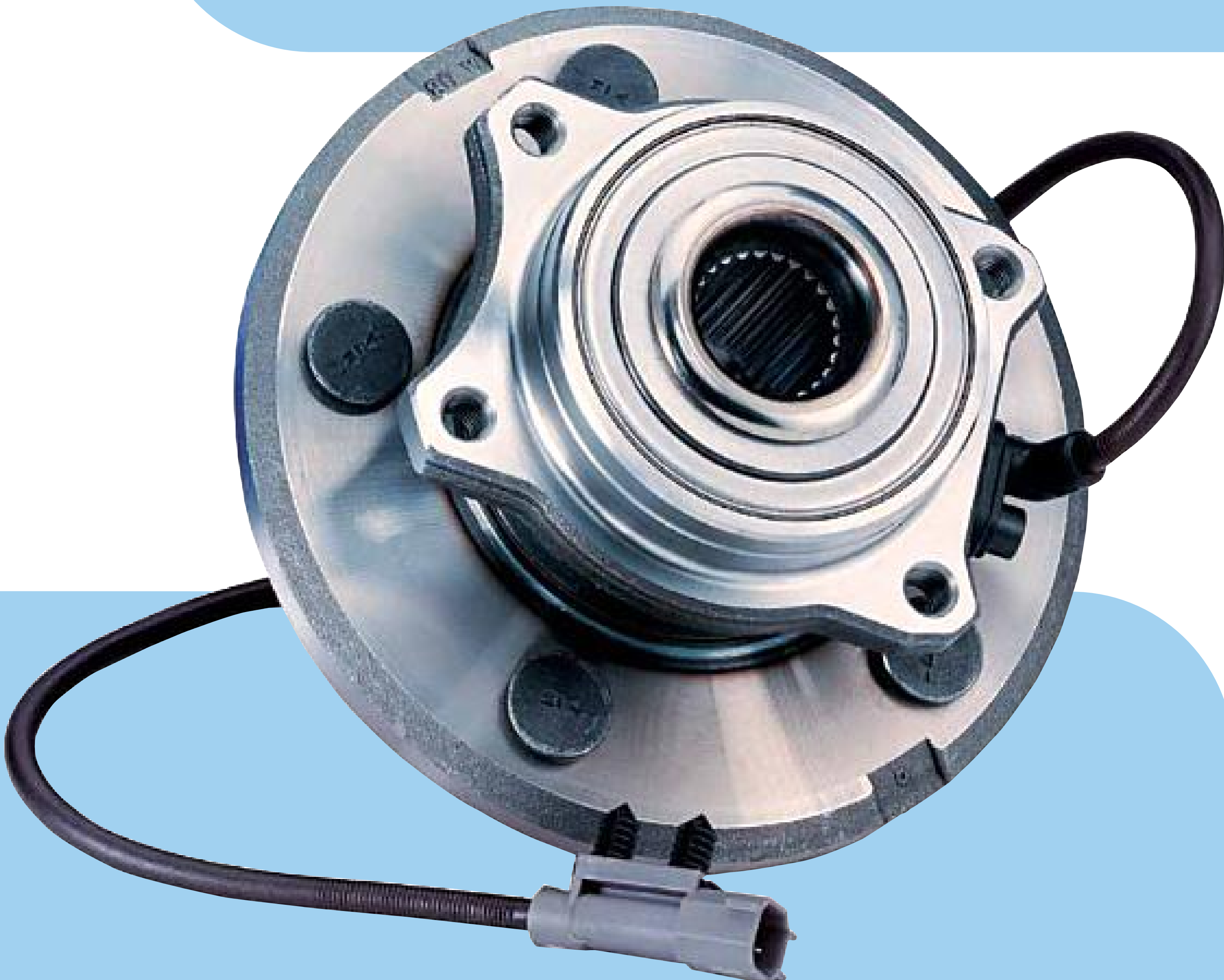
A technician's guide to

The next generation of hub units



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Install confidence

SKF's first hub bearing unit was introduced more than 50 years ago. Since then, an increasing number of functions have been incorporated into hub units. Today, these integrated, sealed, pre-greased and preset wheel bearing hub units have proven themselves over millions of road miles. Wheel hubs may also transmit driveline torque, provide a mounting point for the brake disc and wheel, and serve as a structural member of the suspension.

Ever since the first wheel speed signal system was introduced, SKF's attention has been focused on optimizing the integration of sensor functions in hub bearing units.

Due to the position and mechanical precision of hub units, they are a perfect point for monitoring vehicle speed. For reasons of both safety and driving comfort, more and more vehicles are being equipped with speed sensing devices (primarily sensors that provide the signal system with the wheel speed information). The optimum wheel speed sensor solution is unique for each individual application.

Depending on vehicle requirements, the sensor can be either non-integrated, which is the case in the most simple application; or an integrated design, which improves reliability, saves weight, and facilitates assembly.

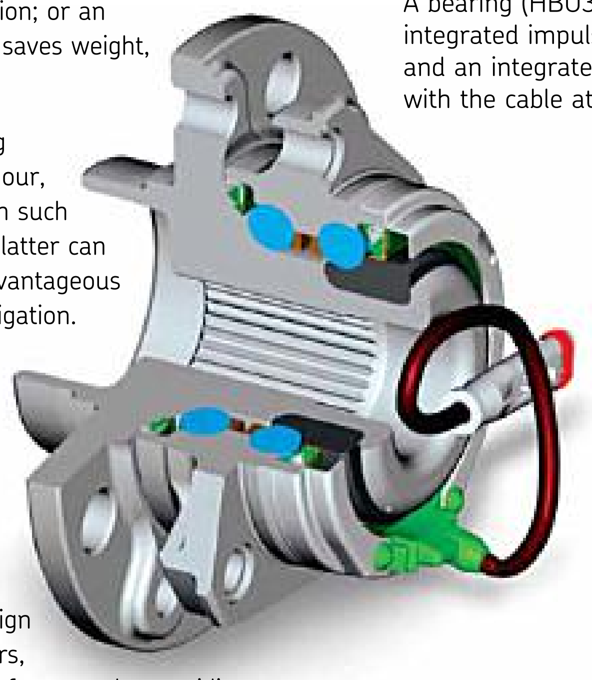


Figure 1
A bearing (HBU3) with an integrated impulse wheel and an integrated sensor with the cable attached.

Sensors may be passive, capable of providing a signal down to speeds of a few miles per hour, which is sufficient for a vehicle sensor system such as ABS; or they may be the active type. The latter can provide the signal at zero speed, which is advantageous for systems such as traction control and navigation.

Whatever the solution, integration of the sensor in the hub offers the potential to:

- Reduce assembly time
- Improve reliability
- Reduce space requirements
- Reduce weight

Speed sensor integration presents many design opportunities for today's automotive engineers, and SKF assists the original equipment manufacturers by providing:

- A wide range of existing solutions to cover customer needs for both passive and active systems
- The experience and know-how to identify, develop and optimize the best solution for each specific application
- The ability to partner with major sensor and brake system suppliers
- Experience gained from supplying millions of sensors to vehicle manufacturers throughout the world.

Bearing function

Wheel forces

The vehicle suspension and tire/wheel assemblies are subject to several forces as the vehicle accelerates, decelerates and corners.

F_W	=	Gravitational force	=	Perpendicular to surface
F_A	=	Acceleration force	=	Between tire and surface in the driving direction
F_S	=	Cornering force	=	Between tire and surface
F_B	=	Brake force	=	Between tire and surface opposite the driving direction

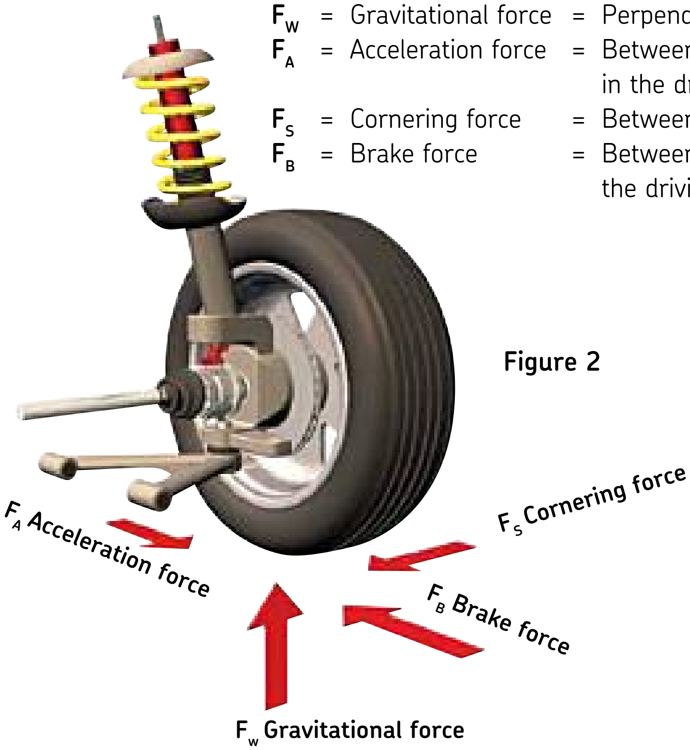


Figure 2

Wheel bearing loads

The forces acting on tire/wheel assembly result in loads being applied to the wheel bearing, which must absorb them.

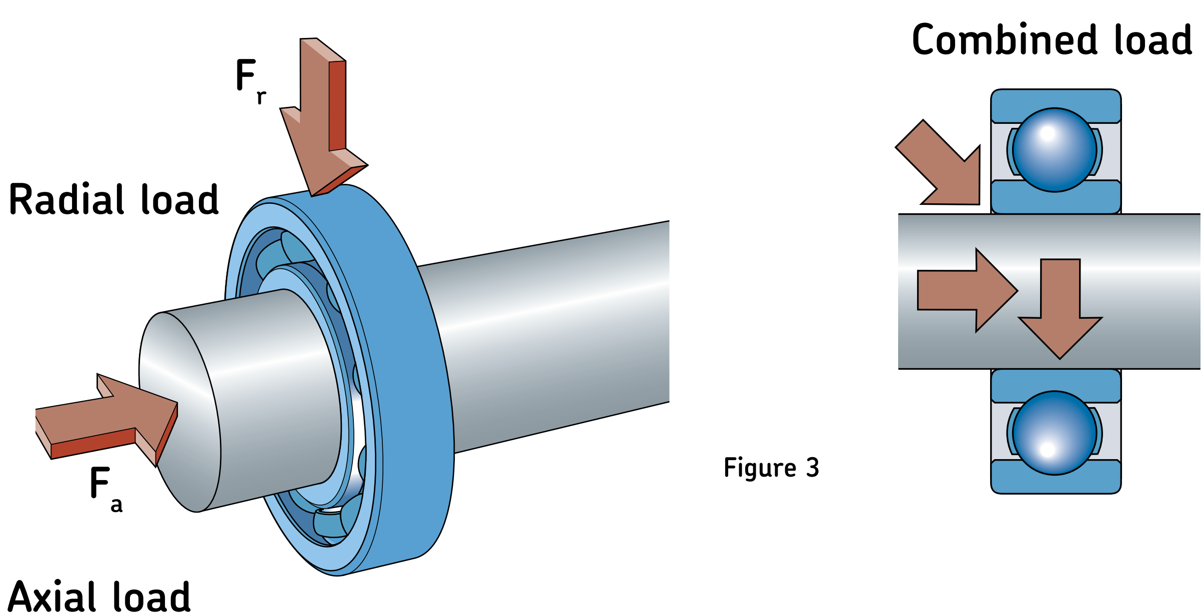


Figure 3

Wheel bearing families

Figure 4a
Taper roller bearings

Figure 4b
HBU1

Figure 4c
HBU2

Figure 4d
HBU3

Wheel bearing types and applications

SKF is the world's leading producer of bearings, including wheel bearings for virtually every car and truck on the planet. Today, every other car on the world's highways is equipped with SKF bearings. Over 45 million units were supplied in 2002, one third of which had integrated electronics for ABS. Electronics will continue to play an increasing part in wheel technology, as a vast array of control technologies use information from sensors incorporated into wheel bearings.

SKF pioneered the wheel hub unit back in the 1930s when it designed the unit used on the revolutionary Traction Avant front-wheel drive sedan introduced by Citroen.

More recently, SKF developed wheel hub units that incorporate sensors to feed information to anti-lock braking systems, traction control systems, and even to facilitate tire pressure monitoring systems. SKF continues its role as a development partner with automakers, pioneering new control technology with several prototype vehicles incorporating brake, steer, and shift by-wire systems. Additionally, SKF supports the automotive aftermarket with state-of-the-art wheel bearings and seals.

Wheel bearing families

Taper roller bearing – TRB

Though unitized hubs are more and more common with each new generation of vehicles, taper roller bearings without integrated seals are still prevalent in the aftermarket.

SKF offers a wide range of tapers with pressed steel cages, manufactured to rigorous quality standards in both metric and inch sizes.

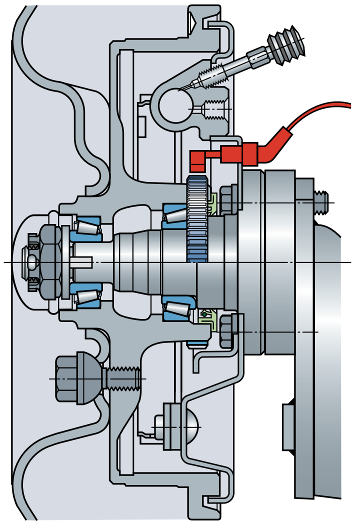


Figure 5

With low cross sections and precise contact angles, these wheel bearings are designed to accommodate axial and radial loads when mounted with proper clearance.

Taper roller bearings are typically used for non-driven front/rear wheels. The bearings are generally used in pairs, and they contain one inner ring and one outer ring, matched precisely with the rollers.

ATTENTION: TRBs should always be packed with high quality grease and care should be taken when installing the new seal. Adjust the free play following the vehicle manufacturer's guidelines.

In figure 5, the impulse wheel is mounted on the rotating hub and the sensor is mounted on the non-rotating brake backing plate.

Hub unit 1 – HBU1

Based on a double row angular contact ball bearing, HBU1 is optimized for the special operating characteristics encountered on car wheel applications. The unit offers specific support the moment load is applied to the bearing during cornering. The main components, an outer ring and two inner rings, are matched with the ball set to give the correct clearance.

The cages for the two ball rows are made from glass fiber reinforced polyamide. HBU1 is greased and sealed for life.

Used mainly for driven wheels, HBU1 is also found in integral drum designs on the non-driven wheels of smaller cars. With assembly space at a premium, the very compact taper units (HBU1Ts) are often selected.

Seals

Figure 6a: An HBU1 with an integrated impulse wheel in the seal. An elastomeric material with magnetic particles is applied directly to the seal flinger, which then functions as an impulse wheel.

Figure 6b: The sensor on the car is situated on the side of the bearing in close proximity to the seal with integrated impulse wheel.

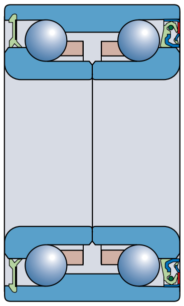


Figure 6a

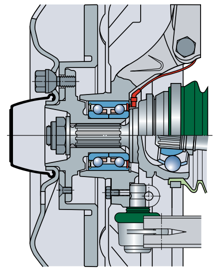


Figure 6b

Hub unit 2 – HBU2

Designed with the experience gained from HBU1, HBU2 has an outer ring with an integral flange, replacing the function of a separate hub.

The flange outer ring is designed as a lightweight structural component; outer ring raceways are induction hardened for bearing performance. The flange is tough, with threaded holes or studs to center and mount brake and wheel.

Figure 7a

The dimensions of the flange are engineered to specific customer requirements. HBU2 is typically used with a rotating outer ring for non-driven front or rear wheels.

Figure 7a: The flange is rigid, with threaded holes or studs to center and to allow mounting of the brake/wheel components.

Figure 7b: An HBU2 with an impulse wheel as part of the outer ring, produced by cold forming.

Figure 7c: This is an application with an HBU2 with an impulse wheel mounted on the bearing. You can see the wheel speed sensor just above the impulse wheel.

Figure 7b

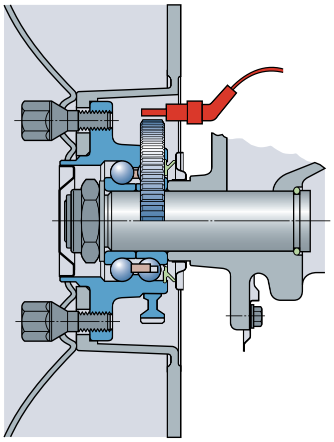


Figure 7c

Attention!

It is vital that the bearing is mounted with the correct side face, the one containing the magnetic impulse wheel, towards the sensor. There is no visual difference from an ordinary seal.

The handling of such an HBU1 is also very important for the ABS function. It has to be handled with care and the magnetized seal should not be exposed to other magnetic objects or subjected to hits and bumps. This might affect the ABS function.

Wheel bearing families

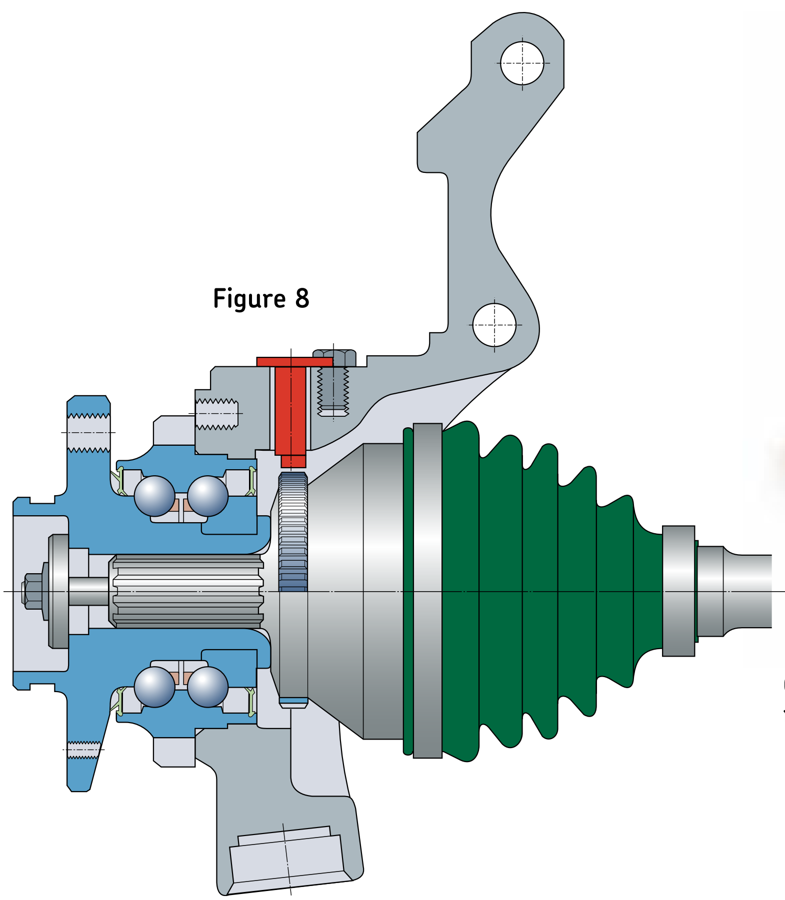
Hub unit 3 – HBU3

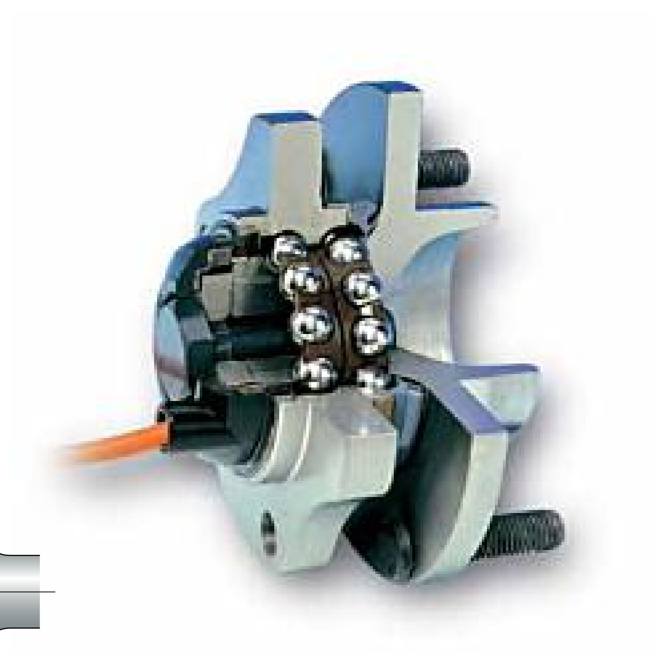
The third-generation hub bearing units carry a flange for wheel and brake rotor attachment and a second flange for fixing the unit to the suspension. This fully integrated system provides a significant simplification in corner design and handling when compared with more traditional designs.

The dynamic load carrying capacity is maximized by the use of a separate inner ring for the inboard ball row. This ring is mounted with an interference fit. The outer ring flange is bolted to the suspension. The rotating inner ring, with its tough flange, spigot and threaded holes or studs, is designed for mounting of the brake and wheel.

HBU3 is greased and sealed for life, and used for both driven and non-driven wheel applications. For driven wheel applications, torque is transmitted to the inner ring via an included spline. See figure 8 below.

Figure 8





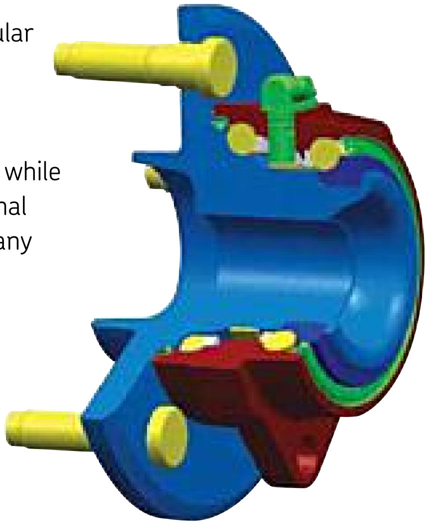
Cross sectional view of HBU3 mounted on axle.

X-Tracker

X-Tracker — a new line of rugged hub units.

SKF engineers continue to explore new hub designs which will benefit auto manufacturers and, ultimately, consumers. Most recently, SKF introduced a new line of performance engineered hub bearings, called X-Tracker, in response to growing use of light trucks as robust family sport vehicles.

By employing new designs and advanced processing techniques, the X-Tracker series brings car-like handling and comfort characteristics to high performance light duty truck and SUV applications



SKF's X-Tracker consists of a double row angular contact ball bearing arrangement, in which the outboard row is at a higher diameter and contains more balls than the inner row. This unique design increases the bearing's capacity while improving hub stiffness by 50% over a traditional tapered bearing unit. A stiffer hub provides many benefits including:

- Allows the wheel to run truer during cornering and acceleration.
- Reduces deflection of the hub face and wheel, which provides better steering, handling and vehicle dynamic behavior.
- Reduces brake wear due to true running of rotors, which helps reduce brake warranty costs.
- Improves both NVH (noise/vibration/harness) characteristics and bearing performance.
- Provides designers and systems integrators an alternative to a tapered bearing unit, freeing them to improve overall vehicle performance.

Wheel speed signal usage

Anti-lock braking system, ABS

On slippery roads even slight pressure on the brake pedal can lead to wheel lock-up, and, since a locked wheel cannot absorb lateral forces, this means the driver has effectively lost steering control while braking, and can potentially collide with another vehicle or object, or even leave the road. A skid-induced collision is shown in figure 9a.

As can be seen in figure 9b, whenever a driver is confronted with an unexpected obstacle and aggressively applies the brakes, the ABS-equipped vehicle can still be steered around the obstacle since ABS prevents wheel lockup.

The ABS system can react much faster than even a skilled race driver. It is able to react to road situations in fractions of a second. As soon as the system senses a wheel about to lock-up, it compensates by regulating (pulsing) brake pressure on that disc by varying brake fluid pressure to the brake caliper(s).

Figure 9a

Figure 9b

Since a wheel cannot be steered unless it is rolling, a locked wheel offers no steering control of the vehicle. ABS restores steering control by quickly applying and releasing pressure on the affected wheel or wheels. A highly skilled driver can do the same thing, but ABS provides this control automatically with no requirement called for from the driver except to steer the car out of trouble.

This ABS event is repeated rapidly at each affected wheel and alternates from left front wheel and the right rear wheel and switching to the right front and left rear wheel, which allows both maximum braking and steering during an emergency situation. ABS makes it possible for the wheels to rotate and provide the traction needed for safe road holding.

Certain parameters must be heeded for an ABS system to work with maximum effect. Foremost is when an emergency situation occurs: the brake pedal must be firmly pressed to the floor to activate the ABS. The noise and the rapid pedal pulsation experienced on ABS systems may initially alarm the driver, but they simply indicate that the ABS system is functioning correctly.

Traction control, TC

This system prevents the wheels from spinning during takeoff, which in turn prevents wheelspin when the vehicle is being accelerated. It makes it possible to accelerate safely on slick snow- and ice-covered roads and also increases the vehicle's capability to climb slippery hills.

Other names for this system are ASR or ASC.

The system uses a combination of electronic drivetrain controls in conjunction with the ABS system. Since it uses the same wheel speed sensors and components as the ABS system, it can be considered a subsystem and extension of that system. Together, ABS and TCS work to provide the driver with full control over the vehicle under potentially dangerous road conditions.

The system compares signals from all four wheels to see if one wheel is slipping. If one driven wheel is spinning, the TC brake controller applies appropriate brake pressure to eliminate wheelspin.

Figure 10

Wheel speed signal usage

Vehicle stability control, VSC

When moving, all vehicles are exposed to several different kinds of forces at the tire to road contact path. Longitudinal force is applied as torque at the wheel, from the engine when accelerating and from the brakes when decelerating. Lateral side forces are applied to the chassis when the vehicle is cornering. The driver can only control the vehicle when the lateral forces on the wheels are within a certain limit. If these forces are under or above a specific level (which happens when the lateral together with the longitudinal forces exceed or go under the available traction), the wheels will slip. This affects the driver's capability of maintaining car control in the intended driving direction.

The importance of how this system works is in its ability to individually brake each wheel.

Figure 11a

Figure 11b

For example, when a driver goes too fast into a curve or turns the wheel too suddenly, the forces created can make the vehicle rotate around its vertical axis, begin to slide and become very hard to control (figure 11a). This situation is called oversteer. At this point, the stability system would go to work using the braking system to transfer forces.

In a left turn, an oversteering vehicle's tail tends to break away. However, with slight braking on the right front wheel, a stabilizing clockwise opposite force is generated and the vehicle stays on the road without sliding in either direction as seen in figure 11b.

Global positioning system, GPS

By a combination of a global positioning system (GPS) and the ABS sensors, a vehicle's position can be pinpointed wherever it is on the earth. This is accomplished by calculating the time it takes for the signals from different satellites to reach the receivers.

Many of the early GPS systems, approximately 10 years ago, depended heavily on the ABS sensor in wheel hubs; today's GPS systems are more advanced, utilizing their own series of sensors.

The GPS is a system of satellites, computers and receivers that are able to determine the latitude and longitude of a receiver on earth, which in this case is the sensor in the wheel bearing.

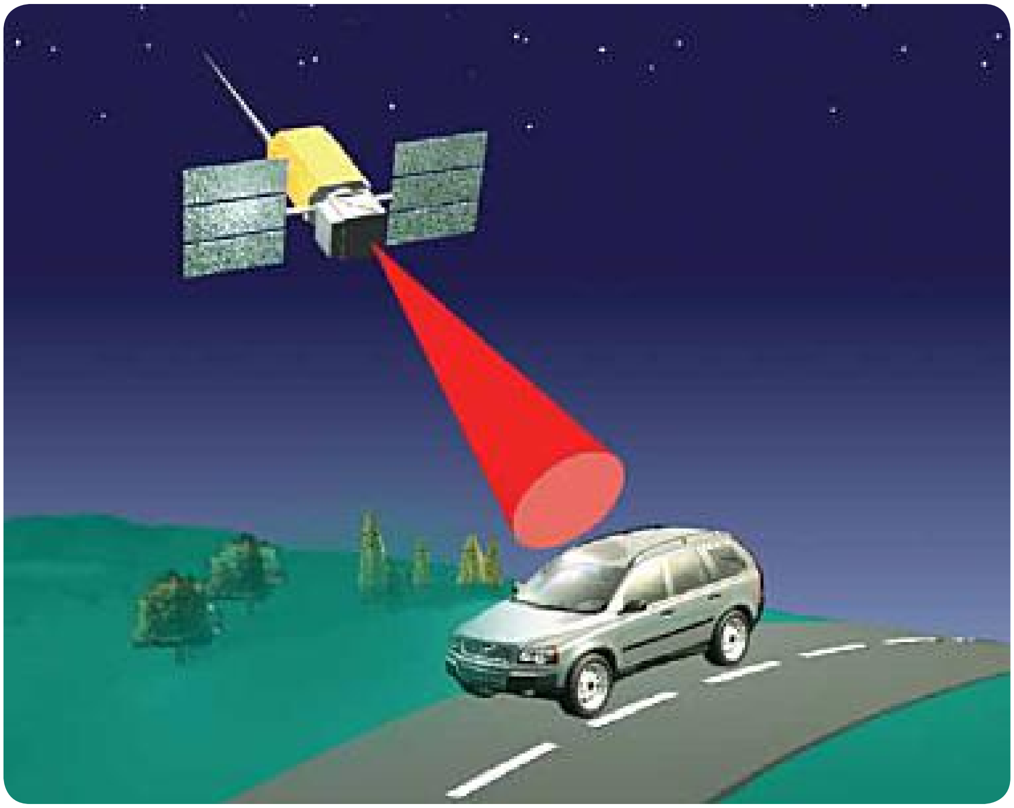


Figure 12

System overview

As we have seen, ABS overrides the operator's braking control by pulsing the brakes off and on to prevent individual wheel lockup. This helps the driver maintain control of the vehicle in emergency situations by providing steering control. A skidding or locked up wheel cannot be steered, so ABS allows the driver to steer out of an emergency road situation.

Vehicle manufacturers have employed several variants of the ABS system since anti-lock was introduced in the 1980s. Rear wheel ABS was used on some early passenger cars, and was also popular on light trucks. In this system, only the rear wheels are equipped with ABS.   This two-channel system is shown below as a **front-rear split** (figure 13). Three-channel ABS (**L-split**, figure 14) employs individual wheel control at the front, while the two rear wheels share a single control. Four-channel ABS (**Diagonal split**, figure 15), which is now the most commonly installed system, provides individual wheel control at each corner of the vehicle.

Front-rear split

This system is fitted to cars with rear wheel drive and is the simplest system. One channel is connected to the front brakes and one to the rear brakes.

It is able to guarantee driving stability only for straight-ahead braking and provides no steering ability, which does not result in an optimal stopping distance.

It consists of two sensors on the rear wheels and its primary function is to prevent the rear wheels from locking if the front circuit should fail.

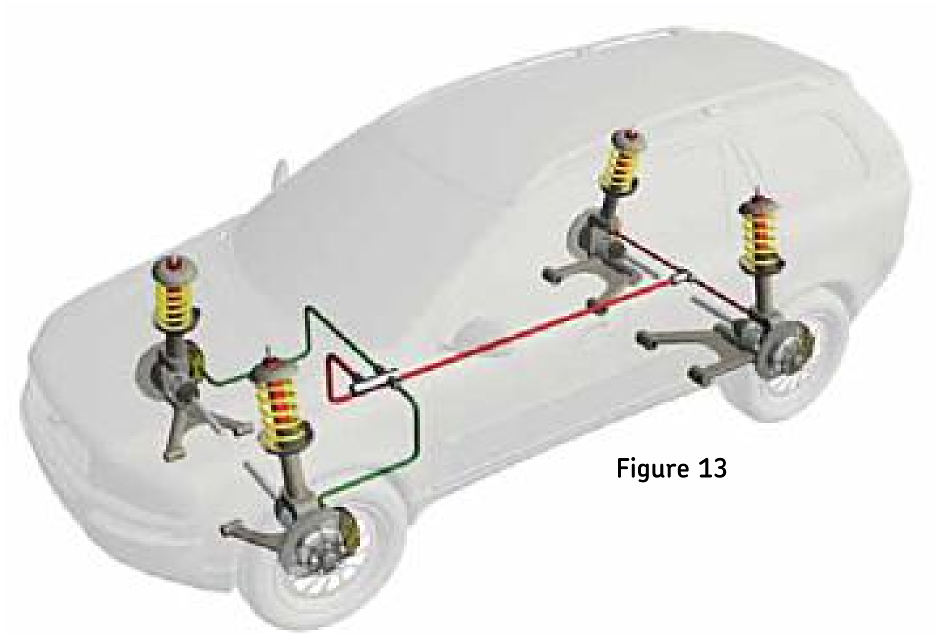


Figure 13

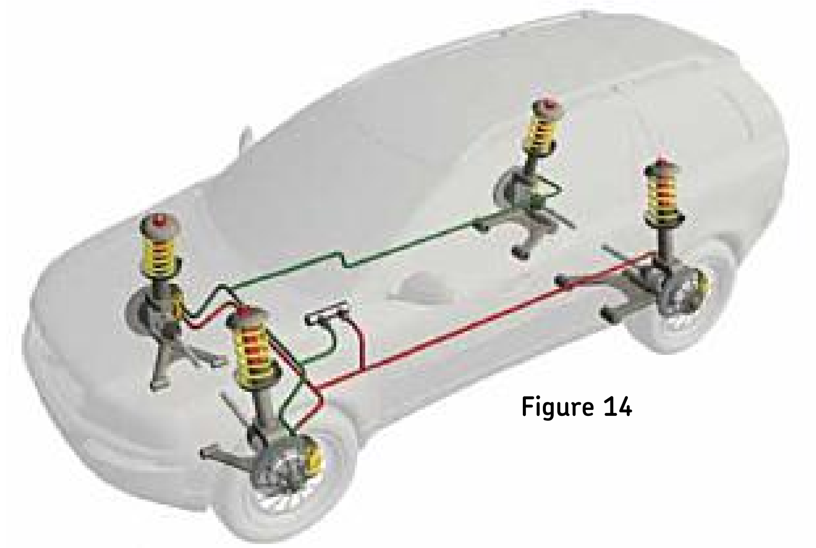


Figure 14

L-split

In this system the brake pressure at the front wheels is controlled individually, which means that if one of the front wheels locks up, it will pulse independently of the other wheels. The brake pressure at the rear wheels is jointly controlled; if one of them locks up, it will pulse together with the other rear wheel.

If one circuit should fail, the front calipers are always involved in the braking effort, thus increasing stability.

Diagonal split

This system consists of four ABS sensors, one on each wheel. In addition, two ABS channels are arranged in a criss-cross pattern (left front and right rear, right front and left rear). For example, when a left rear wheel locks up, the right front wheel and the left rear wheel pulse together.

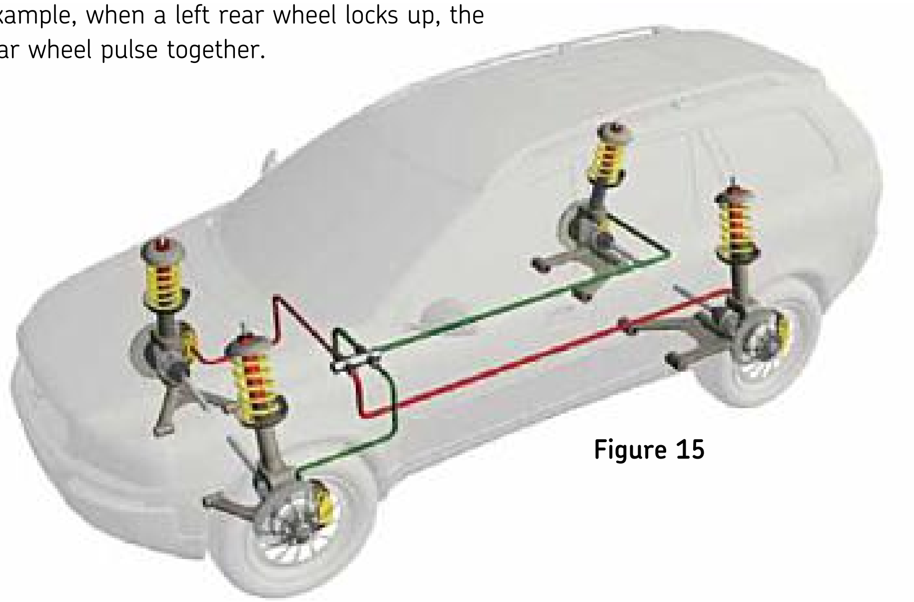


Figure 15

The electrical system

The EHCU is the complete unit combining the ECU and the HCU explained below. These units are used to receive and send signals.

ECU – A microprocessor that forms the central part of the engine management system. It uses closed-loop control and monitors system outputs to control inputs. It is the brain of the ABS system and reads impulses from the wheel speed sensors to see if anti-lock braking is required. If so, the ECU controls the cycling of the valves in the HCU.

HCU – The electronic signal from the ECU goes into the HCU and becomes a hydraulic output that controls the pressure in the different valves in the car.

General

The closed-loop process can be described as follows: The wheel speed sensor closest to the bearing distributes signals to the ECU, which sends the signal to the HCU with a command to perform the correct action. This action depends on the input signal to the ECU and what the situation requires. When the action is performed, since it is a closed-loop process, a signal goes back to the ECU and it decides what to do next.

Anti-lock braking system

When the brakes are applied in an emergency situation, the wheel speed sensor closest to the bearing distributes a signal to the ECU, which in turn sends the signal to the HCU with a command to activate the valves in the HCU. This allows the brake fluid to apply the brakes on the car, which reduces the speed at the wheel. Since it is a closed-loop process, the speed sensor sends a new signal to the ECU and so on.

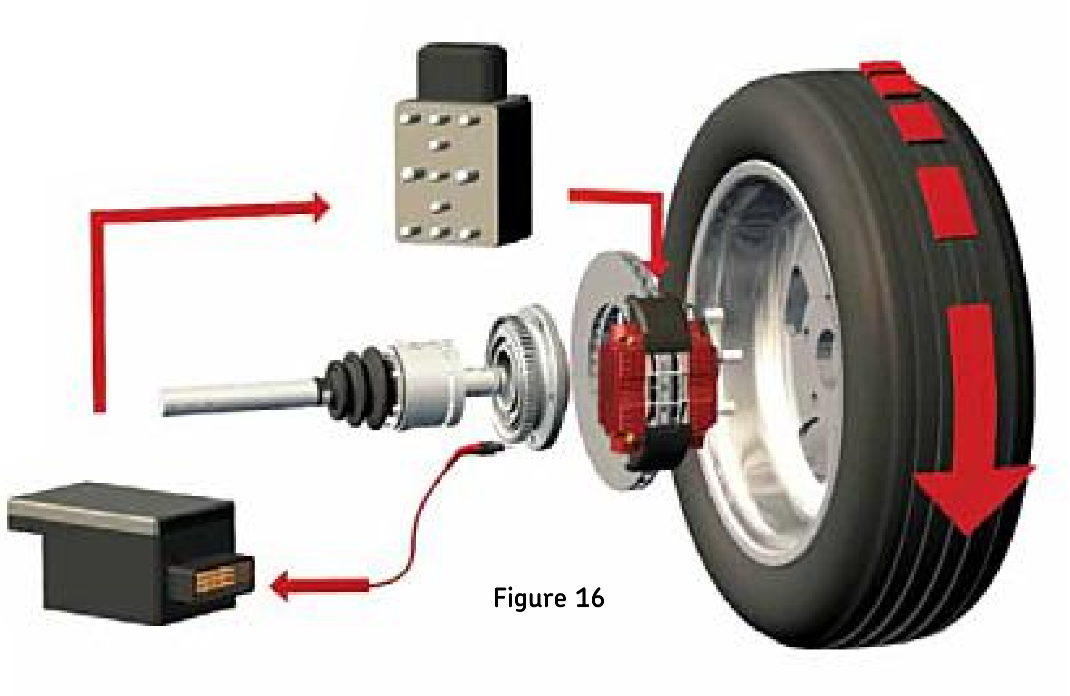
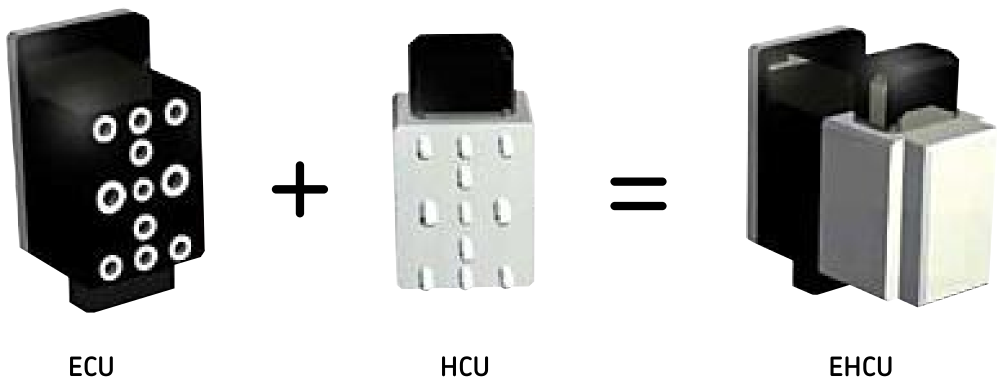


Figure 16

Figure 17



Traction control system

The same sensors used for ABS are employed, and continuously send signals to the ECU which calculates what kind of action is required, if any.

It compares all wheel signals to see if a wheel is slipping and, if needed, the HCU gets a signal to open its valves so the brake fluid can apply the brakes on the wheel. It can also send a signal to reduce the engine torque, which in turn assists the deceleration of the vehicle. The required reduction is executed immediately without the driver being made aware.

Vehicle stability control

The same principle works here. Whenever a car starts to slide and is oversteered, the wheel speed sensors send a signal to the ECU that feels which wheels are slipping. It then sends a signal to the HCU to apply the brakes on the correct wheel to stabilize the car by applying an opposite force.

Signal generation

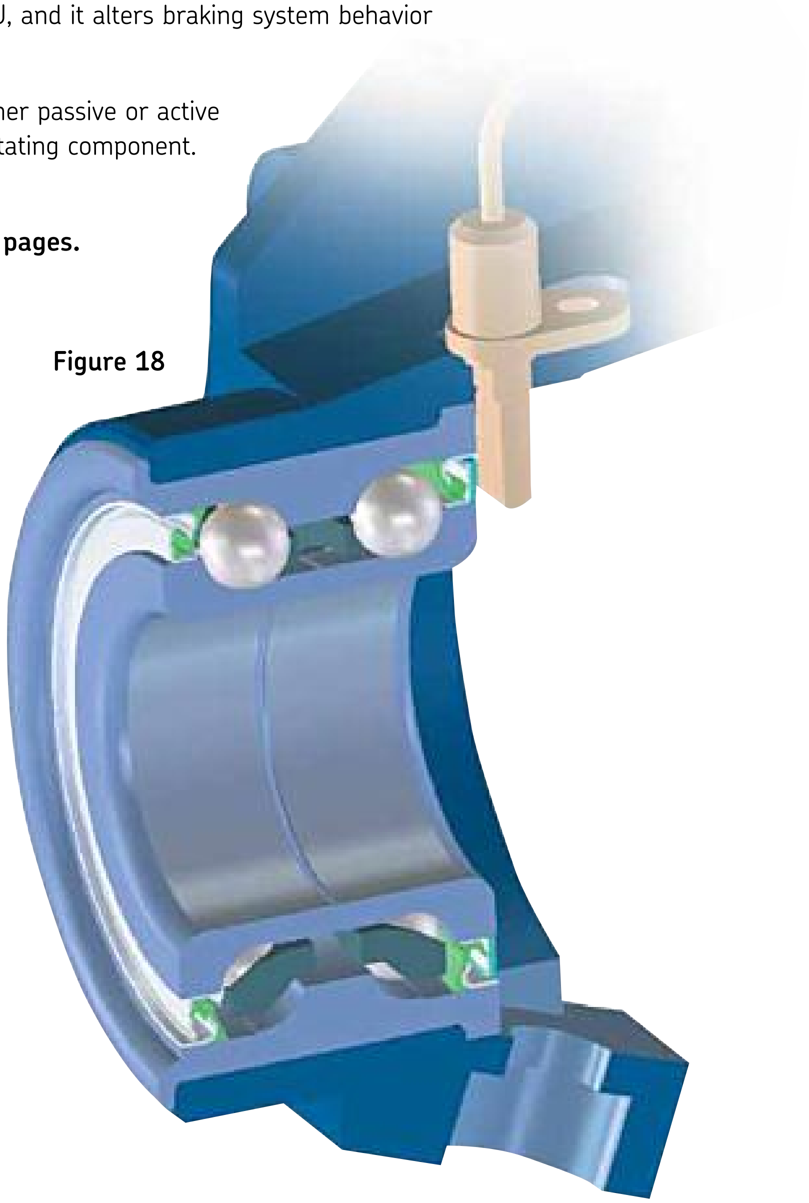
Component explanation

Computer-controlled vehicle systems such as ABS, TCS, etc., depend on sensors to report active data and conditions so that control decisions can be made to accurately react to changing road conditions. The sensor signals the system control unit that, for example, one wheel is slipping. The ABS controller can then signal the brake system to pull the brake caliper at the wheel, alternately applying and releasing it so that the wheel stops skidding. For purposes of this advanced hub unit discussion, we will deal with the generation of signals achieved by a rotating part. Engine control system sensors, on the other hand, measure parameters such as air density, manifold pressure, coolant temperature, etc. An ABS sensor used to measure wheel rotational speed reads pulses generated between itself and a rotating part, in this case the brake rotor. The sensor then sends the signal via the electrical system to the ABS control unit, or ECU, and it alters braking system behavior accordingly.

This system of components can be either passive or active depending on the technology of the rotating component.

Passive and active technologies are explained in detail on the following pages.

Figure 18



Passive systems

Impulse wheels for passive ABS

There are many different terms for the rotating component: impulse wheel, stator ring, exciter, tooth wheel, etc. In this brochure, we will call it an impulse wheel.

Impulse wheel design varies in type and size, but the operating principle is the same. An impulse wheel has either square teeth or rectangular openings.

Figure 19a: A bearing with a cold-formed impulse wheel, machined on the outer ring.

Figure 19b: A separate impulse wheel that is pressed on the rotating component. (teeth parallel to the axle)

Figure 19c: A bearing with an impulse wheel pressed onto the outer ring. (teeth parallel in 45-degree angle)

Figure 19a

Figure 19b

Figure 19c

Alternative solution

The SKF tapered HTU3 bearing (figure 20) is a solution for brake design that includes an impulse wheel embedded between the tapered roller rows. In this design, the sensor is plugged into the outer ring.

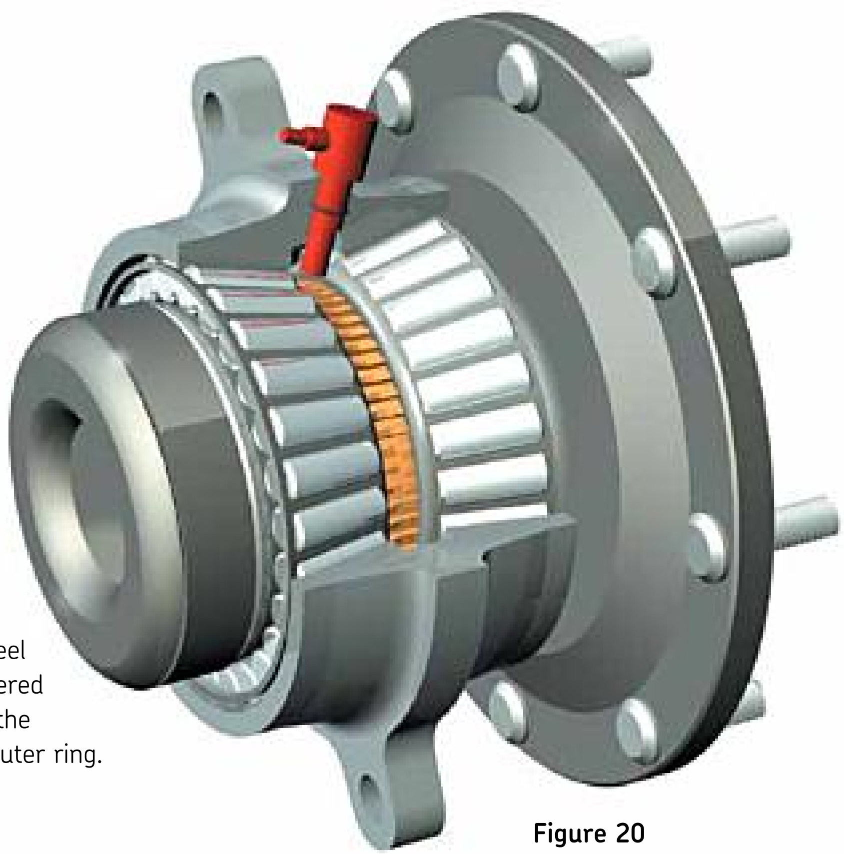


Figure 20

Passive systems (cont.)

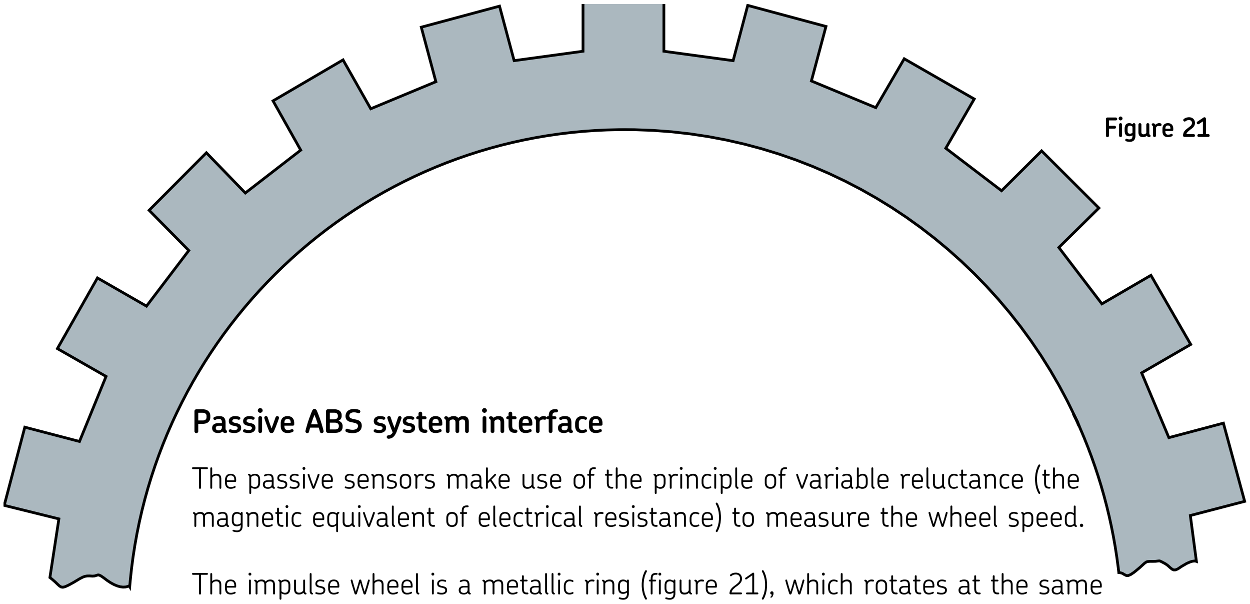


Figure 21

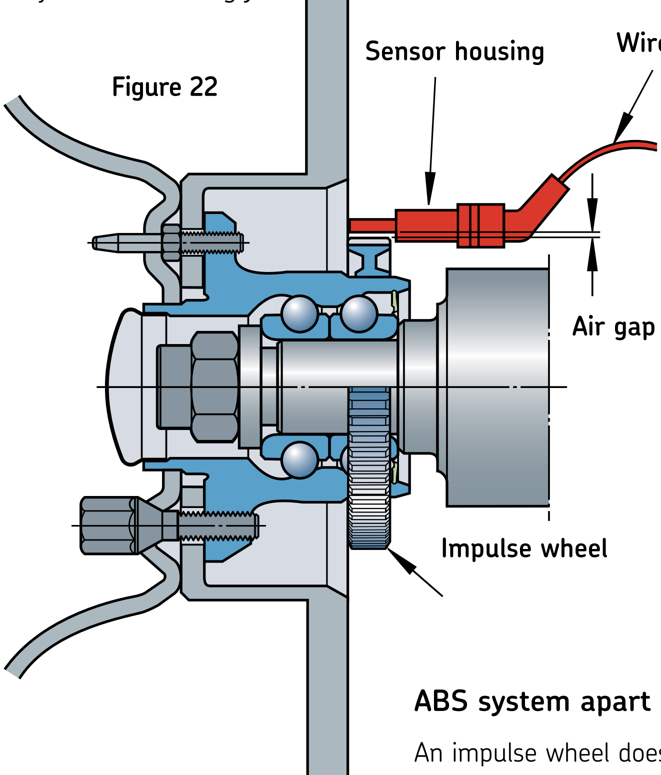
Passive ABS system interface

The passive sensors make use of the principle of variable reluctance (the magnetic equivalent of electrical resistance) to measure the wheel speed.

The impulse wheel is a metallic ring (figure 21), which rotates at the same speed as the wheel. The sensor is mounted so that there is a small air gap between it and the impulse wheel (figure 22).

Signals are transferred from the sensor to the ECU, and then to the control module, which is an integral part of the ABS unit. From there, brake force is adjusted accordingly.

Figure 22



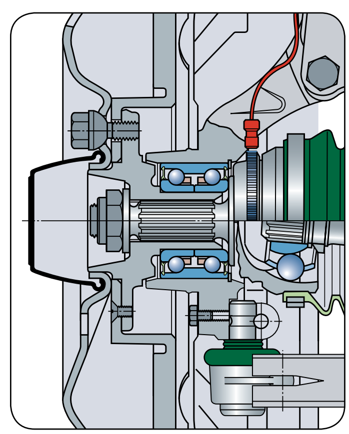


Figure 23

ABS system apart from bearing

An impulse wheel does not have to be mounted directly on the bearing. It can instead be positioned on rotating components that are in close contact with the bearing. In this example, the impulse wheel is mounted on the CV-joint (Figure 23).

Passive ABS principle

A sinusoidal signal is produced as the impulse wheel teeth opening pass in front of the sensor, which causes changes in the magnetic field. The change occurs as the metallic teeth and open spaces on the impulse wheel pass the sensor.

Working cycle

In figure 24, the impulse wheel rotates at wheel speed 1.) as the tooth passes the sensor = the magnetic core increases, there is high magnetic flux 2.) this increases the signal amplitude. As the impulse wheel continues at wheel speed, 3.) the gap passes the sensor, which causes the magnetic field to collapse, which in turn creates low magnetic flux 4.) Signal amplitude is decreased, which completes the cycle for a complete signal.

Passive systems are as a rule efficient and reliable, but note that tolerances of the sensor location and impulse wheel diameter must be closely held to maintain the required air gap (compare vehicle manufacturer specifications).

The sensor and impulse wheel are exposed to a harsh environment, including temperature extremes, vibration, grit and dirt, water, etc., all of which can affect the system efficiency.

At low speeds (i.e. 2.5 mph), a very low signal amplitude is produced. Below the speed, the signal becomes unreliable.

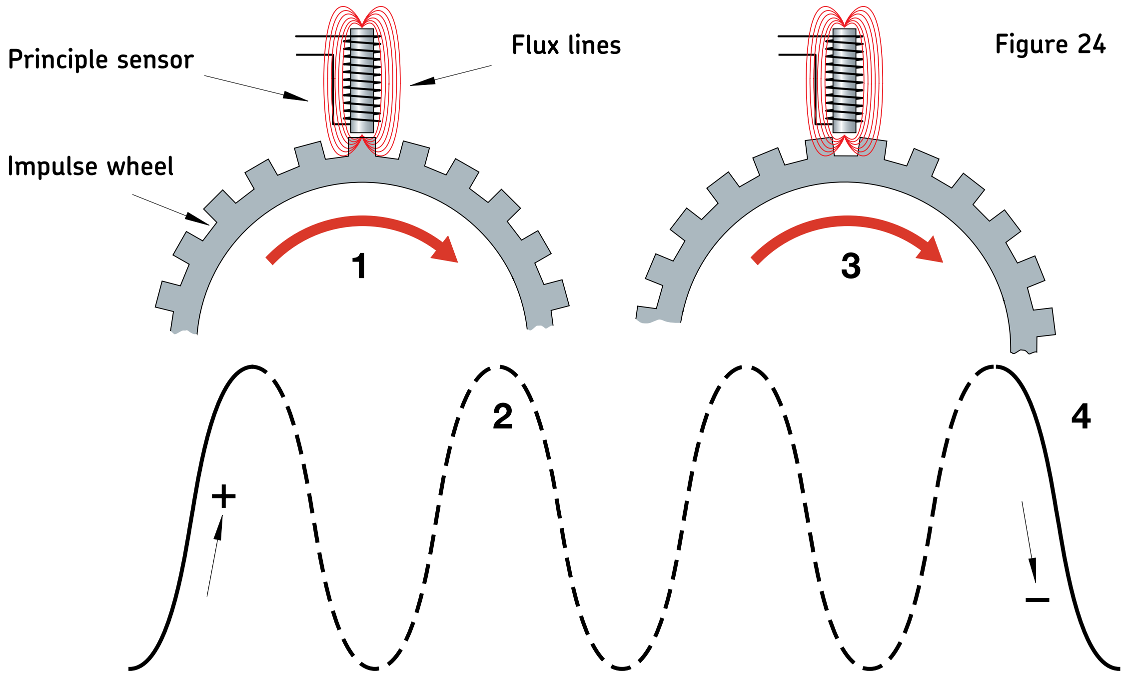


Figure 24

Active systems

Impulse wheels for active wheel speed sensors

As we have seen, the impulse wheel nomenclature and design varies.

The impulse wheel for active ABS sensors is a multi-pole magnetized ring affixed to the rotating part of the bearing.

Figure 25a: A magnetized rotating impulse wheel mounted on the outer ring of a bearing.

Figure 25b: A seal that functions both as a radial seal and an impulse wheel for the active ABS sensor.

Figure 25c: A magnetized impulse wheel integrated in the bearing seal. An elastomer material with magnetic particles is applied directly onto the seal flinger.

Figure 25a

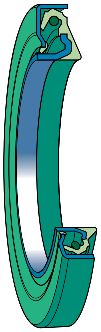


Figure 25b

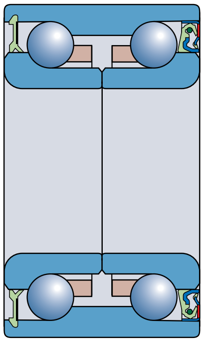


Figure 25c

Magnetized impulse wheel in seal

This type of impulse wheel, integrated into the seal, is difficult to visually identify. However, since it is magnetic, light metallic objects will be attracted to the seal. Identification can be done with careful use of a paper clip, as the magnetic encoder is dirt and scratch sensitive.

Seal cutaway enlarged (Figure 26):

Green color = rubber material
Blue color = steel
Red color = magnetized rubber material

A layer of elastomeric material, containing magnetic particles, is applied directly on the seal flinger.

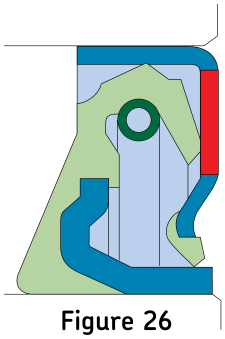


Figure 26

Active ABS system interface

The latest ABS sensor generation is the active wheel sensor.

Figure 27a: An integrated solution where the sensor (red) is plugged directly into a carrier (yellow) mounted onto the non-rotating part of the bearing and a multi-pole magnetized impulse wheel fixed to the rotating part of the bearing.

Figure 27b: The same principle, but in this example, the carrier holds a non-detachable sensor; its purpose is simply to attach a cable through the connector.

Figure 27c: The impulse wheel is magnetized and consists of alternating North and South poles. Note that there are no "teeth"– only magnetized fields face the sensor.

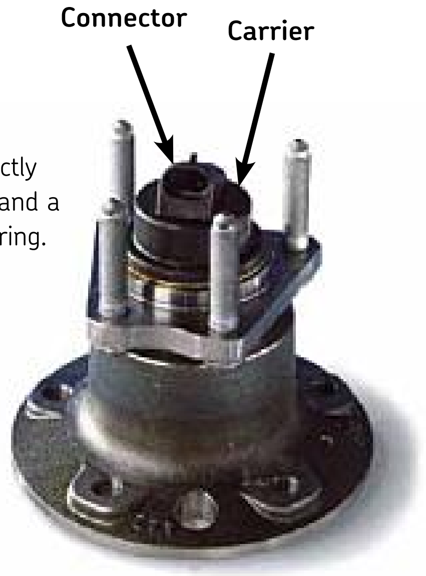


Figure 27b

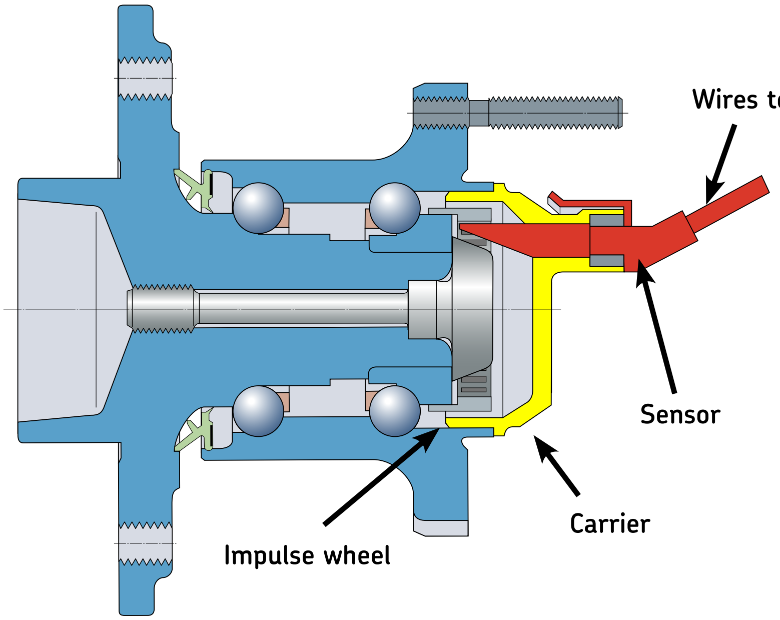


Figure 27a

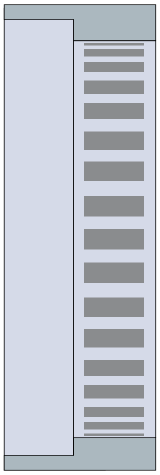


Figure 27c
Impulse wheel

Active systems (cont.)

Figure 28a

Figure 28b

Figure 28c

HBU3 – Complexity levels for active systems (seal with magnetized encoder)

Figure 28a: Sensor connected to vehicle

- Air gap to be checked

Figure 28b: Cap added to bearing above seal with sensor plug

- Air gap size is automatically correct

Figure 28c: Bearing with integrated sensor, cable connection to ECU

All three bearings have integrated magnetic impulse wheels in their seals.

Active ABS system

Active sensors are based on two different concepts:

- Hall effect cell
- Magnetic resistance

Active sensors (figure 29a) deliver a constant amplitude square wave to the ECU where only the wave frequency varies with vehicle speed. The higher the speed of the vehicle, the closer the signals get to each other.

The magnetized poles on the impulse wheel create the signal and influence the changes between high and low voltage (figure 29b).

This means that the signal still can be read at low speeds (0 mph). Therefore, it can be used for other functions as well, e.g. traction control, stability control, navigation systems (GPS), etc.

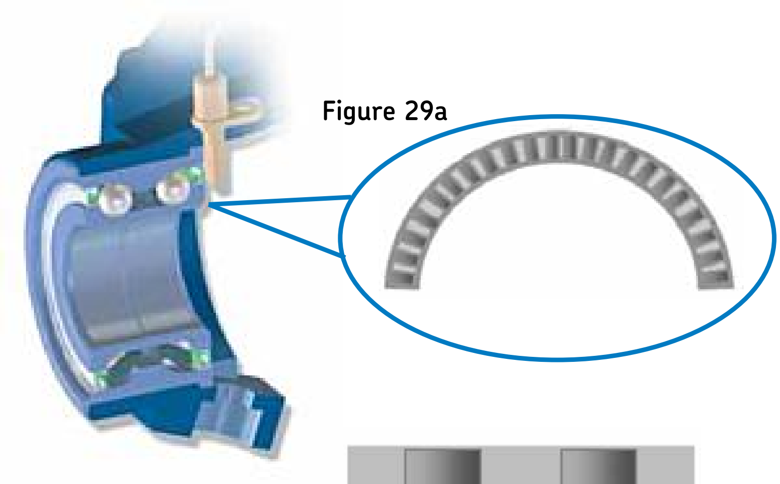


Figure 29a

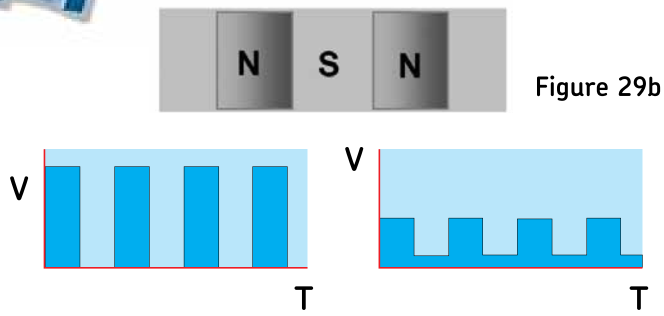
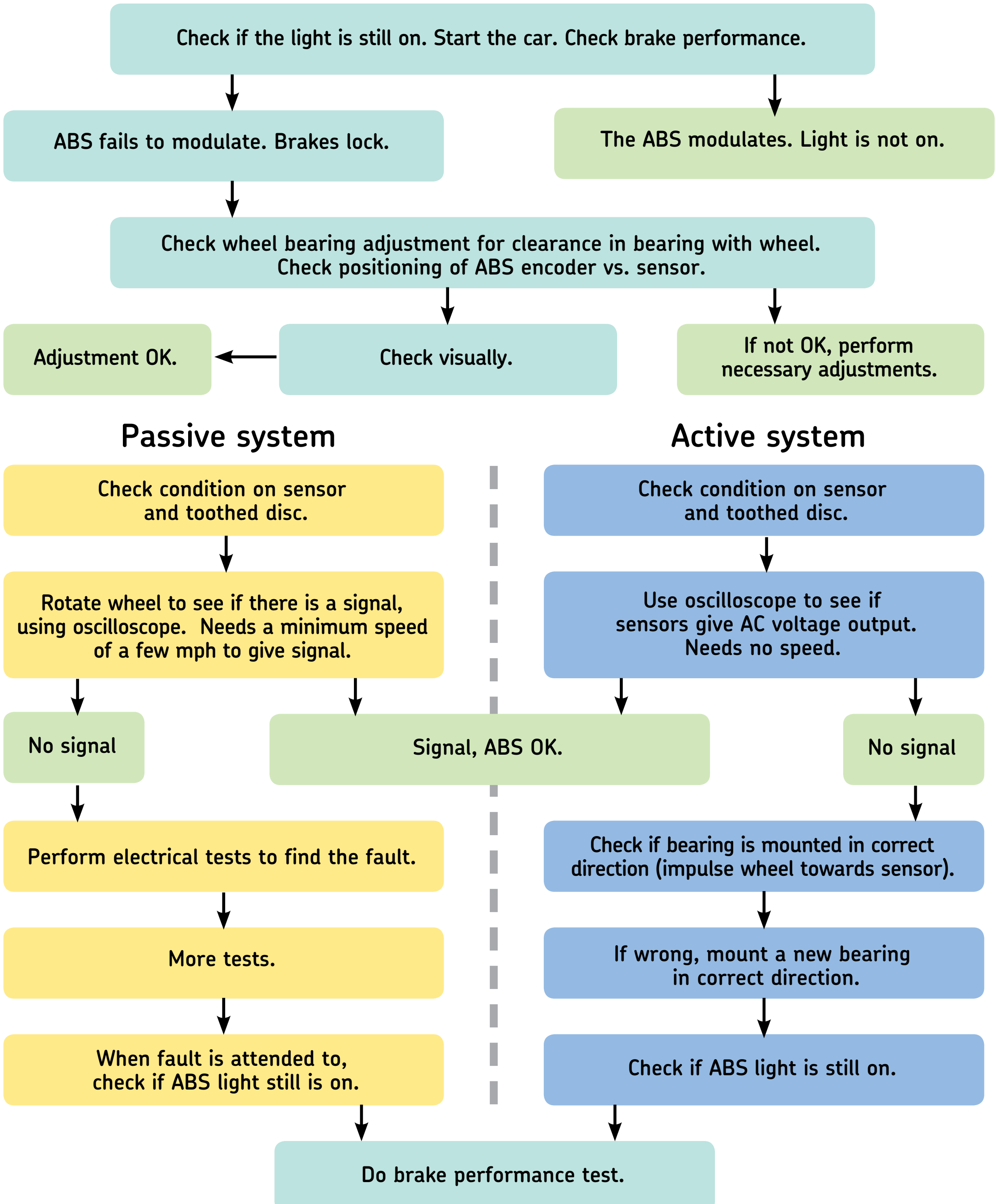


Figure 29b

Failure analysis diagram

This chart illustrates a comprehensive sample of how a failure analysis can be performed when an ABS problem appears. In this case, the ABS warning brake light is on.



Frequently asked questions

Q: If a bearing has a magnetic impulse ring for ABS, how can you be sure what side of the bearing the impulse ring is situated on and how should the bearing be turned when mounting?

A: Use the magnetic encoder detector and place it against the side of the bearing; the magnetism from the impulse ring will form a distinct pattern.

Q: Why is it important to turn the impulse ring toward the inside of the ABS sensor?

A: Incorrect mounting can lead to the failure of the ABS system to work properly.

Q: Are there any other special handling requirements with ABS systems?

A: Yes. It is important to avoid subjecting the impulse ring to hits and bumps, or making contact with other magnetic fields.

Q: Is it possible for a vehicle to have ABS but no impulse wheel on the bearing?

A: Yes. In some cars, the encoder or impulse wheel is mounted somewhere other than on the bearing. In this case you do not need a bearing with impulse wheel. See Figure 18.

Q: Is it permissible to use a replacement bearing with impulse wheel on a vehicle that does not have ABS?

A: Yes. A bearing with impulse wheel can be used on both ABS and non-ABS applications. In the cases when the car does not have ABS, the impulse wheel is there but is not used. It does not affect the function of the bearings.

Q: Are all anti-lock brakes the same?

A: No. Anti-lock braking systems use different designs depending on the type of brakes in use and vary with how many valves are individually controlled and the number of speed sensors.

Q: What is the difference between 4-channel and 3-channel ABS?

A: 4-channel, 4-sensor ABS is the best arrangement, with a speed sensor on all four wheels and a separate valve for all four wheels. With this set-up, the controller monitors each wheel individually to make sure it is achieving maximum braking force.

A 3-channel, 3-sensor design is commonly found on light trucks with four-wheel ABS. This incorporates a speed sensor and a valve for each of the front wheels, with one valve and one sensor for both rear wheels. The speed sensor for the rear wheels is located in the rear axle.

Q: Is there a one-channel, one-sensor ABS?

A: Yes. This system is commonly found on pickup trucks with rear-wheel ABS. It has one valve, which controls both rear wheels, and one speed sensor, located in the rear axle.

This system is easy to identify. Usually there will be one brake line going through a T-fitting to both rear wheels. You can locate the speed sensor by looking for an electrical connection near the differential on the rear-axle housing.

Q: Can anti-lock brakes ever lock up?

A: In certain situations. For example, with 3-channel, 3-sensor or 1-channel, 1-sensor designs used commonly on light trucks, the rear wheels are monitored together, so they both have to start to lock up before the ABS will activate on the rear. With this system, it is possible that one of the rear wheels will lock during a stop, reducing brake effectiveness.

Q: When the brake pedal vibrates violently during ABS use, should the driver let off or pump the brakes?

A: No. In an emergency stop in a car with ABS, the driver should apply the brake pedal firmly and hold it while the ABS does all the work. Though the pulsing felt in the pedal might seem like a malfunction, this is normal and pressure should be maintained on the brake.

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Publication **457102** (rev. 05/12)

Printed in U.S.A. on environmentally friendly paper.

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890 N. State Street
Suite 200
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www.vsm.skf.com