger impact on acceleration in order to do live up to a more dynamic driving style.

ACC/DCC is **operated** in a simple and intuitive manner. Pressing the Set/Res button applies the current riding speed as the set speed in the ACC/DCC control. By pressing the button again forwards (plus direction) the set speed can be increased. A short press increases the set speed by 1 km/h (1 mph). A long press of the button increases the set speed by 10 km/h (5 mph). If the rider keeps the button pressed, the set speed is increased in steps of 10 km/h (5 mph) until the button is released. Pressing the Set/Res button to the rear (minus direction) reduces the set speed in the same way.

With **ACC**, the **set speed** can be selected in the range of **30-160 km/h**. The ACC can be activated in the speed range of 28 - 250 km/h (depending on the gear). However, always only one set speed of 30-160 km/h is accepted as the rider's choice and set.

With **DCC**, the **set speed** can be selected in the range of **15 km/h (1st gear only) – 220 km/h**. The DCC can be activated at speeds of 220 km/h to 250 km/h. However, then only a maximum set speed of 220 km/h is applied.

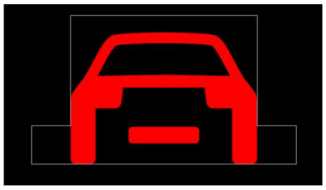
The rider can override ACC/DCC at any time by accelerating using the throttle twist grip. ACC/DCC is deactivated by brake actuation or by turning the throttle twist grip forwards past the zero position. ACC/DCC is interrupted after 1.5 seconds by applying the clutch.

Gear shifting is generally supported for both shifting up and shifting down in ACC/DCC mode and the ACC/DCC control remains active throughout the gear change. Gear shifting can be carried out conventionally by manual operation of the clutch or using the Gear Shift Assistant as an addition to ACC which is strongly recommended (if available as optional equipment).

The **distance adjustment in ACC mode** can be done individually in **three stages** using the distance button. Distance 1: Short distance. Distance 2: Medium distance. Distance 3: Long distance.

ACC warning levels: Take over request (TOR).
At the TFT display of the instrument cluster, ACC warns the rider, if necessary, by means of a conspicuous red symbol.

The **first warning level** (TOR1) is displayed when ACC control is disabled by the system and a vehicle in front is detected. The rider must then intervene and ensure the distance to the vehicle in front. TOR1 is activated, for example, if the speed drops below the minimum of 18 km/h in ACC mode and the control is deactivated to avoid stalling the engine.



The **second warning level** (TOR2) is displayed if the system detects a dangerous situation in which the distance control cannot ensure the required minimum distance even at maximum permitted brake actuation (ACC must not activate emergency braking). Any abrupt possible braking manoeuvre of the vehicle in front is taken into account. ACC continues to carry out any necessary braking, but the rider has to be ready to brake and if necessary must brake to avoid a collision.

Active support of the Active Cruise Control by the rider.
For optimal function and operation of the ACC, the rider can make an active contribution, in particular to establish the best possible prerequisites for vehicle detection by the radar sensor and distance control.

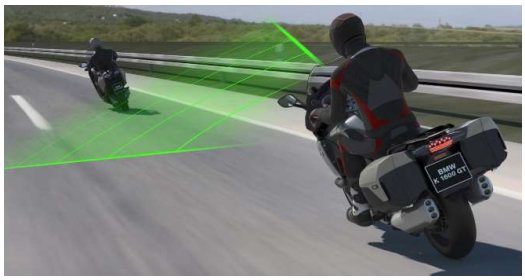
ACC is supported by a calm riding style and it is recommended to ride as much as possible in the middle of the driving lane behind the vehicle in front and to avoid any offset riding to the vehicle in front.

When overtaking, on the other hand, it is advisable to change the driving lane clearly in order to support deselection of the vehicle in front by the radar sensor. The system is also supported by using the turn indicator. An overtaking assistant is activated and a faster deselection of the object in front as well as an earlier selection of a vehicle on the new lane takes place. After overtaking, it is best to cut in as early as possible in order to give the radar sensor a maximum amount of time to detect a new vehicle in front.

4 Challenges during development and system limits.

All rider assistance systems are generally subject to certain system limits. They work within certain boundary conditions optimally, reliably and safely. However, none of these systems relieves the motorcyclist of personal responsibility. Correct object detection by the radar sensor is subject to environmental influences, for example, and can be restricted by heavy rain, snow or dense fog. The range of the radar is also limited, meaning that not all possible approach situations can be detected.

Above all, however, ACC in motorcycles poses a far greater technical challenge than in cars, because pitch, rolling and yaw movements are much more pronounced, resulting in greater degrees of freedom of vehicle movements. However, BMW Motorrad has still succeeded in meeting these special technical challenges with the new BMW Motorrad ACC, thus also making the ACC function usable for motorcycles.



In addition to significantly less pitch, rolling and yaw movements, considerably more measured variables are available for passenger cars with lower vehicle dynamics to determine the **predicted driving lane** (yaw rate and speed). In the case of the motorcycle, the driving lane is much narrower, however. The position of the motorcycle does not have to be in the centre which makes selection or deselection of the target objects much more difficult.

The **detection of the environment** has been adapted to the large structural movements that cause the objects to be detected by the radar sensor to move very strongly in the detection field of the radar when changing inclined positions. Unlike a passenger car, the BMW Motorrad ACC has **two selectable dynamic modes**. They also take comfort and the typical higher driving dynamics of motorcycles into account.

ACC takes safe **cornering** into account in particular. Compared to a passenger car, the motorcyclist should never be surprised by unexpected

acceleration or braking when cornering and thus in an inclined position. This is ensured by a **curve controller** in the ACC control when cornering.

The **ease of use** of the ACC has also been adapted to the motorcycle. The challenge here was to combine the operating logic of the cruise control known today with the existing operating elements and the display philosophy familiar from passenger cars. In addition, with the BMW Motorrad ACC, an **increase in convenience** of the cruise control could also be implemented by supporting gearshifting operations. This was not possible with the cruise controls to date.