



BMW Motorradprogramm
BMW Motorcycle Range
Gamme motos BMW
Programma motociclette BMW
Programa de motos BMW

ABS

BMW Anti-Blockier-System

1988



Erstmals Anti-Blockier-System
im Motorradbau

Unprecedented: motorcycle
anti-lock braking system

Pour la première fois:
le système antiblocage dans la
construction des motos

Per la prima volta il sistema
antibloccaggio

Sistema de antibloqueo por
primera vez en la construcción
de motocicletas

Postanschrift
Postfach 4002 40
D-8000 München 40

Hausanschrift
Petuelring 130, BMW Haus

Telefon
(089) 3695-4556
-4569

Telex Presse
5 286 937 bmw d

C O N T E N T S

BMW MOTORCYCLE ABS

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SHORT STORY: WHAT ABS MEANS TO THE MOTORCYCLE RIDER

BRAKING EVEN BETTER WITH THE UNIQUE SAFETY OF ABS: BMW PRESENTS THE WORLD'S FIRST MOTORCYCLE ABS

Experts call it a "technical revolution" and a "revolutionary milestone" in the second centennial of the motorcycle. In spring 1988 BMW is becoming the world's first manufacturer to introduce an electronic/hydraulic anti-lock brake system (ABS) for motorcycles.

When automobile ABS was introduced 10 years ago, BMW was also among the pioneers of this new brake technology which offers an even greater improvement in active safety in the case of two-wheel vehicles. To introduce this innovative technology, all BMW K 100 models will be available from now on with motorcycle ABS as an option.

At the Cologne International Bicycle and Motorcycle Exhibition (IFMA) 1 1/2 years ago, BMW first presented the ABS prototype developed in cooperation with FAG Kugelfischer. Due to delays in the subsequent endurance tests, BMW then decided in the interest of absolute riding safety to postpone the production start of the new system originally scheduled for early summer 1987.

ABS can achieve more than even the best rider

While the technical standard of motorcycle brakes, running gear and tyres has certainly been able to keep up with the increasing output of modern motorcycles in the last 20 years, the human factor has remained the weak point in the brake/control system. To this very day, driving schools rarely teach young riders how to apply the brakes properly

in an emergency - and it goes without saying that riders will hardly want to "try out" such an emergency on public roads. Whereas applying the brakes all-out on a dry road is relatively easy in an automobile even for a beginner, applying the brakes all-out on a motorcycle presents far greater risks for physical reasons alone.

Since a single-track vehicle is not balanced in itself, it only remains stable at low speeds due to the force exerted by the rider holding the handlebar, and at higher speeds due to the gyroscopic effect of the two wheels - above all the front wheel. Accordingly, whenever the wheels stop turning for more than 0.5 seconds the motorcycle will suddenly become unstable.

Often when the rear wheel stops turning - and almost always when the front wheel stops -, the rider will take a nasty (and perhaps even a very severe) fall. Accordingly, it takes a lot of practice and feeling on the part of the rider to "dose" brake power properly. Indeed, just how difficult it is for the rider to apply the brakes all-out in an optimum manner, is underlined by the fact that the rider has to brake the front wheel by hand and the rear wheel by foot at the same time. And, as mentioned, he must do this with a lot of feeling.

Studies have shown that roughly one out of ten riders fall off their machines due to over-braking. And the number of accidents attributable to the fact that the rider failed to apply the brakes all-out and thus required a longer stopping distance, is unknown - but it's certainly a substantial number.

Now ABS adds brake safety to the high degree of efficiency already achieved by modern brake systems in minimising the

stopping distance required. In simple terms, ABS now allows the rider - as long as he is riding straight ahead - to apply the brakes as hard as he can without running the slightest risk of the wheels (or one wheel) locking. This enables even the relatively inexperienced rider to achieve the shortest possible stopping distance.

On roads with a low frictional coefficient - such as wet roads, gravel, dirt, sand or oil - ABS is far superior to even the most skilled and experienced rider. Particularly on surfaces with a sudden change in frictional coefficients - such as dry/wet - no human being could ever hope to react quickly enough to cope with the situation. ABS, on the other hand, responds quickly and safely without giving up any stopping distance.

ABS does not allow full application of the brakes in bends

Even ABS cannot override certain laws of physics. Braking in bends always presents a problem due to the complex interplay of longitudinal and transverse acceleration. A wheel subject to maximum lateral stability forces cannot convey longitudinal forces - and, accordingly, brake forces - at the same time.

When the motorcycle is at an angle in a bend, the tyre/road contact point will move over from the middle of the tyre. Should the rider brake in such a situation, the motorcycle will automatically move upwards from its inclined position and thus start to run straight ahead. Hence, the rider cannot apply the brakes all-out when riding at an extreme angle under maximum transverse forces. For even ABS cannot change the laws of physics.

With or without ABS, therefore, the brakes cannot be fully applied in bends. While an automobile equipped with ABS still responds to the steering when the brakes are applied all-out, a motorcycle does not.

ABS checks itself

Here's how motorcycle ABS works: Monitoring the 100-tooth impulse generator gears on the front and rear wheel, a sensor compares their speed of rotation and informs the control unit fitted in the rear section when a wheel is about to lock. Within fractions of a second the electronic control unit will then activate one of the two pressure modulators fitted at the side above the footrests. The pressure modulator, in turn, will reduce the hydraulic pressure in the wheel brake cylinder until there is no further risk of locking, then increasing brake pressure once again. This process is repeated up to 7 times a second, as long as the rider maintains the necessary brake pressure and road speed does not drop below 4 km/h (2.5 mph). Unlike ABS on a car, motorcycle ABS operates without any noticeable effect on the brake lever or pedal, as a valve interrupts the reflow of brake fluid.

The aim to build a system with optimum safety is also reflected by the electronic control unit supplied by Hella in Lipstadt. The two control lines for the front and rear wheel, for example, are both fitted twice for absolute redundancy. Operating alternatively in 10-second cycles, one control line monitors or controls the system while the other is supervised for proper operation by a central processor. In the event of a deficiency ABS switches off automatically and a warning system comes on: Two red flashlights in the cockpit will inform the rider immediately that while his "normal" brakes still work, he will have to do without ABS until the deficiency is repaired

(and must therefore modify his style of riding accordingly). Even before the rider starts out, the electronic control unit checks ABS to make sure it is working and shows via the two red lamps in the cockpit that all systems are operating properly.

Riders must get used to ABS

Unlike automobile ABS, the control process generated by motorcycle ABS makes both the front and rear wheel respond far more significantly, with the rider literally being able to hear and feel ABS in operation. While this feeling is quite harmless, it is something the ABS novice must first get used to. It is therefore advisable - for example on an empty car park - to make oneself acquainted in peace and quiet with the automatic "pumping" of ABS brakes. Riders who get used to ABS this way will not make mistakes when they really have to apply the brakes in an emergency, while the inexperienced rider without the right "feeling" for ABS might possibly release the brakes in such a situation and thus require a longer stopping distance. Particularly on wet and slippery surfaces, riders can therefore overcome their natural inhibitions about applying the brakes all-out, thus gaining confidence in the additional safety potential ABS has to offer.

Braking in an emergency with a "safety net"

Even on an ABS-equipped motorcycle, riders should ride with due care on public roads, always considering the current situation and trying to avoid the need of braking in an emergency. But when such an emergency arises and the

rider has to instinctively - or even in panic - apply the brakes all-out within fractions of a second, ABS provides the "safety net" that can save the rider from a nasty fall when riding straight ahead. In many cases ABS can even help to avoid a crash, since the rider trusting in his anti-lock brakes can apply full brake pressure right from the start, reducing the stopping distance required to an absolute minimum.

A safety factor to be appreciated and not wasted

ABS enables the rider, as the "weak link" in the man/machine system, to make full use of the substantial efficiency offered by modern brakes. However, this extra safety offered by ABS should not induce riders to ride too fast or apply the brakes too late, thus foolishly wasting the extra safety they now have. In particular, the rider must still consider that stopping distances are much longer on wet and slippery surfaces. ABS cannot work miracles. But it can increase the active safety offered by a motorcycle - and, accordingly, the sheer riding pleasure you can experience on the road.

HISTORY AND TECHNICAL FEATURES OF THE BMW MOTORCYCLE ANTI-LOCK BRAKING SYSTEM

With its particular riding characteristics, the motorcycle requires an even more sophisticated ABS than the automobile

The first ABS anti-lock braking systems for cars entered standard production in 1978. Indeed, BMW was one of the pioneers in this area. Even then, however, BMW's motorcycle development engineers were studying anti-lock braking systems for motorcycles. It nevertheless became evident from the very beginning that this technology is far more demanding on the motorcycle than on the automobile: Given the smaller inherent stability of a single-track vehicle, a motorcycle anti-lock braking system must inevitably have much better and more sophisticated control functions. Another factor is that dynamic riding conditions when applying the brakes on a motorcycle are not only different, but rather completely the opposite of what they usually are.

When the front wheels of an automobile are locked, the vehicle will no longer respond to the steering. And when the rear wheels are locked it will swerve and spin. This will hardly happen in practice, however, as all cars nowadays have an exact distribution of brake power making the front wheels lock first. And even if the car should spin, it will hardly roll over or topple on to one side.

When the front wheel locks on a motorcycle, however, the consequences are usually most severe. The motorcycle will immediately lose its stability and the rider will hardly be able to avoid a - bad - fall. On the other hand, locking of the rear wheel does not present any major risks and can be controlled by the experienced rider (provided there are no lateral forces acting on the machine at the same time). Still, it is naturally even better to avoid this risk from the very beginning, too.

The objectives, therefore, were clear: To achieve absolute anti-locking safety on both wheels (100 % ABS) and, accordingly, to minimise stopping distances particularly on varying road surfaces. Given this aim it was clear that a motorcycle ABS would require very sophisticated control qualities and a completely different concept. Another requirement (which does not present itself to such an extent with the automobile) was to have an ABS operating down to very low speeds.

BMW checked out several systems

The first step was to examine the obvious possibility of adapting the anti-lock braking system on BMW cars to the particular requirements of a motorcycle. The test machine used at the time was an R 100 RS. In conducting this experiment BMW accepted the disadvantage that automobile ABS requires more hydraulic components and a far larger brake fluid volume. This, in turn, would have required a far larger system and, in particular, modifications of the BMW motorcycle brakes used so far.

Test rides also showed that the severe pulsation transmitted to the handbrake lever and footbrake pedal was irritating and, indeed, hardly tolerable. It also became evident that pressure control in individual stages and the associated change in brake power - ie, a staggered change in brake efficiency - was not compatible with the sensitive behaviour of a motorcycle.

The next step was to examine the first models of a hydro-mechanical anti-lock braking system developed in Great Britain. Although these studies lasted for several years, the result was not satisfactory in comparison with

the next alternative: Right from the beginning, the ALD anti-lock device developed by FAG Kugelfischer since 1983 showed the most encouraging results. While being relatively expensive, this electronic/hydraulic control unit conceived by the Bavarian manufacturer of hydraulic brake systems offered ideal prerequisites for a motorcycle. Unlike mechanical ABS, this system does not require the additional mechanical drive of a hydraulic pump and does not unduly increase the unsprung masses around the anti-lock device on the wheels connected directly to the brake. A further consideration was that the mechanical system can serve to control brake power only down to road speeds of approximately 10 km/h (6 mph). The FAG Kugelfischer anti-lock braking system, on the other hand, was relatively easy to connect to the conventional BMW brake system without requiring significant modifications.

Safety: the No 1 objective in developing motorcycle ABS

The relatively high cost of the fundamentally simple and straightforward Kugelfischer ABS is a result of the very high and uncompromising quality and reliability standards. For one of the basic lessons learnt in the first phase of testing was that failure of the anti-lock braking system on a motorcycle can have far more significant consequences than in a car.

The wheel speed sensors which compare changes in speed within a certain period and enable the electronic control unit to determine the degree of wheel deceleration are a good example of how motorcycle ABS works: By scanning impulse sensor gears with 100 teeth each, the inductive sensors provide 200 data for each revolution of the wheel.

At a road speed of 200 km/h (124 mph), this is 6,000 data per second. Unlike automobile ABS, the sensors operate without a permanent magnet as induction coils: Since these units are inevitably less efficiently protected on the motorcycle, they must not be susceptible to deficiencies caused by contamination due to magnetic dust particles. Accordingly, the sensors are magnetically excited only when the ignition is switched on.

The sensor therefore informs the control unit when the wheel is about to lock. Within fractions of a second the electronic unit will activate the pressure modulator, continuously reducing the hydraulic pressure in the wheel brake cylinder until the risk of locking has been eliminated. To be more precise, an electronic linear motor briefly taking up a current of 25 Amps pulls back a spring-tensioned piston in the hydraulic circuit and thus relieves the pressure on the brake. The sensor determines that the wheel is running at a higher speed and the linear motor again operating at a lower current allows the brake pressure to increase once again in response to the pressure generated by the pre-tensioned spring. Should the linear motor fail to operate for whatever reason, the spring also serves to provide the normal brake function. This process is repeated up to 7 times a second as long as the rider generates the requisite brake pressure through the pedal or brake lever and road speed does not drop below 4 km/h (2.5 mph). In controlling the rear brake circuit, the system also evaluates the data provided by the front wheel. This ensures that any retardation of the rear wheel caused by reducing gas or shifting gears is not "perceived" by the computer as braking action.

The two electric-motor pressure modulators - one for the front wheel, one for the rear - are not extremely light at a weight of 3.8 kg (8.4 lb) each, but nevertheless weigh a lot less and are much smaller than the original versions. They are located at the side above the footrests near the motorcycle's centre of gravity - that is in a position very good for optimum riding characteristics. Nobody at BMW wanted to go too far, saving too much weight and, accordingly, reducing the safety reserves. After all, the spring-loaded step piston acting as the control unit must reliably handle differences in pressure between 70 bar (for the front-wheel brake), 105 bar (for the rear-wheel brake) and 0 bar. As already mentioned, the linear motor serves to move the piston up to 7 times per second against the maximum spring force in the pressure modulator. The resulting change in volume in the hydraulic cylinder causes a change of pressure in the brake calliper. This control function is performed without any effect on the brake lever or pedal, since a valve prevents the reflow of brake fluid.

Perfect system supervision - with switch-off and alarm in the event of a defect

Perhaps the best example of this safety-first concept is the electronic control unit supplied by Hella in Lippstadt. Housed in the tail section of the motorcycle, this electronic control unit features two separate control lines for both the front and rear wheel. These lines operate intermittently in intervals of 10 seconds: While one control line is working - ie, checking or controlling the brakes - the other is supervised for its function by a central processor unit. This supervision process comprises a switch-on, start-off, permanent operation and cycle test, and includes the electronic system voltage, sensors and pressure

modulators. Two red telltales in the cockpit inform the rider that ABS is operating and ready to go. As soon as the rider switches on the ignition, the ABS flashlight will go on and off and the brake light telltale will come on. After the rider has operated the hand and foot brake, the brake light telltale will also start flashing on and off, provided the entire system is working properly and the check-up shows a positive result. The start-off test takes place automatically at a road speed of 4 km/h (2.5 mph). If this test is also positive, both lamps will go out. The brake light telltale will however remain switched on until the rider has operated the hand and foot brake.

Should there be a deficiency in the anti-lock brake system, both lamps will remain switched on. Similarly, in the event of a functional deficiency while riding, ABS will switch off automatically and the two lamps will start flashing on and off. This will inform the rider that the brake system as such is still working properly, but that he must do without ABS itself until the defect is remedied. Following this message the rider can switch over the red flashlights to a permanent red light which will not distract him from the road. After 10 minutes the red light will once again flash on and off, until the rider again presses the button to switch on the light permanently. This process will continue until the defect is repaired at a workshop.

Very easy service

In striving to achieve optimum safety, BMW's engineers have also given due consideration to service and proper maintenance of this motorcycle ABS. Using the BMW Diagnostic Tester, the mechanic can easily detect any deficiency in the system and determine immediately through an LCD display

whether the defect concerns one of the two sensors, pressure modulators, electronic control unit, safety relay, connection lines or the battery itself. All he then has to do is replace the unit concerned.

From the prototype to standard production: Individual problems and how they were solved

Developing the prototype first presented in autumn 1986 to the standard of all-round dependability required of production motorcycles in spring 1988, BMW has conducted very extensive endurance tests, determining and solving a large number of specific problems in the process. Both hardware and software were constantly improved, checked and rechecked during this thorough process of development.

The sensors, for example, must not provide incorrect information even on very bumpy roads, and ABS control frequency must not be affected by the bending resonance of the telescopic forks. The electric lines and connectors must be absolutely dependable also when subject to severe corrosion, and the electrical/electronic components must not result in brake failure even when subject to powerful electromagnetic fields.

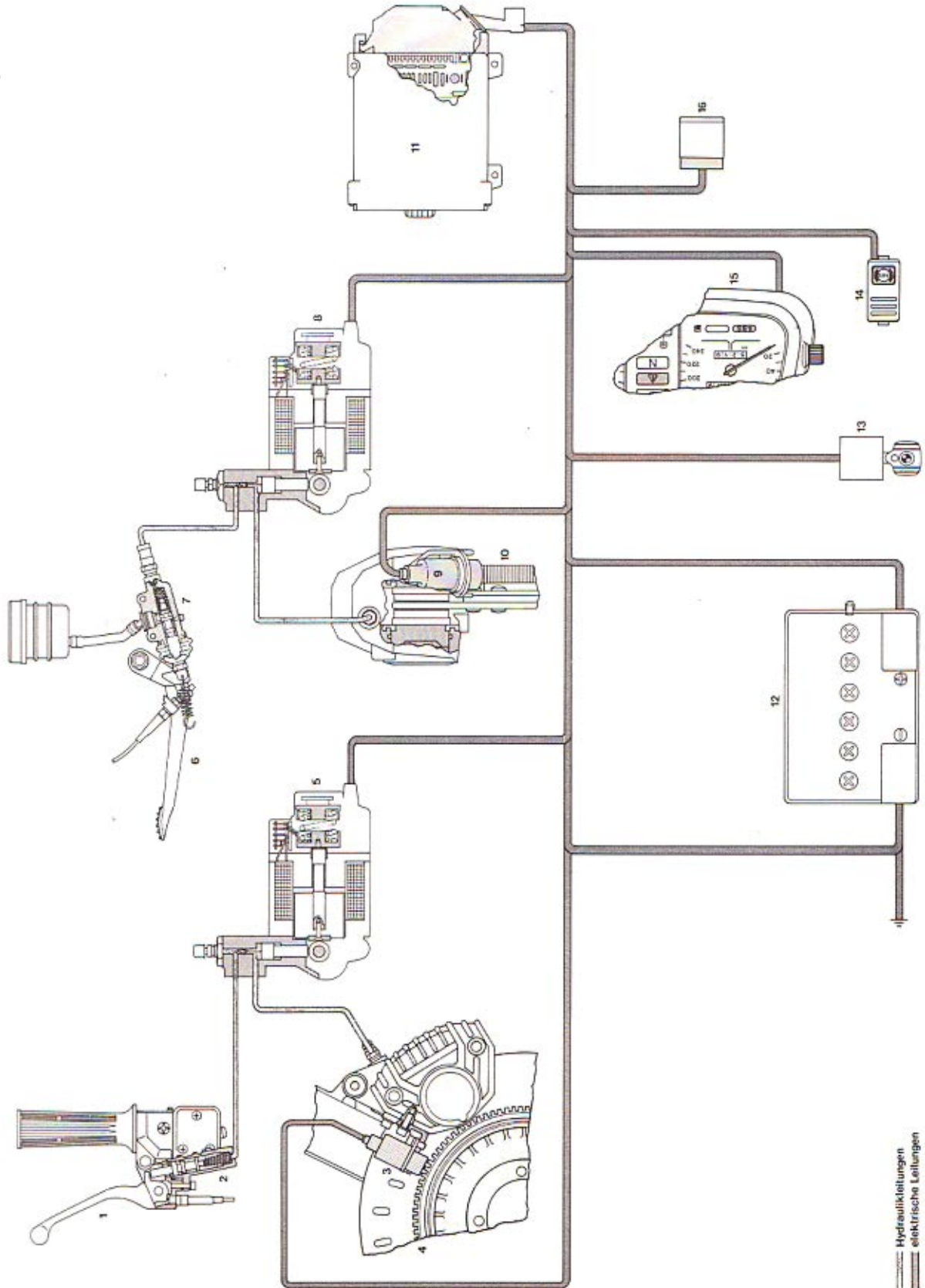
Due to a problem involving the supervisory and warning system BMW decided in 1987 to postpone the start of production until 1988. While the overall system as such already provided a very high standard of reliability, the warning telltales still tended to flash on and off occasionally without a defect actually occurring. Obviously, BMW did not want customers or workshops to be irritated by such a "false alarm".

Technical progress for greater safety

"This is the greatest increase in active riding safety since the introduction of the disc brake two decades ago". Comments like these were made by the experts who had the opportunity to conduct initial tests of this anti-lock braking system during development. Everybody agreed in these tests that BMW motorcycle ABS offers genuine progress dedicated to the all-important cause of riding safety - and is not just a kind of fad or fashion trend.

Motorrad Anti-Blockier-System

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Motorrad Anti-Blockier-System

- 1 Handbremshebel
- 2 Bremszylinder vorn
- 3 Sensor vorn
- 4 Drehzahlgeber vorn
- 5 Druckmodulator Vorderrad
- 6 Fußbremshebel
- 7 Bremszylinder hinten
- 8 Druckmodulator Hinterrad
- 9 Sensor hinten
- 10 Drehzahlgeber hinten
- 11 ABS-Steuergerät
- 12 Batterie
- 13 Zündschloß
- 14 Quittierung
- 15 ABS-Kontroll-Leuchte
- 16 ABS-Sicherheitsrelais

Systeme Antiblocage pour Motos

- 1 Levier de frein avant
- 2 Maître-cylindre avant
- 3 Capteur avant
- 4 Générateur d'impulsions avant
- 5 Modulateur de pression roue avant
- 6 Pédale de frein arrière
- 7 Maître-cylindre arrière
- 8 Modulateur de pression arrière
- 9 Capteur arrière
- 10 Générateur d'impulsions arrière
- 11 Unité de commande ABS
- 12 Batterie
- 13 Serrure de la clé de contact
- 14 Accusé de réception
- 15 Témoin de contrôle ABS
- 16 Relais de sécurité ABS

Motorcycle Anti-Lock Braking System

- 1 Handbrake lever
- 2 Brake cylinder, front
- 3 Sensor, front
- 4 Speed impulse generator, front
- 5 Pressure modulator, front wheel
- 6 Footbrake lever
- 7 Brake cylinder, rear
- 8 Pressure modulator, rear wheel
- 9 Sensor, rear
- 10 Speed impulse generator, rear
- 11 ABS control unit
- 12 Battery
- 13 Ignition lock
- 14 Cancellation button
- 15 ABS telltale
- 16 ABS safety relay

Sistema antibloccaggio per motociclette

- 1 Leva freno a mano
- 2 Cilindretto freno anteriore
- 3 Sensore anteriore
- 4 Datore impulsi di velocità anteriore
- 5 Modulatore pressione alla ruota anteriore
- 6 Pedale del freno
- 7 Cilindretto freno posteriore
- 8 Modulatore pressione alla ruota posteriore
- 9 Sensore posteriore
- 10 Datore impulsi di velocità posteriore
- 11 Centralina ABS
- 12 Batteria
- 13 Serratura dell'accensione
- 14 Conferma
- 15 Spia ABS
- 16 Relè di sicurezza ABS