

2002-07 GENINFO**Steering and Suspension - Overview - MINI****MINI STEERING AND SUSPENSION****BASIC SUSPENSION GEOMETRY****Caster**

Caster is the forward or rearward tilt of the steering axis centerline, as viewed from the side of the vehicle, and is measured in degrees from a vertical. It is a directional control geometry angle that helps keep the vehicle moving straight ahead.

If the steering axis is tilted rearward, it is called "Positive Caster". A forward tilt is called "Negative Caster".

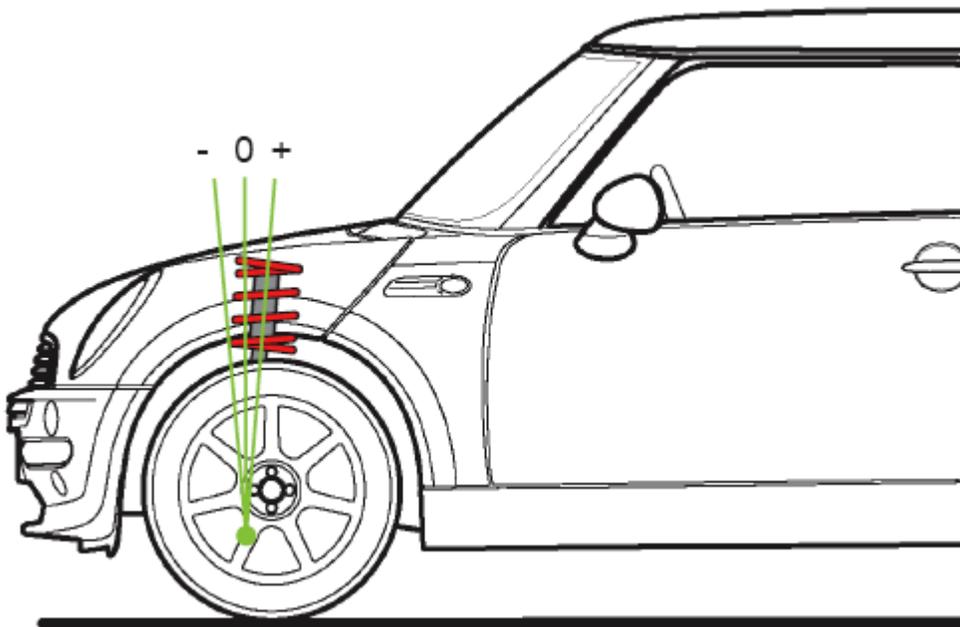


Fig. 1: Caster Angle

Courtesy of BMW OF NORTH AMERICA, INC.

On MINI vehicles, Caster is always positive. Positive Caster increases stability at high speeds. Positive Caster also causes increased steering effort at low speeds. Systems such as Servotronic help minimize this negative effect. In addition to increased high speed stability, cornering is enhanced and steering wheel returnability is improved by positive Caster.

Caster is measured in degrees. On MINI vehicles, Caster is a non-adjustable angle. But Caster is influenced by damaged suspension components. When performing a wheel alignment, always check Caster to insure there is no hidden damage.

Cross Caster

Cross Caster is the difference in the Caster measurement from left to right. Excessive Cross Caster can cause the vehicle to pull to the side with the least positive caster.

Camber

Camber is the inward or outward tilt of the wheels when viewed from the front of the vehicle. The amount of tilt is measured in degrees from the vertical and is called the camber angle.

If the wheel tilts out at the top, the camber angle is positive and if the wheel tilts in at the top it is negative.

Excessive Positive Camber will cause abnormal wear on the outer edge of the tire.

Excessive Negative Camber will cause abnormal wear on the inner edge of the tire.

Camber is measured in Degrees and Minutes and is measured at the front and rear of the vehicle. Camber is adjustable on some MINI models.

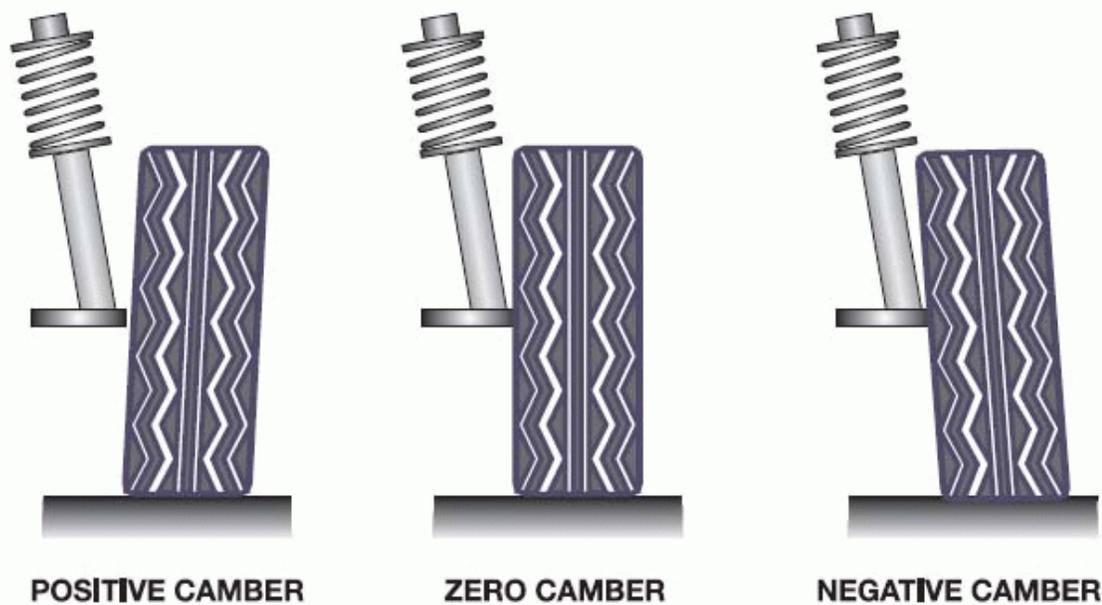


Fig. 2: Camber Angle

Courtesy of BMW OF NORTH AMERICA, INC.

Cross Camber

Cross Camber is the difference between camber angles from left to right. If Cross Camber is excessive, the vehicle will pull to the side with the **most** positive Camber.

Toe In/Toe Out

Toe is the difference in length by which the wheels of each axle differ from each other, front to rear, in the straight ahead position. The rear wheels are also subject to toe measurement.

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI

Toe is measured at the center of the wheels from one wheel rim to the other. When the distance is greater at the rear of the wheels, it is called toe-in.

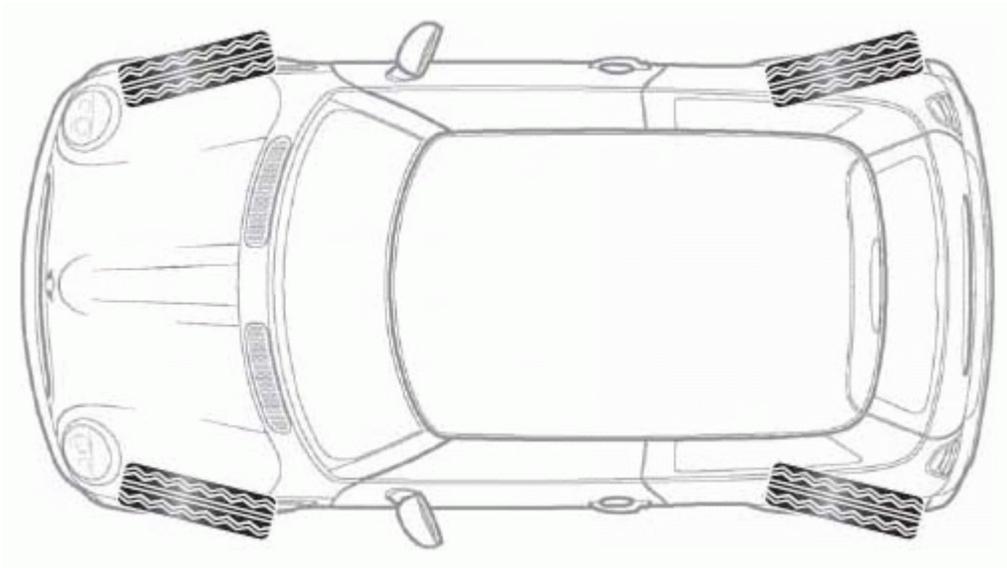


Fig. 3: Toe In Angle

Courtesy of BMW OF NORTH AMERICA, INC.

When the distance is greater at the front of the wheels, it is called toe-out.

Front wheel drive vehicles generally will have a small amount of toe-out at the front wheels. This will allow the wheels to toe-in when rolling to achieve a zero running toe.

Toe is measured in degrees when using MINI specifications. Front toe is adjustable on all MINI vehicles. Rear toe is only adjustable on some models.

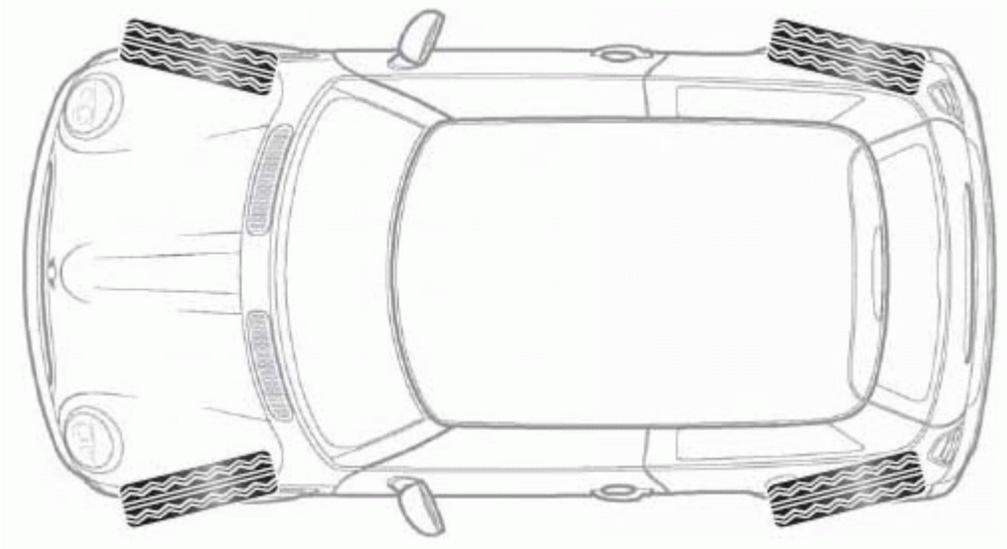


Fig. 4: Toe Out Angle

Courtesy of BMW OF NORTH AMERICA, INC.

Steering Roll Radius (Steering Offset)

The steering offset is the distance between the point of contact of the projected line drawn through the steering axis to the road surface and the center point of the tire contact area (foot print). The roll radius is the distance between these two lines.

- A positive roll radius exists when the steering axis line is inside the center line of the tire.
- A negative roll radius exists when the steering axis line is outside of the tire center line.

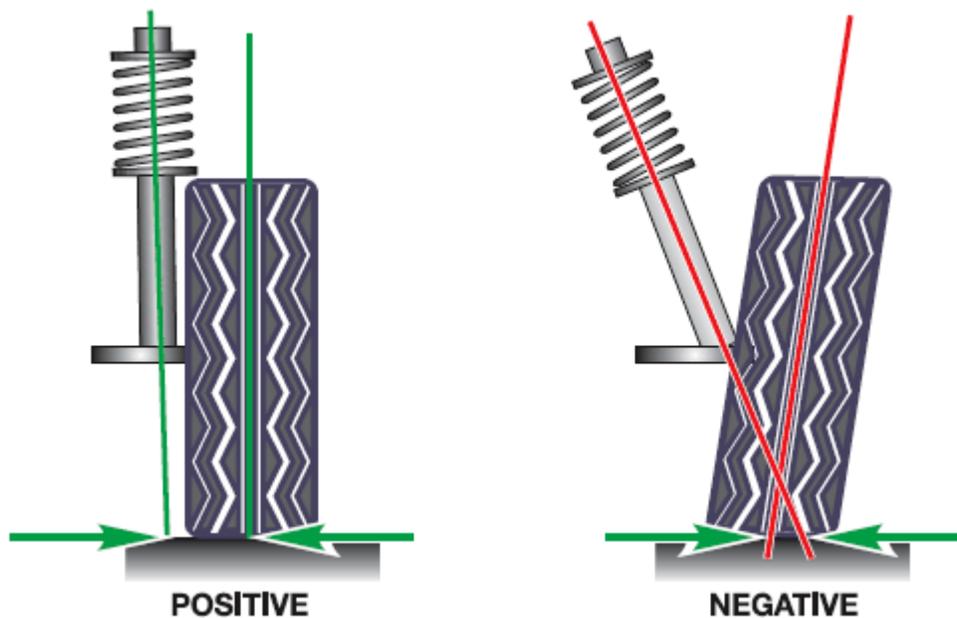


Fig. 5: Steering Roll Radius (Steering Offset)

Courtesy of BMW OF NORTH AMERICA, INC.

When the Steering Roll Radius is excessively positive, stability during braking is reduced. When the Steering Roll Radius is excessively negative, the directional stability is reduced and there is reduced feedback to the driver through the steering wheel. MINI vehicles are designed with a slightly positive Steering Roll Radius. This gives the driver a better "road feel" without compromising braking stability.

Steering Roll Radius is not adjustable, but can be influenced by improper tire and wheel combinations. Wheels with incorrect offsets can compromise handling characteristics.

Scrub Radius is another term used to describe Steering Roll Radius.

Steering Axis Inclination (SAI)

Steering Axis Inclination is the inward tilt (angle) of the strut assembly with respect to a vertical line to the road surface.

SAI results in self-correcting forces that cause the front wheels and steering wheel to return to a straight ahead position after cornering.

SAI is not adjustable, but is affected by damaged suspension components. Most current alignment equipment can measure SAI and can aid in the diagnosis of damaged parts. Bent strut or spindle assemblies are common causes of incorrect SAI readings.

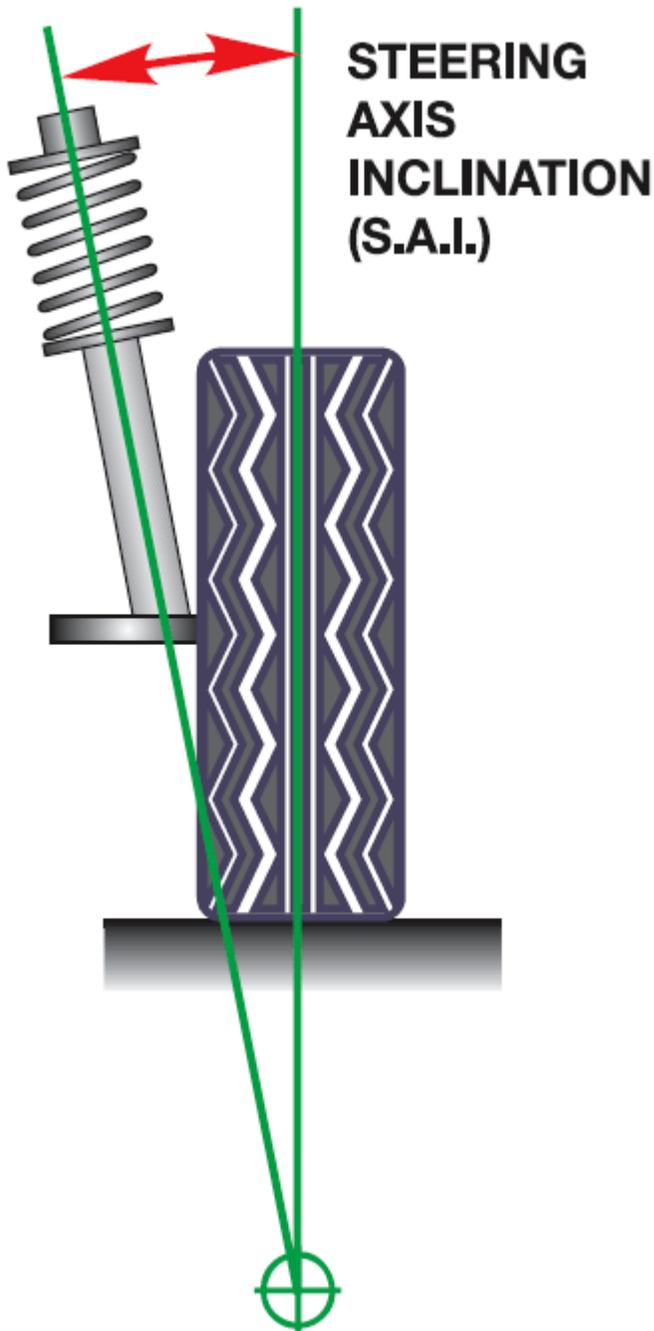


Fig. 6: Steering Axis Inclination (SAI)
Courtesy of BMW OF NORTH AMERICA, INC.

Included Angle (IA)

Included angle is the Camber angle and SAI combined. IA is also helpful when trying to diagnose bent suspension components. Knowing the IA and SAI is helpful when adjusting Camber. If the desired Camber angle cannot be achieved, then looking at SAI and IA could help determine the cause.

Toe Out on Turns

Also referred to as "Turning Angle", Toe out on turns results from the different angles (arcs) taken by the front wheels when driving through a corner. When turning a corner, the outside wheel must travel a greater distance than the inside wheel. The additional toe angle is determined by the steering arm design. Deviations from the specified value could indicate possible bent steering linkage. A typical complaint that would be associated with this condition would be excessive tire squeal or "scrubbing" on turns. When looking for this specification in TIS, look for the "Track Differential Angle" specification.

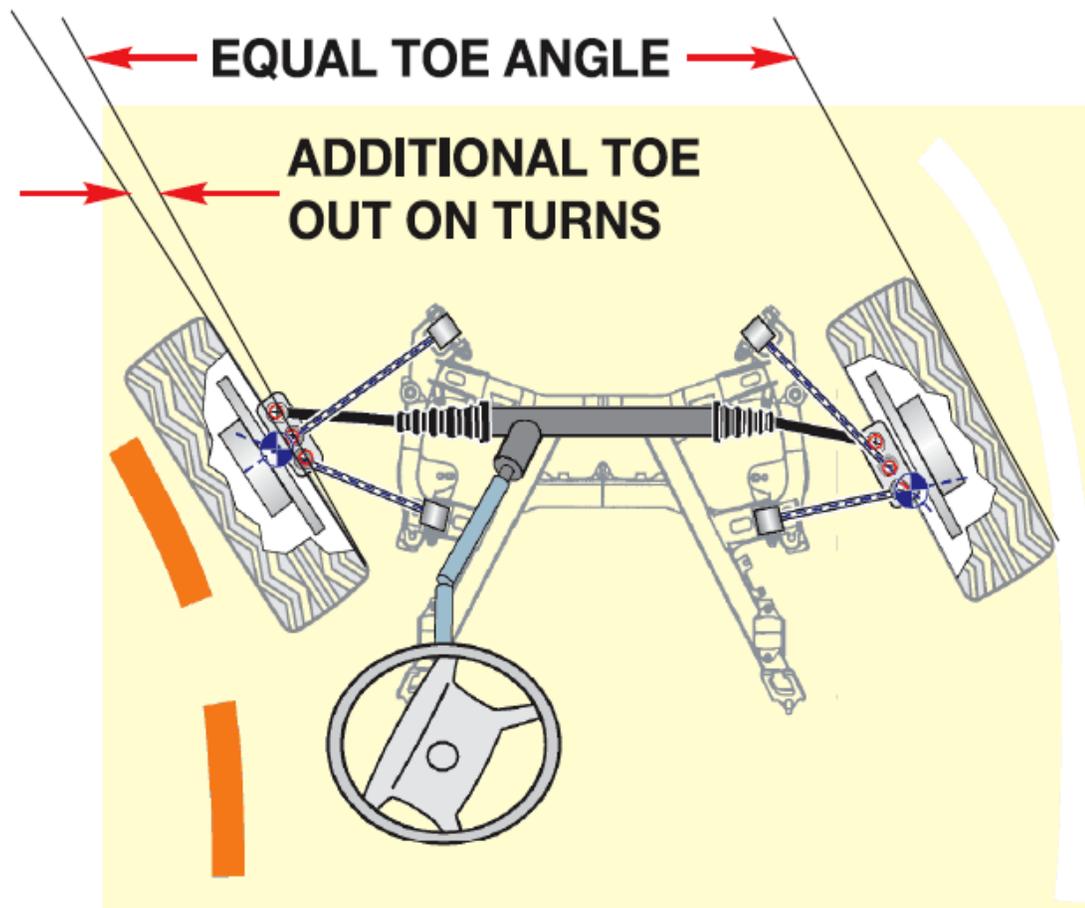


Fig. 7: Toe Out On Turns

Courtesy of BMW OF NORTH AMERICA, INC.

Geometric Axis

The Geometric Axis (Centerline) is an imaginary line that is drawn between the midpoints of both front and rear

wheels. The Axis is perpendicular to front and rear axles at 90 degrees This is an imaginary angle that is not adjustable.

Thrust Line/Thrust Angle

The Thrust Line is represented by an imaginary line that bisects the rear toe angle. This angle represents the overall "direction" in which the rear wheels are pointing. The Thrust Angle is the difference between the Geometric Axis and the Thrust Line. The optimum Thrust Angle is Zero Degrees, any deviation from this will affect the position of the steering wheel.

Positive Thrust Angle

Positive Thrust Angle is formed when the Thrust Line is to the right of the Geometric Axis (Centerline). When this situation occurs, the steering wheel position will be off to the right as well. The rear of the vehicle will tend to move to the right which will cause the front of the vehicle to steer left, the driver will move the steering wheel to the right to compensate.

Negative Thrust Angle

Negative Thrust Angle is formed when the Thrust Line is to the left of the Geometric Axis (Centerline). When this situation occurs, the steering wheel position will be off to the left as well. The rear of the vehicle will tend to move to the left which will cause the front of the vehicle to steer right, the driver will move the steering wheel to the left to compensate.

Alignment Procedures

When performing a wheel alignment, make sure that the thrust angle is as close to zero as possible. Failure to do so can result in a steering wheel that is not centered.

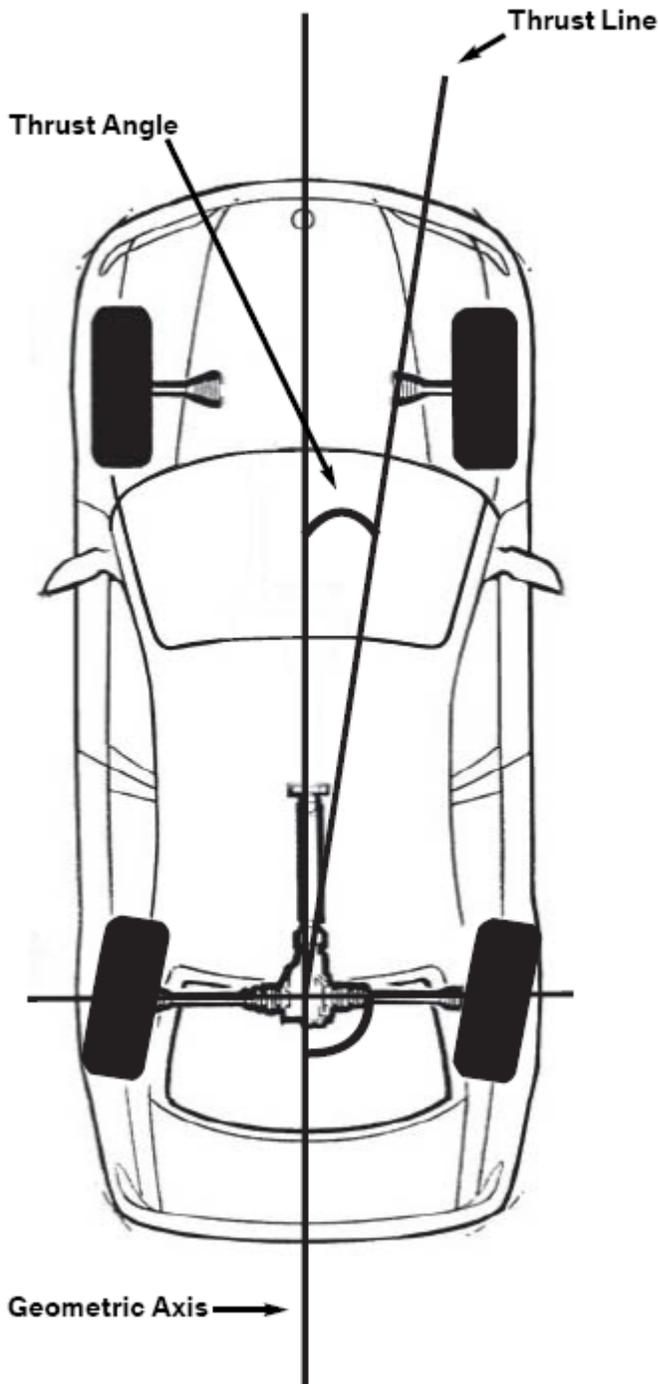


Fig. 8: Geometric Axis
Courtesy of BMW OF NORTH AMERICA, INC.

Elasto-Kinematics

Elasto-kinematics relates to the suspension system design type. The term "elasto" implies stretching, which in fact the system does. Under extreme load (acceleration, turning, braking) the suspension changes its geometry to counteract inherent changes induced by the increased loads.

The system changes are pre-determined and built into the system. The geometry changes provided by this system correct for unwanted changes that occur under load in non-elasto-kinematic systems.

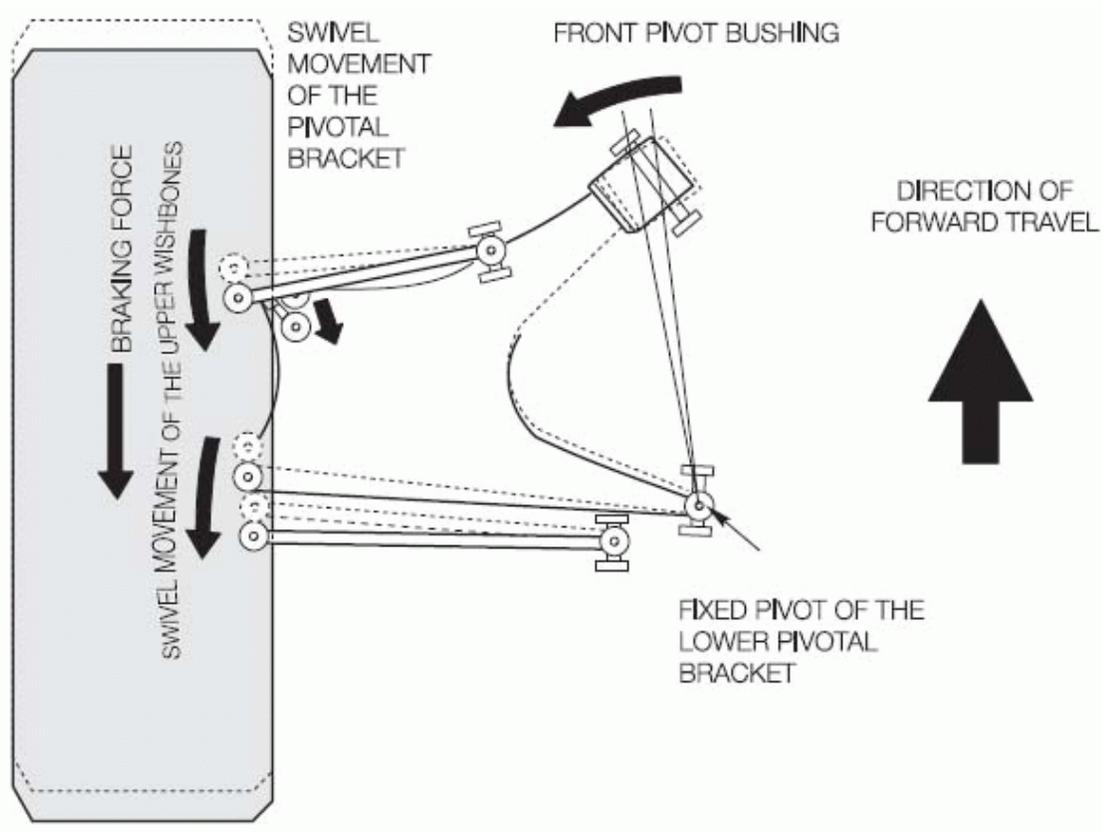


Fig. 9: Elasto-Kinematics

Courtesy of BMW OF NORTH AMERICA, INC.

SUSPENSION SYSTEM

The suspension system used on MINI provides a firm and responsive ride with superb levels of comfort and good acoustic properties. The weight distribution between the front and rear axles is biased to the front due to the front wheel drive configuration.

Adjustment to the camber at the front and rear suspension is not possible, only the front and rear toe is adjustable.

Power assisted steering using an electric pump and ABS is standard, with DSC available as an option on MINI COOPER. ASC is standard on the COOPER S, DSC is optional.

Front Suspension

The front suspension design features anti-dive and anti-squat geometry via the anti-roll bar and 1:1 strut movement ratio. The layout of the design minimizes camber loss due to side forces, thus improving handling and steering response.



MINI Front Suspension

Fig. 10: Front Suspension

Courtesy of BMW OF NORTH AMERICA, INC.

Advantages of MINI Front Suspension

- Firm and Responsive
- Positive Driver Feedback through Steering
- Strict Camber Control

The front suspension consists of the following main components:

- Front Subframe
- Lower Control Arms
- Anti-Roll Bar and Links
- McPherson Struts
- Front Shocks
- Front Springs
- Front Top Mount
- Front Hubs

System Components

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI



1. Front Mounting Points
2. Rear Mounting Points
3. Attachment Point for Crush Tubes

Front Subframe

Fig. 11: Front Subframe

Courtesy of BMW OF NORTH AMERICA, INC.

Front Subframe

A main component of the front suspension is the Subframe. It is made from hydroformed steel tubing and bolts directly to the body. The subframe provides the location for all suspension and steering components with the exception of the upper strut mounts. Attached between the front of the subframe and the bumper are the crush tubes. These tubes are attached with two bolts to the subframe and are designed to deform in an accident.



1. Attachment Point to Front Subframe
2. Attachment Point to Front Bumper Armature

Crush Tubes

Fig. 12: Crush Tubes

Courtesy of BMW OF NORTH AMERICA, INC.

Lower Control Arms

The pressed steel lower control arm links the subframe to the hub assembly via two ball joints. The inner joint is bolted to the subframe and the outer joint to the hub assembly.

The rear of the lower control arm has a hexagonal shaft onto which the compliance bushing is press fit. The compliance bushing is attached to the body with a single mounting and to the subframe with two bolts, which also secure the anti-roll bar.



1. Lower control Arm
2. Rear Bushing Shaft
3. Lower Arm Compliance Bushing and Housing
4. Ball Joint (Lower Control Arm to Subframe)
5. Ball Joint (Lower Control Arm to Hub)

Lower Control Arm Assembly

Fig. 13: Lower Control Arm Assembly
Courtesy of BMW OF NORTH AMERICA, INC.

As the suspension moves, the lower control arm pivots on the inner ball joint. The linear movement of the suspension is changed to rotational movement of the lower control arm, which is controlled by the radial stiffness of the compliance bushing.

Should replacement be necessary a new bushing and housing assembly will be required. Both ball joints are available as separate service parts.

Anti-Roll Bar and Links

Two sizes of anti-roll bar are used at the front axle:

- 19 mm for MINI COOPER
- 24 mm for the COOPER S.

**Front Anti-Roll Bar**

Fig. 14: Front Anti-Roll Bar
Courtesy of BMW OF NORTH AMERICA, INC.

The anti-roll bar bushings clamped to the top of the compliance bushing housings are manufactured from low friction PTFE (silicon impregnated rubber). This material requires no additional lubrication. This allows the anti-roll bar to rotate freely and quietly. It also allows the anti-roll bar to respond quickly to roll inputs and the use of stiffer bushings, as there is no compression or twisting as found on conventional bushings. Washers attached to the anti-roll bar located on the inside of each bushing prevent sideways movement.

The anti-roll bar links have ball joints fitted at each end. The ball joint attached to the strut is mounted on the

same axis as the link. The ball joint attached to the anti-roll bar is mounted at 90° to the axis of the link and is attached to the front of the anti-roll bar with the nut facing rearward.

Workshop Hint

The stabilizer links are either attached to the spring seat (where the lower portion of the spring rests), or to the side of the strut depending on production dates.



The ends of the anti-roll bar are attached to the struts by a link. This allows the anti-roll bar to act on a 1:1 ratio to road wheel travel providing maximum effectiveness.

Anti-Roll Bar Link Ball Joint

Fig. 15: Anti-Roll Bar Link Ball Joint
Courtesy of BMW OF NORTH AMERICA, INC.

Modified McPherson Struts

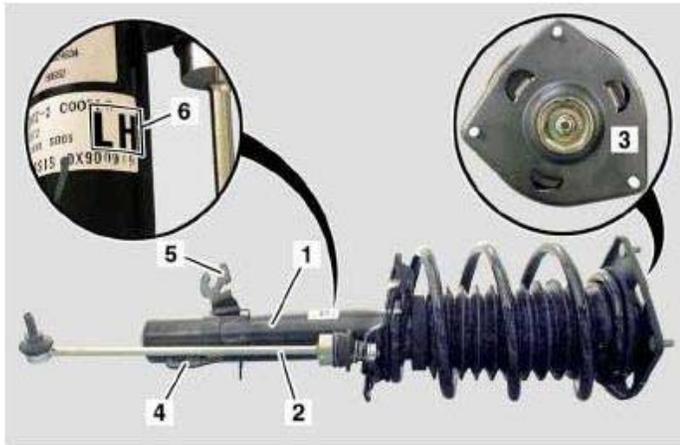
Two twin tube construction Modified MacPherson struts control the damping of the front suspension. Each strut assembly consists of a damper unit, a coil spring and a top mount assembly. The coil spring is retained in a compressed condition between the strut spring seat and the top mount. Isolators at each end of the spring reduce noise transmission from the suspension to the cabin.

A bearing is fitted to the top spring mount that allows the spring to rotate as the steering is operated. The coil spring axis is offset to the axis of the damper. This arrangement reduces friction between the damper and piston during cornering. A dust cover protects the piston rod from dirt ingress.

No provision is made for camber adjustment at the top mounting.

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI



1. Damper
2. Anti-Roll Bar Link
3. Top Mount
4. Damper Location Bracket to Hub
5. Brake Hose and ABS Sensor Bracket
6. Label Left or Right Designation

McPherson Strut Assembly

Fig. 16: McPherson Strut Assembly

Courtesy of BMW OF NORTH AMERICA, INC.

Front Shocks

The front shocks are designed as twin-tube gas pressure shocks, similar to the E46. The lower end of the damper is inserted into a cylindrical sleeve on the swivel hub. The damper bracket determines the correct orientation of the damper; the bracket slides into a machined slot in the swivel hub cylindrical sleeve and is secured with a pinch bolt. A label is adhered to the damper for side identification.

The top mounts attach to the body with three studs and are replaced as a complete assembly. There is no provision for adjustment of the camber at the front top mounts.

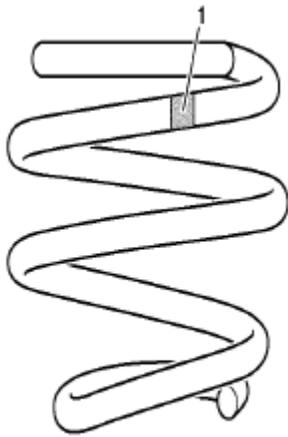


Front Swivel Hub

1. Machined Slot for Damper Bracket
2. Pinch Bolt Hole

Fig. 17: Front Swivel Hub

Courtesy of BMW OF NORTH AMERICA, INC.



Front Spring

Fig. 18: Front Spring

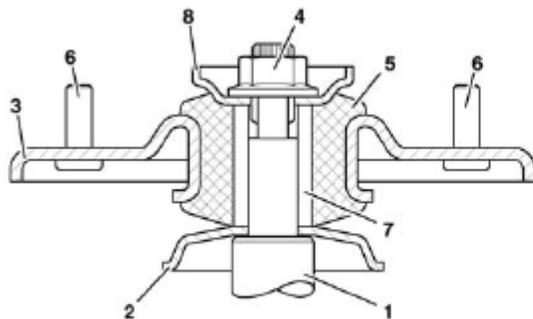
Courtesy of BMW OF NORTH AMERICA, INC.

Front Springs

The spring mounts between the seat on the damper body and the top mount, and is color coded to suit the suspension type and equipment level of the car.

Top Mount

The top mount assembly includes the top mounting plate, with a bonded rubber bushing and integral metal sleeve; three studs are pressed into the plate to retain the assembly to the body. The steel insert in the bushing prevents the damper rod retaining nut from over compressing the bushing when it is tightened. The bushing is not serviceable and a new top mount plate assembly must be fitted if replacement is required. Three lugs on the underside of the top mount plate provide location for the top mount bearing. The bearing is available as a service part separate from the top mount plate.



- 1. Damper rod
- 2. Bump Plate
- 3. Top Mount Plate
- 4. Retaining Nut
- 5. Elastomer rubber
- 6. Stud (Top Mount to Body)
- 7. Bushing inner (Steel Inserts)
- 8. Rebound Plate

Front Damper Top Mount Assembly

Fig. 19: Front Damper Top Mount Assembly

Courtesy of BMW OF NORTH AMERICA, INC.

GENERAL SUSPENSION DATA

| | |
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| | |
|--|--|

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI

| Data | MINI COOPER / MINI COOPER S |
|----------------------------------|--|
| Ride height front ⁽¹⁾ | 660 mm ± 10 mm (15") 673 mm (16") 686 mm (17") |
| Ride height rear ⁽²⁾ | 543 mm ± 10 mm (15") 556 mm (16") 571 mm (17") |
| Toe front left | 0° 00' ±7.5' |
| Toe front right | 0° 00' ±7.5' |
| Total toe front | 0° 00' ±15' |
| Toe rear left | 0° 12' ±0° 04' |
| Toe rear right | 0° 12' ±0° 04' |
| Total toe rear | 0° 24' ±0° 08' |
| Camber front left | -0° 54' ±0° 30' |
| Camber front right | -0° 54' ±0° 30' |
| Maximum variation | 1° |
| Camber rear left | -1° 32' ±0° 30' |
| Camber rear right | -1° 32' ±0° 30' |
| Maximum variation | 0° 30' |
| Castor left | +4° 58' ±30' |
| Castor right | +4° 58' ±30' |
| KPI left | +11° 32' ±30' |
| KPI right | +11° 32' ±30' |
| Setback (Thrust angle) | 0° 00' ±0° 10' |
| Wheel Base | 2467 |
| Front track | 1462 mm / 1456 mm (COOPER S) |
| Rear track | 1465.6 mm / 1460 mm (COOPER S) |
| | (1456 mm with 205/45 R17 tires on COOPER S) |

(1) Ride height is measured between bottom of rim flange and special tool.

(2) Ride height is measured between bottom of rim flange to lower edge of wheel arch.

Suspension Loading Information for Alignment

SUSPENSION LOADING INFORMATION FOR ALIGNMENT

| Driver Seat | Passenger Seat | Rear Seat | Trunk |
|-------------|----------------|-----------|-------|
| 68 kg | 68 kg | 0kg | 14kg |

Rear Suspension



MINI Rear Suspension

Fig. 20: Rear Suspension

Courtesy of BMW OF NORTH AMERICA, INC.

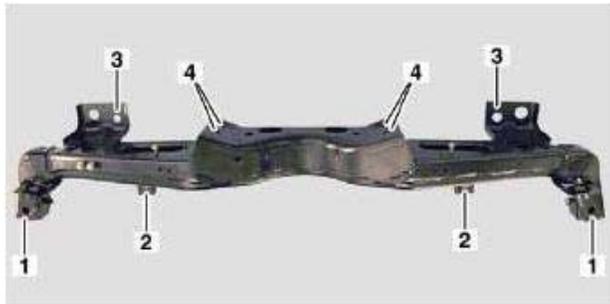
The multi-link rear suspension is used for all models of MINI, making it the only car in its class to use such a sophisticated system. Benefits of this suspension are the exceptional handling characteristics and ride comfort, with good acoustic properties.

Main components of the rear suspension include:

- Rear Subframe
- Trailing Arms
- Lateral Links
- Anti-Roll Bar
- Rear Springs
- Rear Shocks

System Components

The fabricated subframe is attached to the body by four bolts. The inside bolt (3 on illustration) on the left side of the subframe is the master bolt to ensure the subframe is in its correct lateral position. The subframe also provides attachment points for the fuel tank straps and rear suspension lateral links. The anti-roll bar attachment points are on the top of the subframe and cannot be seen on the illustration.



1. Subframe to Body Mounting Points
2. Fuel Tank Strap Mounting Locations
3. Master Mounting Bolt Location
4. Rear Suspension Lateral Link Mountings

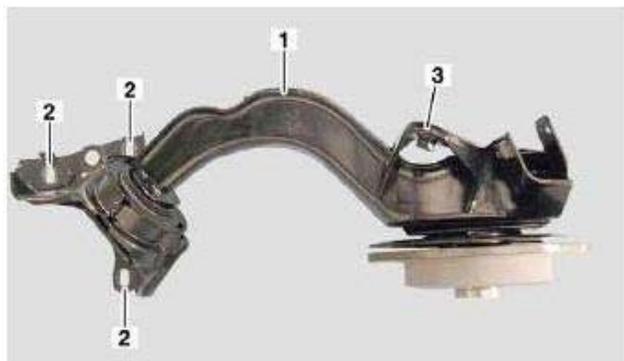
Rear Suspension Subframe**Fig. 21: Rear Suspension Subframe**

Courtesy of BMW OF NORTH AMERICA, INC.

Trailing Arms

The trailing arms are fabricated from steel with a wall thickness of approximately 4 mm. The trailing arm provides toe-in control; counters brake lift and provides a low roll center. The arm also provides attachment for the brake caliper, damper unit and anti-roll bar. The trailing arms have two attachment points for the upper and lower lateral links to aid in the track control.

Attached to the front of the arm is the compliance bushing and housing. The housing is attached to the trailing arm by a single bolt. This controls side-force steer performance and enhances ride and noise levels. The bushing is located in a fabricated bracket held to the body by three bolts. The bolt holes in the bracket are slotted to allow for toe-in adjustment. Correct orientation of the bracket to the trailing arm is important to ensure correct wind up when fitted to the body.



1. Z Axle Trailing Arm
2. Mounting Bolts (also rear toe adjustment)
3. Damper Lower Mounting

Trailing Arm Assembly**Fig. 22: Trailing Arm Assembly**

Courtesy of BMW OF NORTH AMERICA, INC.

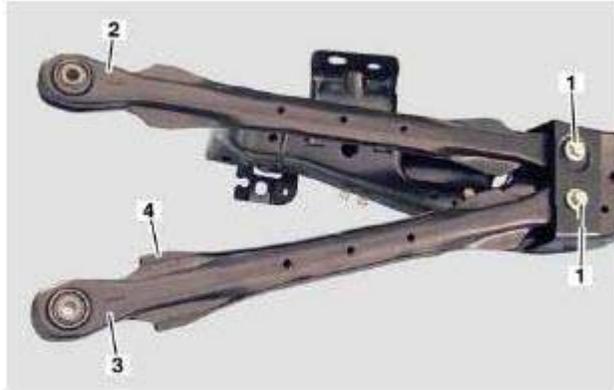
Lateral Links

The lateral links control the track of the rear wheels and are made of fabricated steel with elasto-kinematic bushings at both ends. The bolts locating the lateral links to the subframe and trailing arm should only be torque tightened with the car in curb side condition (full weight of the car on the suspension).

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI

The lateral links are not side specific. The two lower lateral links have protective covers fitted (forward facing) to protect them from becoming damaged by impact.



Lateral Links to Subframe

1. Inner Mounting Bolts to Frame
2. Upper Lateral Link
3. Lower Lateral Link
4. Lateral Link Protective Cover

Fig. 23: Lateral Links To Subframe

Courtesy of BMW OF NORTH AMERICA, INC.

Rear Anti-Roll Bar and Links

Two sizes of anti-roll bar are used at the rear axle:

- 16 mm for MINI COOPER
- 17 mm for the COOPER S.

The anti-roll bar is attached to the top of the rear subframe by two PTFE bushings secured with clamp plates. The low friction PTFE bushings allow the anti-roll bar to rotate freely and quietly and require no additional lubrication. The anti-roll bar is made of solid spring steel. The anti-roll bar links from the anti-roll bar to trailing arm have ball joints at both ends and can be installed only one way, with the ball joints on the inside.



Rear Anti-Roll Bar

1. Rear Anti-Roll Bar
2. Anti-Roll Bar Bushing and Clamp to Subframe

Fig. 24: Rear Anti-Roll Bar

Courtesy of BMW OF NORTH AMERICA, INC.

Rear Springs

Coil springs, manufactured from silicon steel, are fitted to the shock assembly. The springs are retained at the lower end by plates attached to the shock. Between the spring and shock is an isolator. The top of the spring is contained with an isolator and cup that is clamped between the shock rod and rebound plate by a nut.

Rear Shocks and Top Mounts

The shocks at the rear are of the twin-tube gas pressure design, and like the front axle, the rear shocks are side specific. The shock rod is located in a bushing in the top mounting and is secured with a rebound plate and a locknut. The top mounts are side specific and identified by the letter "R" or "L" and attached to the body by two bolts.



Fig. 25: Rear Damper

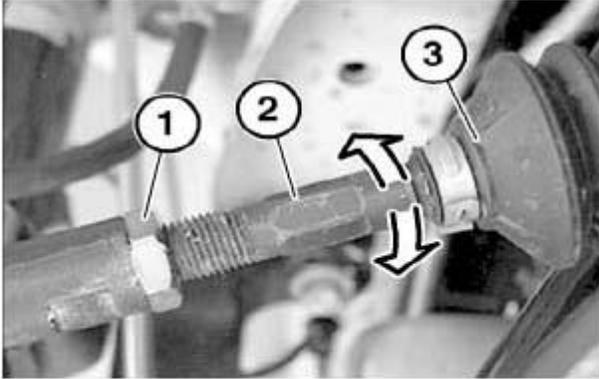
Courtesy of BMW OF NORTH AMERICA, INC.

Adjustments

Front and rear Toe are adjustable on all variants. Caster and Camber are NOT adjustable, but should always be checked during the wheel alignment to insure there is no damage. If the proper Toe, Caster and Camber measurements cannot be obtained, check for suspension damage.

Front Suspension Adjustments

The front toe angle is adjusted via the tie rods. Loosen the lock nut and turn inner tie rod until required measurement is obtained.

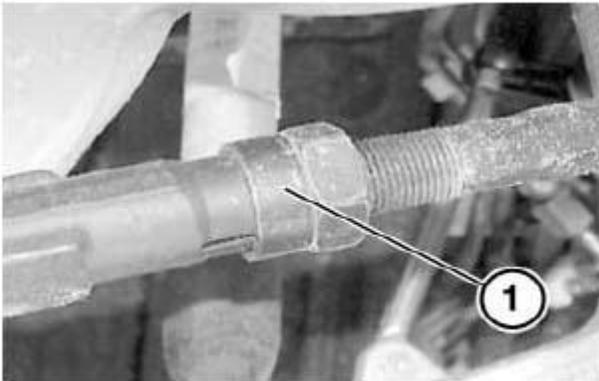


Tie Rod

- 1. Locking nut
- 2. Inner tie rod
- 3. Rubber boot

Fig. 26: Tie Rod (1 Of 2)

Courtesy of BMW OF NORTH AMERICA, INC.



Tie rod

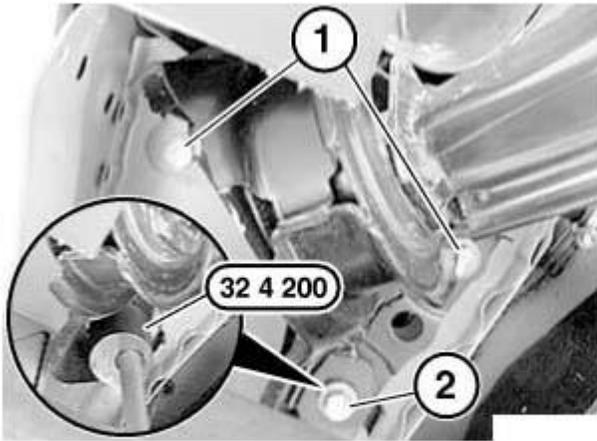
- 1. Collar

Fig. 27: Tie Rod (2 Of 2)

Courtesy of BMW OF NORTH AMERICA, INC.

Rear Suspension Adjustments

The rear toe angle is adjusted by moving the forward central arm bushing mount with special tool # 324 200, once the three mounting bolts are loosened. The central arm has slotted holes which allow for movement.



Forward central arm bushing

- 1. Mounting bolts
- 2. Eccentric tool adjustment point

Fig. 28: Forward Central Arm Bushing
Courtesy of BMW OF NORTH AMERICA, INC.



Special tool #324 200

Fig. 29: Special Tool #324 200
Courtesy of BMW OF NORTH AMERICA, INC.

Alignment Procedures

The following procedure is an outline to follow based on TIS. The actual alignment procedures will vary depending upon the alignment equipment being used. Refer to the alignment equipment manufacturers procedures for specific information. The steps listed below should be followed as closely as possible to perform a quality alignment.

- **Vehicle Inspection** - The vehicle inspection should include a road test before and after the alignment. Note any concerns during the pre-alignment road test and verify that the concern has been rectified during the post-alignment road test.

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI

- Install Specified Weight - 2 x 68 kg on front seats (seats in central position), 1 x 14 kg in luggage compartment (center) and full fuel tank.
- Install Alignment Sensors - Install alignment sensors as per the alignment equipment manufacturers recommended procedures.
- Compensate Sensors - Depending upon the alignment sensors being used, compensation may not be necessary. Compensation may require the vehicle to be lifted from the alignment rack. If so, be sure to remove the pins from the front and rear slip plates. If the sensors do not need to be compensated, the next step can be ignored.
- Lower Vehicle and Jounce - Make sure the pins are removed from the slip plates. Lower the vehicle back onto the alignment rack and jounce the vehicle. This will insure that the suspension has settled.
- Check Ride Height - Check ride height using metric tape measure. Ride height specifications can be found in Technical Data in TIS. Front ride height specs can be found under group 31 and rear can be found under group 33. Always check ride height after compensating the sensors. This will avoid having to check the ride height twice.
- Perform Alignment - There are various types of alignment equipment used in MINI workshops. Refer to the equipment manufacturers instructions for the next steps of the alignment.

Vehicle Inspection

Before attempting to align any vehicle, it is important to inspect the vehicle completely to insure there are no damaged or loose suspension components. Regardless of the age or mileage of the vehicle, a complete inspection should be performed. The following items should be checked thoroughly:

- Tires and Wheels - Check tires for wear patterns that could indicate suspension problems. Make sure the tires are the correct size and type. Check for the correct inflation pressures. Look for wheel/rim damage which could indicate impact damage.
- Wheel bearings - Check to make sure there is no excessive wheel bearing play. This needs to be addressed for safety reasons, but loose wheel bearings will affect the quality of the alignment as well.
- Steering Linkage- Check the tie rods. On vehicles with rack and pinion steering, check for loose inner/outer tie rods etc.

Check flexible coupling between steering shaft and rack and pinion assembly.

- Suspension Components - Check Struts/Shocks for leakage or damage. Check springs and perform ride height measurements.
- Subframe - Check the front and rear axle carriers. Look for bent/twisted subframes. Check the crossmembers for evidence of shifting or displacement. Check the mounting bolts for "clean spots" which could indicate shifting or movement.
- Brakes - Check braking system by road testing the vehicle. A road test could help to identify brake related issues such as pulling or brake induced vibrations.
- Drivetrain - While road testing the vehicle, observe and vibrations and/or noises and try to isolate the cause. Noises and vibrations under acceleration (rather than coasting) may be an indication of drivetrain issues.

Road Testing

Whenever possible, a vehicle should be road tested before and after an alignment. If time allows, drive on various road surfaces and note the vehicle behavior. Check for brake pull when stopping. And most importantly, note the position of the steering wheel before and after the alignment. These are important steps to avoid comebacks and unnecessary return visits.

Ride Height Measurement

When performing alignments on MINI vehicles, the ride height must be set and checked before proceeding with any measurement or adjustments. Ride height is measured from the lower edge of the wheel rim to special tool #324 110. Ride height specifications are in millimeters. The specifications can be found in Technical Data. The front axle ride height is in Group 31 and the rear axle ride height is in Group 33. In order to obtain the correct specification and suspension type must be identified.

Ride height specifications depend upon rim size (15", 16", 17" etc.), engine size and the type of suspension. There are 4 different types of suspension packages:

- Series - Standard production vehicle
- Sports Suspension - Used on the R50 with Sports Package Option.
- Sports Suspension Plus - Used on the R50 and R53 with Sports Package Option
- Sports Suspension, JOHN COOPER

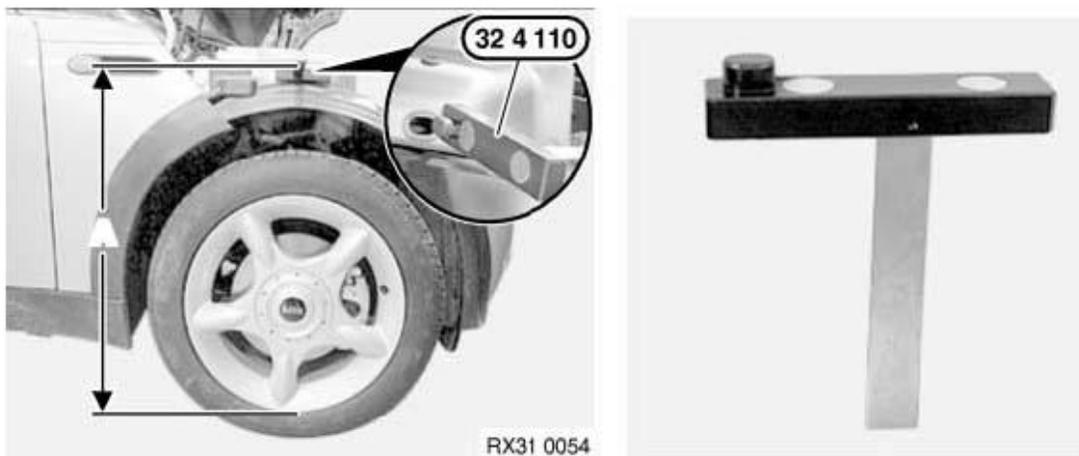


Fig. 30: Ride Height Measurement Tool
Courtesy of BMW OF NORTH AMERICA, INC.

MINI Ride Height Tool

When measuring ride height on the MINI. Use special tool # 324 110. Due to the design of the hood on the MINI, this tool is used to simulate the lower edge of the wheel opening.

NOTE: To properly check ride height, the vehicle should be weighed down. Place 2 x 68 kg on front seats (seats in central position), 1 x 14 kg in luggage compartment (center) and full fuel tank.

Alignment Specifications

The alignment specifications can be found in Technical Data under Group 32. There is a slight difference in terminology between this information and the information found on most alignment equipment. The following text should be helpful in understanding the different terms used. The alignment specifications are shown on the opposing page:

- Front Toe - The Total Toe specification represents the left and right toe specs added together. Toe is measured in degrees and minutes.
- Front Camber - Camber is also measured in degrees and minutes. Camber is adjustable only a some vehicles. The maximum amount of Camber adjustment is approximately .5 +/- degrees.
- Track Differential Angle with 200 lock on inside wheel - This angle is also known as "Toe Out on Turns". With the inside wheel turned to 20 degrees on the front turn plates, the difference in the toe angle should be as specified.
- Caster - Caster must be measured by sweeping the wheel through an arc of 10-20 degrees. (Most alignment equipment requires at least 20 degrees). Ride height is crucial to this specification. If the vehicle is too high or low in the rear, the Caster measurement will be affected. Caster is NOT a "live angle", the wheels must be reswep to check the measurement again. Although Caster is NOT adjustable, it should always be checked to insure there is no "hidden damage".
- Front Wheel Displacement - More commonly known as "Setback", this is a measurement of the angle formed between the front axle to the Geometric Axis. The front axle centerline should be at 90 degrees to the Geometric Axis. A quick check of setback is to look to see if the wheel is centered in the wheel opening. Setback is a good diagnostic angle, if the Caster is off, the Setback measurement could indicate the cause. Look for bent suspension components or damaged suspension carrier/subframe.
- Maximum Wheel Lock - Also known as "Maximum Steering Angle". This is the maximum angle of the wheels when turned to the inward and outward lock position. When this measurement is out of specification, check to see if the steering rack or steering box is centered. This can cause a hazardous condition and premature tire wear.
- Rear Toe - Just as with front toe, this is the combined measurement of the rear left and right toe. Rear Toe is also measured in Degrees and Minutes.
- Rear Camber - Rear Camber is not adjustable.
- Geometrical Axis Deviation - The Geometrical Axis Deviation is also known as the "Thrust Angle". The optimum angle is zero degrees. The Thrust Angle is the angle formed between the Geometric Centerline and the Thrust Line which is the imaginary line which bisects the rear toe angle. A Thrust Angle of Zero Degrees is Optimal.

Depending upon the type of alignment equipment used, the specifications can be expressed a number of ways. Whenever possible, set the alignment equipment to read in degrees and minutes. Some alignment equipment has this option, this is more desirable than trying to convert from inches to degrees etc.

The alignment angles are expressed in degrees and minutes.

For example: 6° 30' is expressed as 6 degrees, 30 minutes.

There are 360 degrees in a circle and 60 minutes to each degree. There are also 60 seconds to each minute, but

adjustments this fine are rarely used.

Alignment Checklist

Complete

1. Pre-Alignment Road Test

Notes: _____

2. Perform Complete Vehicle Inspection

Notes: _____

3. Check Air Pressure and Set to Specification

Notes: _____

4. Install Specified Weight

Notes: _____

5. Install Alignment Sensors

Notes: _____

6. Compensate Sensors - If Needed

Notes: _____

7. Lower Vehicle and Jounce - If Needed

Notes: _____

8. Check Ride Height

Notes: _____

9. Perform Alignment

Notes: _____

10. Calibrate Steering Angle Sensor (DSC III)

11. Post Alignment Road Test

Notes: _____

Fig. 31: Alignment Checklist (1 Of 2)

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI

Courtesy of BMW OF NORTH AMERICA, INC.

Vehicle: _____ Model Year: _____ Chassis #: _____

Front Suspension Type: _____

Adjustments: _____

Front Caster: Yes No Tool # _____ Front Camber: Yes No Tool # _____

Front Toe: Yes No Tool # _____

Rear Suspension Type: _____

Rear Camber: Yes No Tool # _____ Rear Toe: Yes No Tool # _____

Suspension Variant: (Circle One)

A. Series B. Sports C. Sport Plus D. Sport JOHN COOPER

Vehicle Loading (weight):

Front Right: _____ kg. Front Left: _____ kg.

Rear Seat: _____ kg. Trunk: _____ kg.

Ride Height Specification: Front _____ Rear _____

Ride Height Actual: Front _____ Rear _____

Tire Pressure Specification: _____ Tire Pressure Actual: _____

Wheel Bearing Play: _____

Alignment Equipment Type: _____

Alignment Head Type: _____

Notes: _____

Fig. 32: Alignment Checklist (2 Of 2)

Courtesy of BMW OF NORTH AMERICA, INC.

STEERING

The MINI features a power assisted steering system (EHPS) on all models. The steering rack is of conventional rack and pinion design. The steering column has two collapsible mechanisms and tilt adjustment. The twin

spoke steering wheel is common to all models although there are small differences depending on the model and equipment level. The steering column has 54 mm of tilt adjustment manually controlled by a lever beneath the column. The electrically driven power steering pump is the main difference.

Purpose of the System

The Steering System is designed to offer smooth operation with maximum feedback to the driver. The Electro Hydraulic Power Steering, driven by an electric motor rather than the conventional belt, conserves valuable engine power and provides a 3% savings in fuel economy.

The main components of the steering system are:

- Electro Hydraulic Power Steering Pump (EHPS)
- Rack and Pinion
- Steering Column
- Steering Wheel
- EHPS Cooling Fan

System Components

EHPS

All models and derivatives are equipped with Electro Hydraulic Power Steering (EHPS). This system uses an electric motor to drive the hydraulic pump. This replaces the customary design whereby the pump is permanently driven from the engine via the auxiliary belt.



1. Steering Pump Assembly
2. Connectors
3. Oil Inlet
4. Oil Outlet
5. Support Bracket

EHPS Motor Assembly

Fig. 33: EHPS Motor Assembly

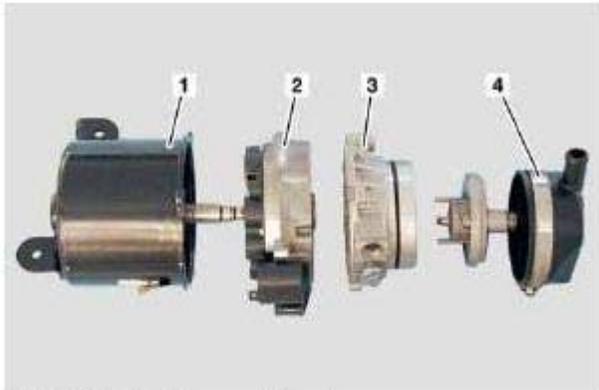
Courtesy of BMW OF NORTH AMERICA, INC.

The EHPS motor weighing 5.5 kg is mounted by four rubber insulators and is positioned in front of the steering rack.

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI

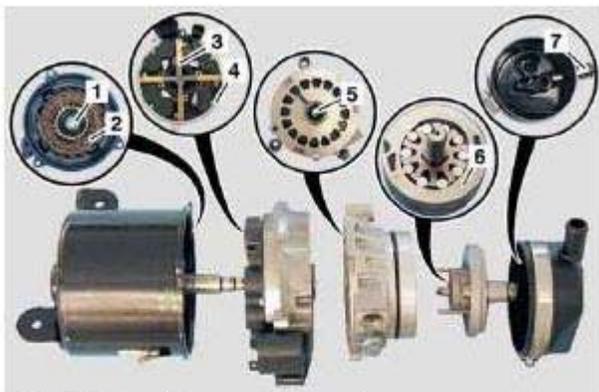
The hydraulic pump displaces 1.25cm³/revolution developing a pressure of 105 bar at a maximum pump motor speed of 4,200 rpm. The hydraulic pump has an incorporated pressure relief valve. The smaller metal pipe from the aluminum bodied pump is the high pressure side and the flexible pipe fitted to the plastic reservoir on the pump is the low pressure side. There is a small reservoir fitted to the end of the pump with a remote reservoir fitted to the bulkhead. The system is filled with Pentosin CHF 11 S. For top-up and refill use the same oil.



EHPS Motor/Pump Housings

1. Motor Housing
2. Brush Housing
3. Pump Housing
4. Reservoir cover

Fig. 34: EHPS Motor/Pump Housings
Courtesy of BMW OF NORTH AMERICA, INC.



EHPS Motor/Pump Internal Components

1. Motor Pump Shaft
2. Motor Windings
3. Brushes
4. Pump Seal Groove
5. Link shaft
6. Oil Pump Assembly
7. PAS Fluid Inlet

Fig. 35: EHPS Motor/Pump Internal Components
Courtesy of BMW OF NORTH AMERICA, INC.



Remote Reservoir

Fig. 36: Remote Reservoir
Courtesy of BMW OF NORTH AMERICA, INC.

Rack and Pinion

The Steering Rack is mounted on the front subframe and is of conventional power assisted rack design. The rack is 2.56 turns lock to lock.

Steering Column

The steering column is mounted on a one-piece aluminum bracket attached to the cross car beam. The steering column features two collapsible mechanisms, the upper part sliding away from the driver and the lower part telescoping to allow for movement of the engine and sub-frame during an impact.

Vehicles equipped with DSC have a steering angle sensor fitted to the lower end of the upper column. The data is transmitted to the DSC control unit via the CAN bus.



1. Steering Angle Sensor

Steering Column Assembly

Fig. 37: Steering Column Assembly
Courtesy of BMW OF NORTH AMERICA, INC.

A grommet with an integral bearing seals the column to the bulkhead and provides additional support at the bottom of the column. A "Yoke" type joint secured by a nut and bolt secures the column to steering rack pinion.

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI

The ignition switch, steering lock cylinder and gearbox interlock (ECVT cars only) is mounted on the steering column tube. The interlock prevents the ignition key from being removed until the ECVT lever is in the Park position.

A slip clutch is fitted beside the steering lock detent pin. If force is exerted on the steering wheel, this prevents the detent pin from shearing off. This improves anti-theft protection. To reduce weight the column/lock assembly is made from pressure die cast magnesium.

The rotary coupler for the airbag is attached to the steering column switch unit. This is screwed to the top of the column.

The steering column has a tilt mechanism that allows the steering wheel to move 27 mm up and down from the center. Thus providing a total tilt adjustment of 54 mm. Adjustment is made by means of a lever located under the column cover. The column is counterbalanced by two springs, one either side of the column.

Steering Wheel

All models feature a two-spoke steering wheel. The MINI COPPER rim is vinyl. The MINI COOPER S (and optional MINI COOPER) steering wheel is leather trimmed. The diameter of the steering wheel is 370 mm. The steering wheel airbag module has a capacity of 57 liters and is a two-stage bag.

There are a number of functions that can be performed without the driver having to remove his/her hands from the steering wheel. Situated on the outside of the two spokes are the horn push buttons, these are on all steering wheels on all derivatives.

Cruise control and audio system buttons are also located on the steering wheel.



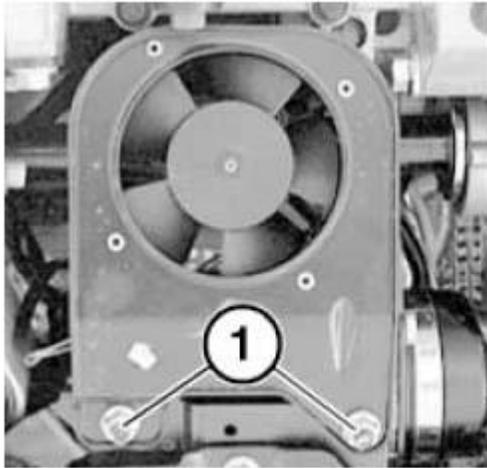
Steering Wheel

Fig. 38: Steering Wheel

Courtesy of BMW OF NORTH AMERICA, INC.

A small electric fan is used to cool off the EHPS. It is mounted on rubber bushing to the subframe to prevent vibrations from transmitting to the chassis. here is a cooling fan

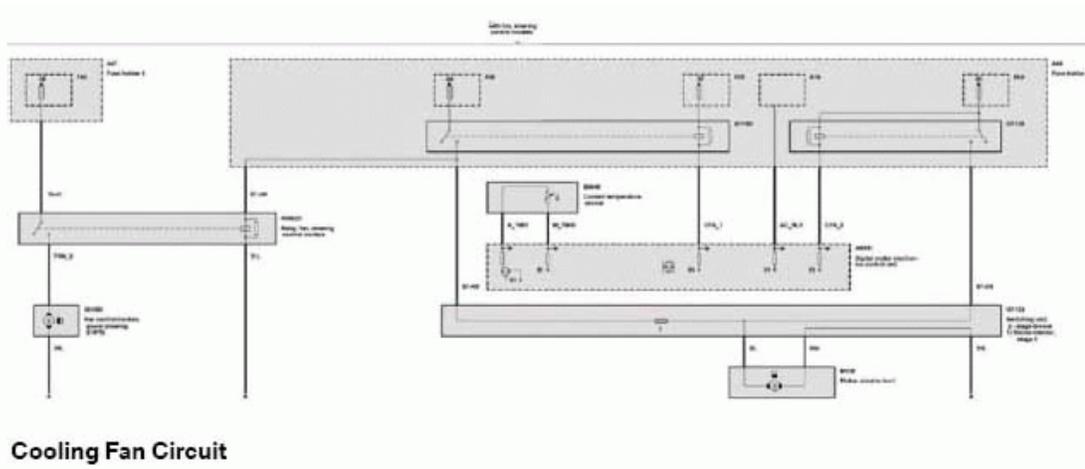
There is no connection nor communication between the EHPS and the cooling fan. The EHPS cooling fan power is supplied from a relay that is activated by the "same" wire that supplies power to the engine cooling fan. When the EMS2000 activates the engine cooling fan, the EHPS also gets power up.



EHPS Cooling Fan

Fig. 39: EHPS Cooling Fan

Courtesy of BMW OF NORTH AMERICA, INC.



Cooling Fan Circuit

Fig. 40: Cooling Fan Circuit Diagram

Courtesy of BMW OF NORTH AMERICA, INC.

Principle of Operation

There are two modes of operation for the EHPS: no steering assistance and steering assistance.

With the engine running and no steering assistance required the pump operates at approximately 80% capacity at a speed of 3.500 rpm. Movement of the steering changes the hydraulic pressure within the circuit which in

2007 MINI Cooper

2002-07 GENINFO Steering and Suspension - Overview - MINI

turn affects the operation of the pump, this is identified at the control electronics by the increase in current, the pump speed is increased to 4,500 rpm and now operates at full (100%) capacity.

The unit's DC motor, is capable of drawing a maximum current of 120 Amperes, but running at an average 11.5 Amperes, powers the system. In standby mode with the engine running but the vehicle stationary the draw is 7.0 Amperes $\pm 10\%$.

PRINCIPLE OF OPERATION

| Condition | Current (Amps) |
|---------------------|----------------|
| Standby Mode | 7.0 |
| Average Consumption | 11.5 |
| Maximum Assist | 120 |

The EHPS consists of two connections:

- 2-pin cable connection
 - KL30
 - KL31
- 3-pin connector
 - KL15
 - KL61 (used to determine if the engine is running)
 - Diagnosis bus (used for communication with the control electronics integrated in the pump)

The pump motor is activated only if the engine is running. If the pump overheats the pump will reduce output to 80%. If the temperature keeps rising, the pump will eventually shut down to protect itself (electronics) from damage.