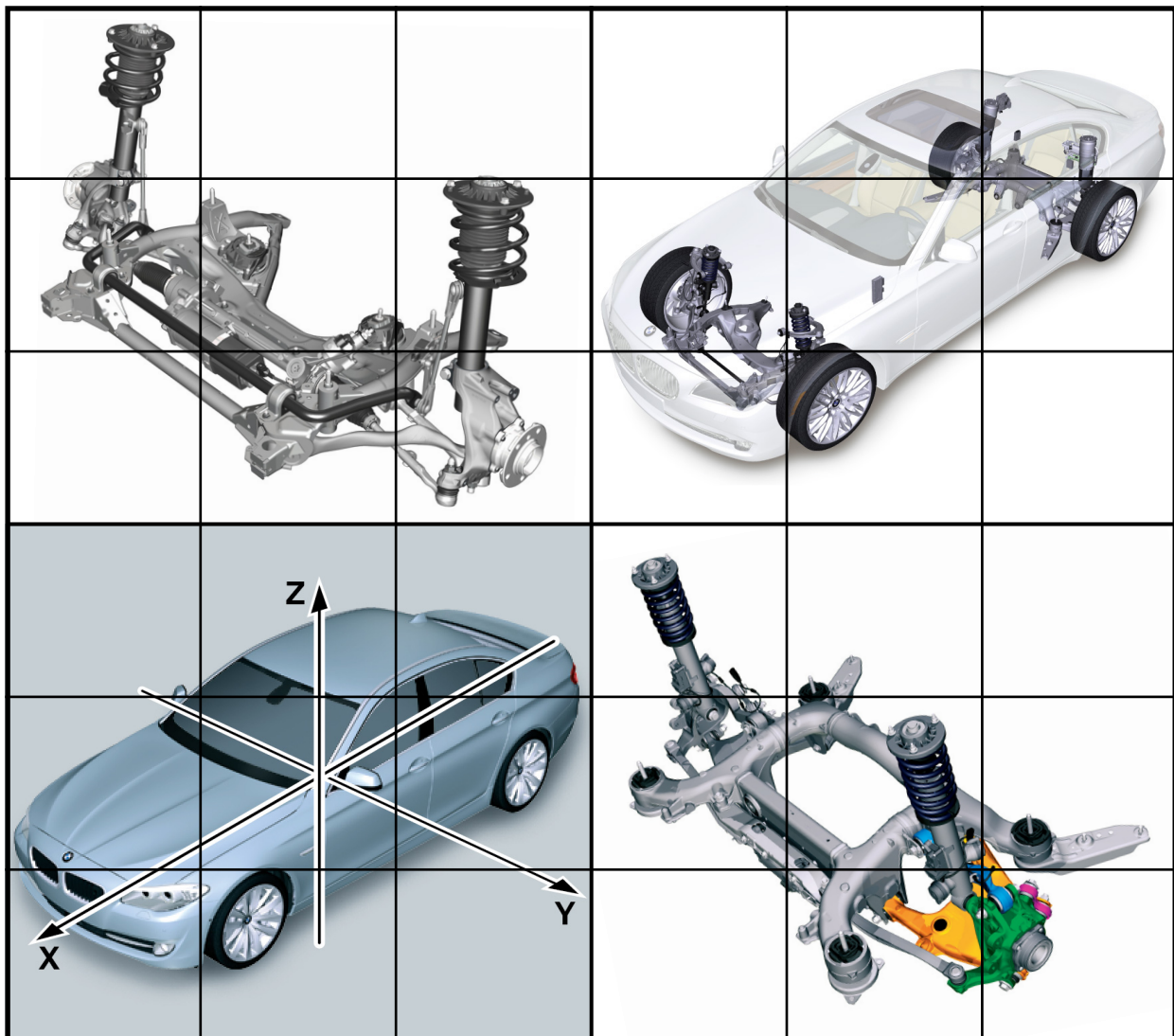




# BMW Technical Training

## Chassis Dynamics



**Information Status:** August 01, 2012

**Course Code:** ST1115 Chassis Dynamics

The information contained in the training course materials is solely intended for participants in this training course conducted by BMW Group Technical Training Centers, or BMW Group Contract Training Facilities.

This training manual or any attached publication is not intended to be a complete and all inclusive source for repair and maintenance data. It is only part of a training information system designed to assure that uniform procedures and information are presented to all participants.

For changes/additions to the technical data, repair procedures, please refer to the current information issued by BMW of North America, LLC, Technical Service Department.

This information is available by accessing TIS at [www.bmwcenternet.com](http://www.bmwcenternet.com).

---

# Table of Contents

## Wheels and Tires

<b>Subject</b>	<b>Page</b>
<b>Introduction</b> .....	<b>5</b>
TREAD Act .....	6
System Identification and Terminology .....	7
<b>Flat Tire Monitoring Systems</b> .....	<b>8</b>
FTM System Overview .....	9
FTM System Operation .....	10
Spare Tire .....	11
System Functions .....	12
Self Test .....	12
System Reset .....	12
Detects Drop in Tire Pressure .....	12
Visual and Acoustic Warning .....	12
Signal Output .....	12
Special Conditions for System Function .....	13
Old or Worn Tires .....	13
System Reset .....	14
<b>TPM Systems (up to 2003 production)</b> .....	<b>15</b>
TPM System Components .....	16
RDC Control Unit .....	16
Receiving Antennas .....	17
Wheel Transmitter Modules .....	18
TPM System Operation .....	19
Autumn Warning .....	19
Tire Failure Warning .....	19
System Reset .....	20

<b>Subject</b>	<b>Page</b>
<b>TPM Systems (from 9/05)</b> .....	<b>21</b>
TPM System Overview .....	22
TPM System Components .....	23
TPM (RDC) Control Unit .....	24
Central Receiving Antenna .....	24
Trigger Transmitter Modules .....	25
Wheel Transmitter Module .....	26
Control Display .....	27
Instrument Cluster .....	28
System Operation .....	29
Wheel Management .....	30
Control Display Screens .....	31
One Tire with Reduced Pressure .....	31
Several Tires with Reduced Pressure .....	32
Workshop Hints .....	33
System Reset (Initialization) .....	33
Reset Procedure .....	35
Vehicles with RPA Button .....	35
Vehicles with BC Button (on-board computer function) .....	35
Vehicles with Central Information Display .....	35
Preconditions for Activation .....	35
Flat Tire Indication .....	35
<b>TPM Systems (from 3/11)</b> .....	<b>36</b>
Operating Principle .....	36
Resetting the Tire Pressure Values .....	36
Teach-in Process .....	36
Service Information .....	42
Teach-in Process .....	42
Service Life of Batteries for Wheel Electronics .....	42
Remove / Install Wheel Electronics .....	42
<b>Runflat Tire Technology</b> .....	<b>43</b>
RFT Operation .....	43
RFT Design .....	43
Tire Manufacturer Information .....	43

---

<b>Subject</b>	<b>Page</b>
<b>Basic Tire Balancing</b> .....	<b>46</b>
Static Imbalance .....	47
Dynamic Imbalance .....	48
Residual Imbalance .....	49
Balance Weights .....	49
Weight Conversion .....	50
Runout .....	51
Wheel Runout .....	51
Lateral Runout (Rim) .....	52
Tire Runout .....	53
Radial Runout (Tire) .....	53
Lateral (Axial) Runout .....	54
Component Runout .....	54
Radial Force Variation .....	55
Vibration Diagnosis .....	57
Harmonics .....	59
First Order Harmonics .....	59
Second Order Harmonics .....	60
Tips on using the GSP9700 Wheel Balancer .....	61

---

# Wheels and Tires

**Model: All with TPMS**

**Production: All**

# OBJECTIVES

After completion of this module you will be able to:

- Identify BMW Tire Pressure Monitoring Systems
- Locate and Identify Components of TPM Systems
- Diagnose and Repair TPM Systems

## Introduction

According to numerous studies and statistical analysis, many vehicles on the roads today are driving with under-inflated tires. First and foremost, this is a safety issue which could ultimately result in catastrophic tire failure (a.k.a. “blowout”). Many “blow-outs” can be traced back to preliminary damage from puncture or a slow loss in tire pressure.



In addition to safety issues, under-inflated tires can cause a reduction in fuel economy and overall tire life. Studies by tire manufacturers have shown that tire life can be reduced by 50% when the tires are under-inflated by as little as 20%.

Therefore the overall consequences of improperly inflated tires include:

- Increased tire wear resulting in decreased tire service life
- Impaired vehicle handling
- Reduction in safety for the vehicle occupants
- Reduced fuel economy

Since most tire pressure loss occurs gradually, the driver does not usually perceive the reduced tire pressure. Therefore various systems have been developed to aid the driver by monitoring tire pressure loss and report this information to the driver.

The intent of this training module is to include all systems which monitor tire pressure loss. The first U.S. model BMW to utilize this technology was the E39 M5. Various systems have been in use since that time on some models.

Recent government legislation now mandates that all light vehicles sold in the U.S. must have a “Tire Pressure Monitoring System” or TPMS.

---

## TREAD Act

In 2000, there was much media attention surrounding tire safety issues. The leading tire manufacturers were involved with many law suits regarding catastrophic tire failures. These well publicized incidents involved injury and fatalities.

In response to these issues, the U.S. Congress enacted legislation entitled the “Transportation Recall Enhancement, Accountability and Documentation (TREAD) Act in November of 2000.

The TREAD Act encompasses many aspects of tire industry issues. The act includes items such as tire labeling requirements, tire testing standards, information on tire safety related recalls etc. There are also provisions for issues on child safety restraints.

However, the focus of this training module is to train technicians about Tire Pressure Monitoring Systems (TPMS). TPM systems are also one of the primary components of the TREAD Act. TPM systems allow early detection of tire pressure loss which is not usually detected by the driver until vehicle handling and safety is affected.

The National Highway Traffic Safety Administration (NHTSA) is the government agency responsible for the creation and enforcement of the mandates of the TREAD Act. Initially, NHTSA approved the installation of “Indirect” TPM systems.

Indirect TPM systems monitor tire pressure “indirectly” by monitoring the rotational speed of the tire via the wheel speed sensors. The ABS/DSC system can then detect pressure loss by comparing wheel speed information between all 4 tires. Any loss in tire pressure would result in a change in tire diameter and therefore a change in rotational speed.

The guidelines of the TREAD Act found that “Indirect” TPM systems are ineffective in detecting tire pressure loss until the tire was under-inflated to an unsafe level. Therefore, NHTSA mandated that auto manufacturers install “Direct” TPM systems on all vehicles.

Direct TPM systems monitor tire pressure directly by using pressure sensors at each wheel which report tire pressure and temperature information to relevant vehicle systems. Tire pressure loss is then reported to the driver via an illuminated warning symbol. Direct TPM systems also offer the capability of monitoring tire pressure when the vehicle is at a standstill. Indirect systems must be driven in order to collect sufficient data to detect tire pressure loss.

As per NHTSA guidelines, passenger cars and light trucks must have the “Direct” TPM systems installed via a specific timeline from 2005. By 2007, all auto manufacturers must be in 100% compliance.

Aside from the obvious safety benefits, Direct TPM systems will also assist the driver by maintaining fuel economy and extending tire life.

This training module will help the technician to diagnose and repair both “Indirect” and “Direct” TPM systems. The first step in the diagnosis the these systems is identification. The following text shows some tips on identifying these systems.



---

## System Identification and Terminology

In order to accurately diagnose TPM systems, the system must be properly identified. These systems have had numerous acronyms which are used to describe the various systems. For the purposes of this training module, the systems will be broken down into two basic configurations. These are as follows:

- **Systems which monitor wheel speed** - These **“Indirect”** systems will be referred to as Flat Tire Monitoring systems or FTM. FTM systems take advantage of components already installed in the vehicle. The wheel speed sensors, which are already an input to the DSC control unit, are used to monitor wheel speed. When a tire starts to deflate, the overall diameter changes. This affects the rotational speed, which is picked up by the DSC module. The DSC module contains software for the purpose of calculating the speed changes and reporting the pressure loss to the driver via an illuminated indicator or symbol. The only additional components which are installed is the switch for system initialization. Early generation systems used a module which received wheel speed input from the DSC module.
- **Systems which monitor actual tire pressure** - These **“Direct”** systems will be referred to as Tire Pressure Monitoring Systems or TPM systems. TPM systems use wireless sensors which are part of the tire valve stem. These sensors monitor actual tire pressure and send this information to a module via multiple antennas. These systems are preferred due to the fact that the actual tire pressure is monitored rather than by variations in tire rotational speeds.

There is a simple way to identify the difference between the two systems. On systems which monitor actual tire pressure, the tire valve stem is threaded and has a “hex head” on the valve stem. The systems which monitor wheel speed have conventional rubber valve stems.

**TPM System**



**“Threaded” Valve Stem on Vehicles, which Monitor Actual Tire Pressure.**

**FTM System**



**“Rubber” Valve Stem on Vehicles, which Monitor Wheel Speed.**

# Flat Tire Monitoring Systems

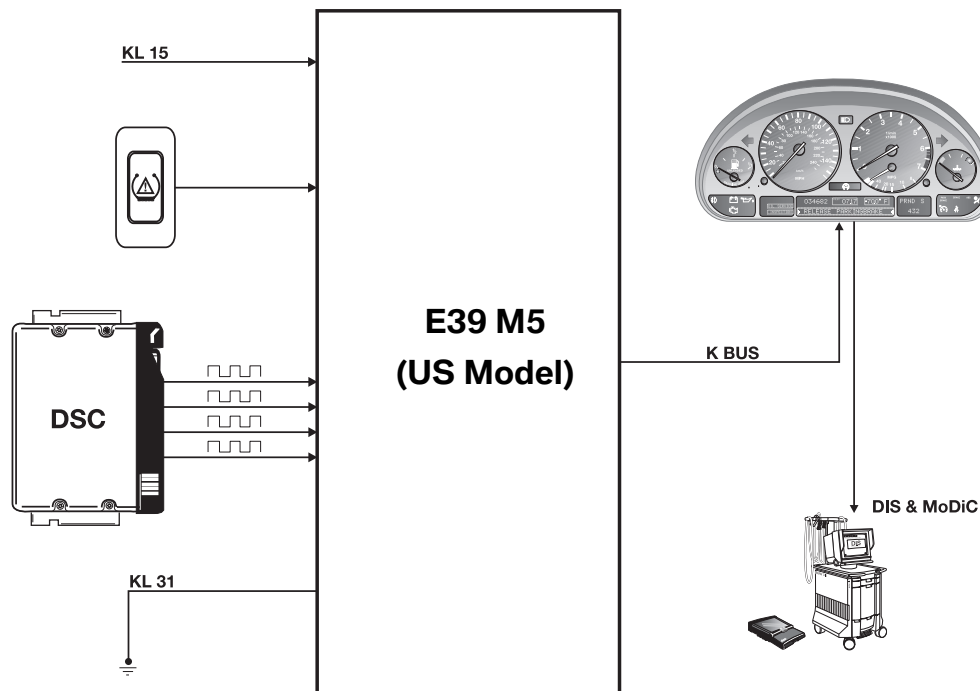
FTM systems are “indirect” systems which were first used on U.S. models with the introduction of the E39 M5 in 2000. Since that time, FTM systems have been included on most other models including the 7 Series.

There have been numerous abbreviations and terminology used to describe FTM systems in the past. However, FTM will be used from this point forward to describe those systems which “indirectly” monitor tire pressure loss through wheel speed detection.

Some of the past abbreviations include:

- **RDW** - is derived from the German term “**R**eifen **D**ruck **W**arnung” which means Tire Pressure Warning. This term was used to describe some of the early systems used on the E39 M5 and E46 M3.
- **RPA** - comes from the German words “**R**eifen **P**annen **A**nzeige” which translates to Tire Failure (Puncture) Indicator. This abbreviation is most closely associated with the E85, E60 and E46 (from 2001).
- **DDS** - This an english based abbreviation for **D**eflation **D**etection **S**ystem. This term is occasionally found when using the diagnostic equipment such as the DISplus/GT-1.
- **DWS** - This is also an english abbreviation for the system used on the Z8 (E52) and it stands for **D**unlop **W**arning **S**ystem.

Regardless of the terminology used, the most important concept to understand is the difference between the Direct and Indirect systems.



## FTM System Overview

FTM Systems (Indirect monitoring systems)					
Series	Chassis	Option/Date	System Design	Deflation Warning	System Reset (initialization)
<b>3 Series</b>	<b>E46</b>	Option from 9/03	System integrated into DSC	Yellow telltale + gong	RPA Reset Button
<b>3 Series</b>	<b>E46 M3</b>	Standard from SOP	System integrated into DSC	Yellow telltale + gong	RPA Reset Button
<b>3 Series</b>	<b>E46 (ix)</b>	Option from 9/01	System uses separate control unit.	Yellow telltale + gong	RPA Reset Button
<b>3 Series</b>	<b>E90/E91</b>	Standard from SOP	System integrated into DSC	Yellow telltale + gong	RPA Reset via Stalk Switch or Controller
<b>5 Series</b>	<b>E39 (M5)</b>	Standard	System uses separate control unit.	Yellow telltale + gong	RPA Reset Button
<b>5 Series</b>	<b>E60/E61</b>	Standard	System integrated into DSC	Yellow telltale + gong and CC Message	Soft Key Reset via CID Menu and Controller
<b>6 Series</b>	<b>E63/E64</b>	Standard	System integrated into DSC	Yellow telltale + gong and CC Message	Soft Key Reset via CID Menu and Controller
<b>7 Series</b>	<b>E65/E66</b>	Optional from 9/02 Standard from 12/03	System integrated into CIM	Yellow telltale + gong and CC Message	Soft Key Reset via CID Menu and Controller
<b>Z4</b>	<b>E85</b>	Standard	System integrated into DSC	Yellow telltale + gong	RPA Reset Button
<b>SAV</b>	<b>E53</b>	Standard from 4/04	System integrated into DSC	Yellow telltale + gong	RPA Reset Button
<b>SAV</b>	<b>E83</b>	Standard	System integrated into DSC	Yellow telltale + gong	RPA Reset Button

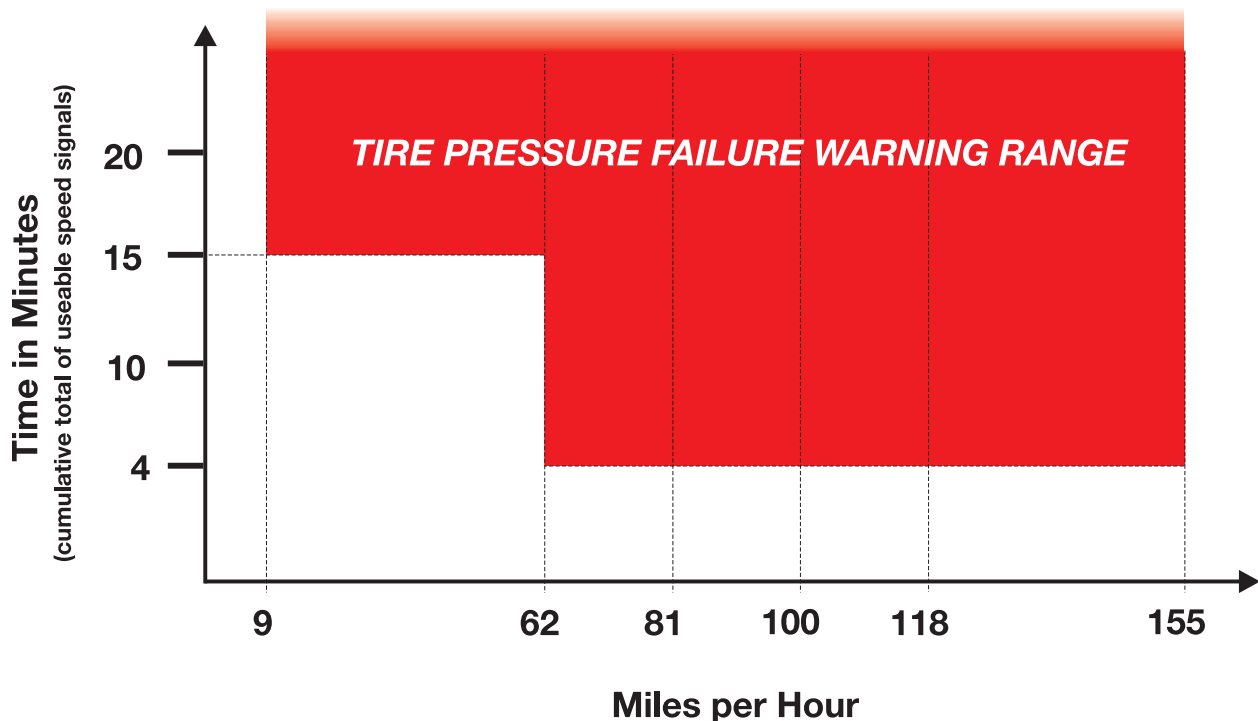
## FTM System Operation

The FTM system is designed to inform the driver of a loss in tire pressure. Rather than monitor actual tire pressure (as direct systems do), the rolling circumference is calculated from the wheel speed signals. When a tire loses pressure, the circumference decreases which corresponds to an increase in wheel speed. The wheel speeds are compared with one another for the purpose of determining rotational irregularities.

A difference in wheel speed is recognized as a pressure loss. The FTM system can inform the driver after a short drive if there is a possible under-inflated tire. Depending upon the vehicle, the driver is warned via an indicator light in the cluster or by a check control message. A gong will sometimes accompany the warning light as an additional method of alerting the driver.

When pressure loss from the tire is gradual, the driver may not perceive a problem until the vehicle handling is compromised. The condition is made difficult to visually detect when “Run Flat” tires are used. This is due to the additional sidewall stiffness which can “mask” an under-inflation situation. The FTM system can alert the driver in advance of any pressure loss in the tires.

The FTM system will detect a drop in pressure below about  $30\% \pm 10\%$  of the initial value. The FTM indicator and warning light indicates a drop in tire pressure. The FTM system will indicate this after just a short distance. Usually, after a few minutes, from a certain minimum speed (e.g. 25 km/h) up to the permissible top speed.



---

During the reset process, the set tire pressure is taken as the initial value for the current set of tires. If all 4 tires lose pressure at the same rate, the wheel speeds will also change at the same rate. The RPA is unable to detect a uniform drop in pressure in all tires (e.g. due to diffusion = natural loss of air from all 4 tires)



As per BMW guidelines, the tire pressure should be checked regularly. The owner's manual states at least twice a month and prior to any long trips. Tire pressure information can be found on the tire pressure placard on the b-pillar. There are also tire pressure charts in the owner's manual as well.



**The overall responsibility for the maintenance of correct tire pressure resides with the driver at all times.**

### **Spare Tire**

When using the "space saver" type spare tire, be aware that the FTM system will not operate properly due to the reduced overall diameter of the spare tire. Have the tire repaired as soon as possible to ensure a high level of driving safety.

---

## System Functions

The Run Flat Indicator (RPA) comprises the following functions:

- Self-test
- Reset (Initialization)
- Detects drop in tire pressure
- Visual and acoustic warning

### Self Test

The RPA performs a self-test when terminal 15 is switched ON. A fault in the RPA is indicated by the RPA indicator and warning light and by a symbol in the LC display.

### System Reset

Reset is started manually (e.g. by pressing the RPA button). Then (after the journey has started), Initialization will run as a fully automatic calibration sequence. In other words, the circumference of individual tires are recorded and evaluated.

To allow a drop in tire pressure to be detected, the system considers different speed ranges and driving situations. Taking account of the driving situation means that the system has to be primed for each speed range individually.

From 09/2004, these speed ranges and driving situations have been combined into 3 calibration ranges. This means greater clarity for output via the BMW diagnostic equipment.

The reset (initialization) phase lasts approximately 5 to 15 minutes for the individual speed ranges. The end of the reset phase is not indicated.

### Detects Drop in Tire Pressure

The RPA records the wheel speeds using the wheel-speed sensors from the DSC. The RPA compares the speeds of the individual wheels and computes an average speed. In this way the RPA is able to detect a loss of tire pressure. (In the event of a tire losing pressure, the tire rolling circumference of the affected tire is also reduced.)

### Visual and Acoustic Warning

A drop in pressure in one tire of approximately  $30\% \pm 10\%$  from the initial value is indicated by the RPA indicator and warning light. In addition, an acoustic signal sounds.

#### ■ Signal Output

Depending on the model concerned, either via the instrument cluster, M-ASK or CCC.



**In the event of a DSC malfunction, the FTM system will also register a malfunction. This is due to the fact that the wheel speed sensors are monitored by both the DSC and FTM systems.**

---

## Special Conditions for System Function

The following operating conditions may cause a delay in the warning being given in the event of a drop in tire pressure:

- Heavy braking.
- Rapid acceleration.
- High rate of lateral acceleration.
- Cornering (in a tight corner).
- Vehicle speed dropping below a minimum speed (the RPA only responds when a certain minimum speed has been reached).
- Large difference in slip (between axles or between wheel on one side of vehicle).
- Initialization not being completed in current speed range (see "Controls").
- Winter conditions.

The following operating conditions may cause a delay in the warning being given in the event of a drop in tire pressure:

- Driving with snow chains fitted.

Driving with snow chains may impair the correct function of the RPA. The system will work as normal again after the snow chains have been removed and the vehicle is driven for a few minutes. (The reset process will not need to be repeated)



**Do not perform reset (initialization) when snow chains are fitted. The reset process will be affected by the irregularities caused by the snow chains.**

## Old or Worn Tires

Only install tires with the same tread depth. Avoid fitting tires with greatly different tread depth (from approximately 2 millimeters) on one axle. The different diameters mean that the correct operation of the FTM system is no longer guaranteed.

In the following cases, the system will not emit a warning despite a drop in tire pressure being detected:

- The same amount of pressure is lost in 2 or more tires.
- Drops in tire pressures caused by diffusion and affecting all 4 tires equally.
- If a tire is damaged with a sudden loss of all pressure (tire blowout, warning is given too late).

---

## System Reset

The FTM system is reset using the following control elements depending upon vehicle and optional equipment:

- FTM button (all early vehicles w/o CCC or E9X).
- On-board computer button on turn-signal/main-beam switch (E90/91/E92 w/o CCC).
- With iDrive in the Central Information Display (CID) with the controller (all with CCC/NAV).



**It is important to always perform a system reset immediately after correcting the tire pressure, especially if a tire is changed or the wheels are interchanged. Only check tire pressures when the tires are cold.**

Set the tires to the correct pressure before performing Initialization. During Initialization, the set tire pressure is taken as the initial value for the current set of wheels.

Correct the tire pressures when the tires are cold to prevent the data recorded from being affected by temperature.



**The maintenance of tire pressure is the responsibility of the driver.**

Check tire pressures regularly, at least twice a month and before embarking on lengthy journeys. During reset, the set tire pressure is taken as the initial value for the current set of tires.

The FTM should be reset during the following scenarios:

- If tire pressure is changed (tire pressure is corrected or reset).
- If the position of the tires is changed (change of axles, wheels), even if the tire pressure is not changed.
- If a tire is changed or the wheels are interchanged (e.g. old tires for new tires, summer tires for winter tires, etc.).

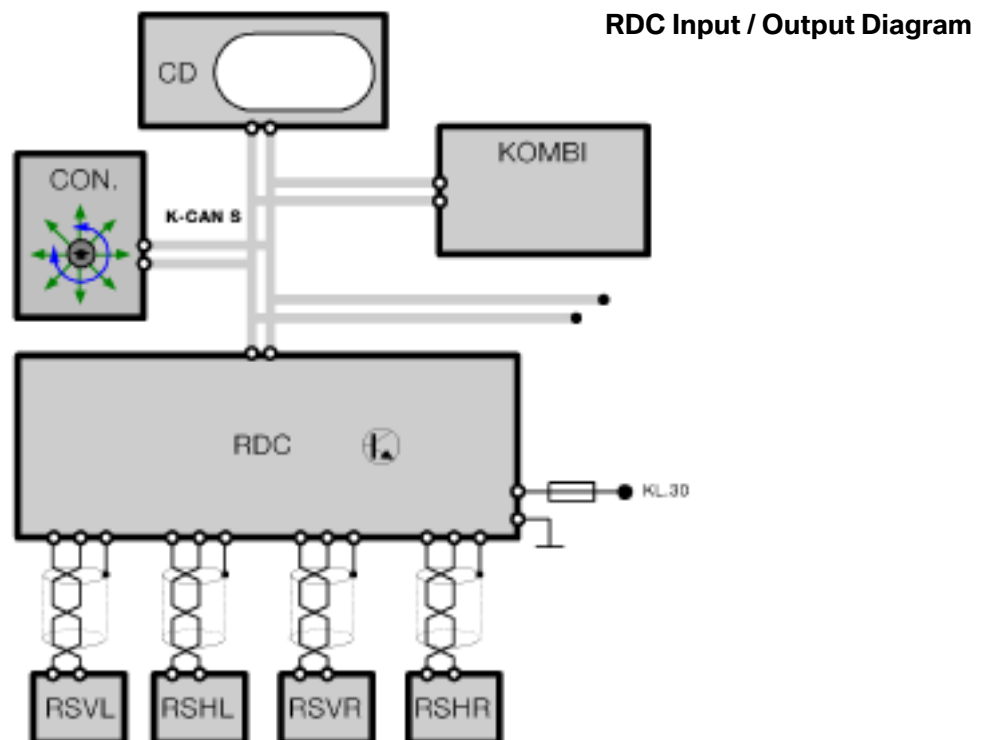


## TPM Systems (up to 2003 production)

TPM systems are “direct” systems which monitor actual tire pressure. The first BMW to use the “direct” system was the early production E65/E66. The system was then referred to as Tire Pressure Control or RDC. The E46 also received an optional version of the RDC type system which was available up to 8/03 production.

The system is capable of monitoring actual tire pressure when the vehicle is stationary or when being driven. There are transmitters which are part of the valve stem assembly. These transmitters send signals to the RDC control unit via antennas mounted in the wheel well area.

When the system detects pressure loss, the driver is warned via a Check Control message and an acoustic warning (gong).



The TPM system on these pages were installed on the E65/E66 and E46 vehicles as options until 2003 production. The newer (NHTSA mandated) TPM systems from 3/2006 are covered on pages 32 through 47.

## TPM System Components

Components of the TPM system differ from the FTM systems. These components include:

- RDC Control Unit
- Receiving Antennas
- Wheel Transmitter Module
- Warning Indicator Lamp
- Control Display (E6X vehicles)

### RDC Control Unit

The RDC control unit is located behind the glove box on both the E65/E66 and the E46. The control unit is connected to the K-CAN bus on the E65/E66 and the K-Bus on the E46.

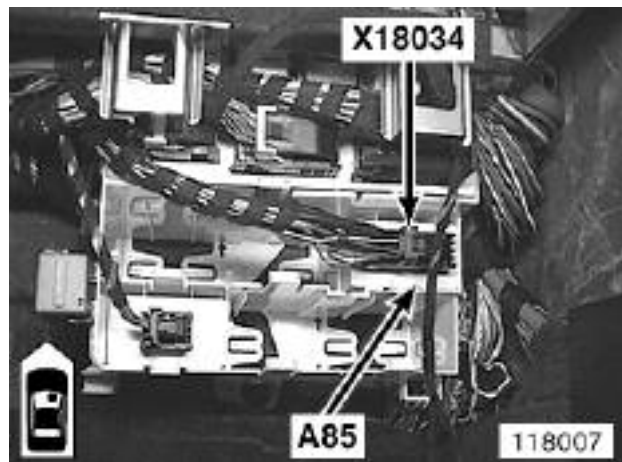
The RDC control unit receives input signals from the 4 antennas and monitors the signals for individual pressure and temperature information.

If the inflation pressure of one of the tires (including the spare) falls below the predetermined threshold, the RDC generates a CC warning telegram on the K-CAN (or K-bus on E46).

The RDC module is designed to operate on a specific operating frequency. It must be matched to the frequency of the 4 antennas. The systems will operate on two possible frequencies - 315 MHz and 433 Mhz.

The label on the RDC module contains information about the operating frequency. All components including the RDC module, antennas (4) and the 4 wheel transmitter modules must have the same frequency rating in order for the system to operate properly.

Operating Frequency



RDC Module Location on E46

---

## Receiving Antennas

The system uses 4 antennas located in each of the 4 wheel well areas behind the splash trim. The purpose of the four antennas is to receive the signals from the wheel mounted transmitters and transfer this information to the RDC control unit.

There are two possible types of antennas used. The 433 Mhz antenna which is black (dark gray) in color and the 315 Mhz antenna which is light gray in color.



**Antenna Location in Wheel Well**

**433 Mhz Antenna**



**315 Mhz Antenna**



---

## Wheel Transmitter Modules

The wheel transmitter modules are located inside the tire and attached to the valve stem. The modules contain sensors which monitor pressure as well as temperature. There is also a 3.6 volt, long-life lithium battery which is used to power up the sensor electronics as the internal transmitter circuitry.

The transmitter modules are active in an energy saving mode even when they are sitting as spare parts on the shelf.

Each transmitter module has its own unique ID code. The ID code is assigned to a position on the vehicle (LR,RR etc.) after a successful initialization has been completed.

The radio signal transmitted by the wheel modules is received when the tire passes close to the antenna. The transmitter module measures internal tire air pressure every minute. If the air pressure increases by 0.5 bar between measurements, the transmission rate increases to every 0.8 seconds.

If the increase in air pressure is detected for approximately 216 seconds, the complete functionality of the transmitter is activated. If the higher pressure continues, the module remains permanently active and measures the air pressure and temperature every 0.3 seconds and transmits the information by radio signal every 55 seconds.

At temperatures over 120 degrees Celsius, the transmitter modules are switched off. Once the transmitter module cools below 100 degrees Celsius, operation resumes.

The wheel electronics modules must match the frequency of the antenna and RDC module. If any of these system components are mis-matched, the system will not function correctly.



**The valve stem of the spare tire should be pointed to the right rear wheel well. The spare tire is monitored by the RDC module, but not displayed on the screen of the control display. Also, special care should be taking when mounting and dismounting tires from the rims. Damage to the wheel electronics could occur.**


## TPM System Operation

During monitoring, the RDC control module takes the measured temperature and pressure readings to determine a target pressure value.

If the tire being monitored falls below the required level by 0.2 bar for more than 8 minutes, a Check Control Message appears in the instrument cluster after the car is started. The driver is prompted to check tire pressure.

### Autumn Warning


If the tire temperature is 20 degrees Celsius lower for 14 days than the previously measured temperature during the last initialization, the RDC system will also prompt the driver to check tire pressures.

Check Control Message displayed in the Cluster	Message displayed in Control Display
<p style="text-align: center;">Check tire pressures!</p> 	<p>“Check tire pressure!” Check tire inflation pressure; refer to owner’s manual or inflation chart.</p>

When the RDC menu on the control display is activated, the car is shown with the tires highlighted in yellow. The tire pressures must be adjusted and an initialization carried out.

### Tire Failure Warning

After the temperature calculation, if the monitored tire falls below the specified pressure of 0.4 bar, a CC message will appear on the instrument cluster with an audible warning tone. These warnings will also be set if the monitored tire pressure falls by more than 16%. A corresponding CC message will also be shown on the Control Display.

Check Control Message displayed in the Cluster	Message displayed in Control Display
<p style="text-align: center;">Flat tire! Stop vehicle carefully.</p> 	<p>Left front tire is flat, refer to owner’s manual or contact BMW roadside assistance.</p>

When the RDC menu on the control display is activated, the car is shown with the defective tire in red. In the case of a spare tire failure, all of the tires are shown in red.

Once the tire pressures are restored to the setpoint in the RDC control unit, the tires will return to green in the control display. The CC message is also withdrawn.

## System Reset

After the tires are replaced, rotated or if their inflation pressures are adjusted, then the wheel transmitter modules must be initialized (reset) using the RDC function in the “Settings” menu of the Control Display.

During initialization the following processes are performed:

- Individual wheel recognition (Identification of wheel transmitter modules).
- Wheel position assignment.
- Plausibility check (setpoint pressures checked).
- Adoption of setpoint pressures as specified pressures.

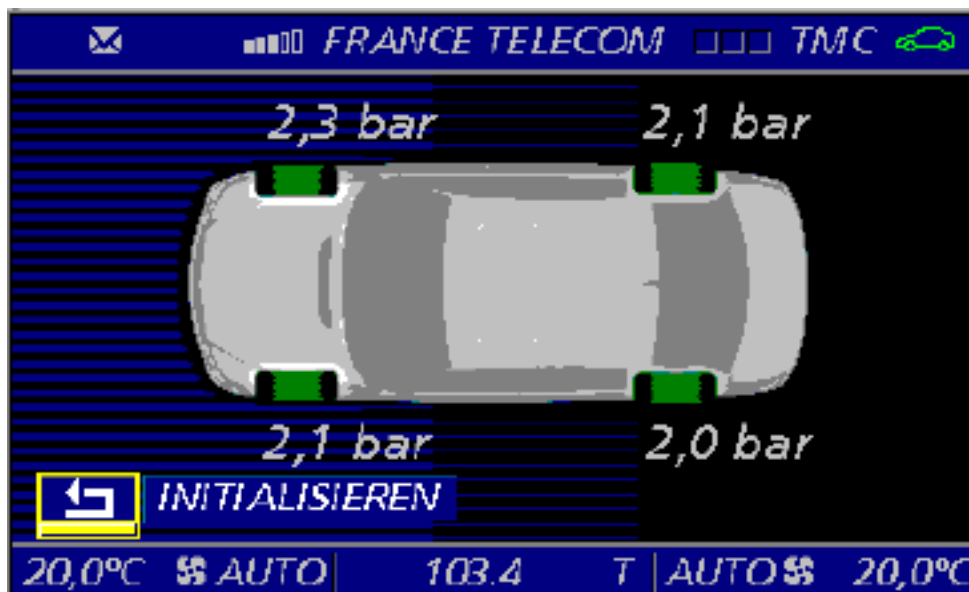
The RDC (TPM) system then learns the wheel transmitter module position.

The minimum air pressure accepted by the TPM system on during reset is 1.7 bar (or 24.7psi). If the tire pressures deviate more than 0.4 bar (6 psi) per axle the reset process is rejected after a plausibility check.

1.3 bar is the lowest pressure detected by the wheel transmitter module. At that point, a tire failure warning will always be issued.

Complete reset procedure can take up to 30 minutes. Only the actual driving time over 6 km/h is taken into account. During initialization, the CC message “Initializing RDC” is displayed on the Instrument Cluster.

When the initialization from the Control Display is activated, the wheels appear black and the pressures are not shown. Once initialization is complete, the tires of the car on the graphic turn green and pressure values are shown for each tire.



## TPM Systems (from 9/05)

As per the TREAD act guidelines, future tire pressure monitoring systems on BMW vehicles will be of the “direct” type. However, there will be some design changes from the first generation “direct” systems. This new system can also be referred to as the “trigger” type system. This is due to the use of trigger transmitter modules which will be explained in more detail later in this section.

The first models to receive the new systems will be the 5, 6 and 7 series from March of 2006. The X3 will also have the new TPM system from March. The 3 series (E90,91,92) as well as the M5 and M6 will be equipped with the direct system as well. The Z4 will balance out the module line in October. To be in compliance with the new NHTSA regulations, all new models produced from September of 2007 will use the new system.



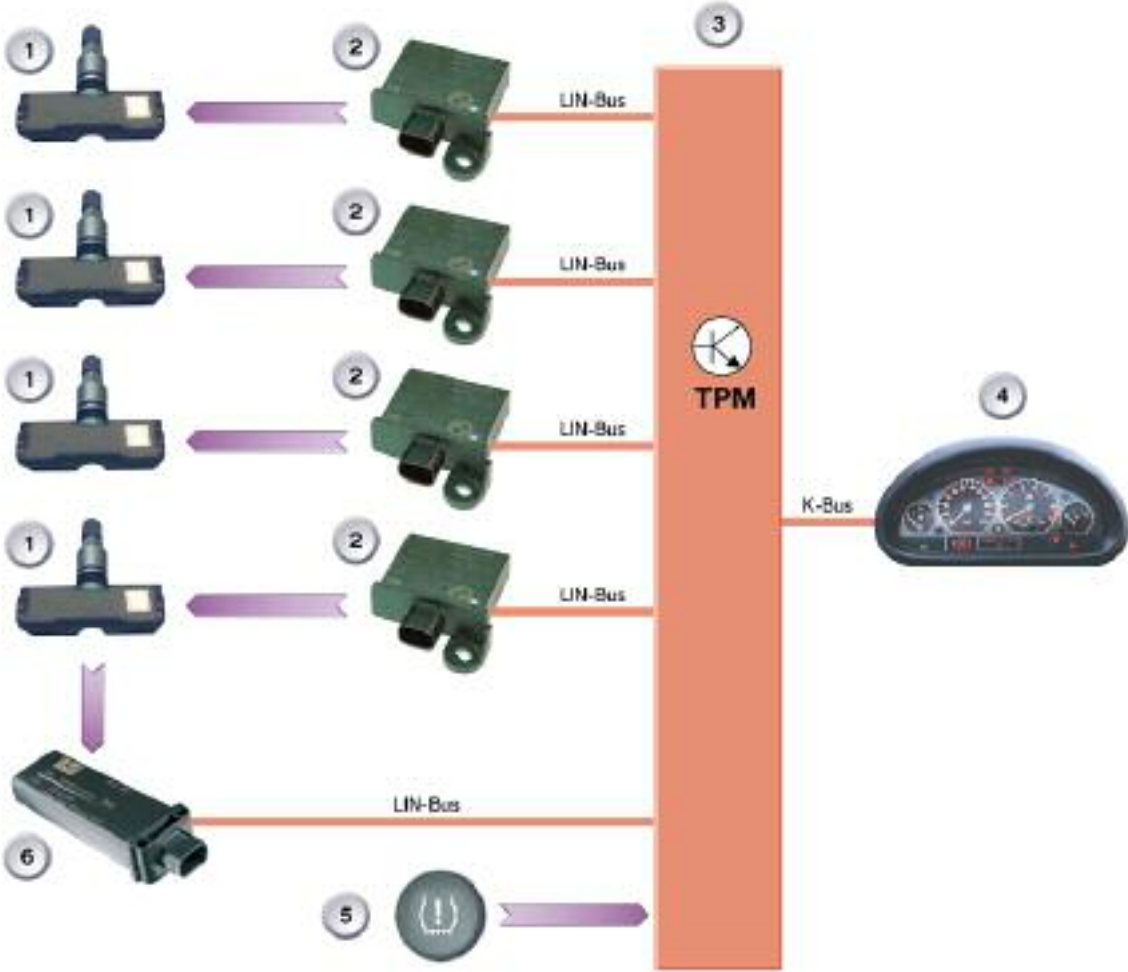
The main function of the system is to monitor the tire pressure during vehicle operation. The most important auxiliary function of the system is the option of independently detecting the wheels (vehicle's wheels) mounted on the vehicle and their position.

The control unit obtains the radio telegrams from the electronic wheel electronic modules which are controlled via the trigger transmitters. The system recognizes the vehicle's own wheels and the mounting position of the wheels by evaluating the trigger location as well as statistical evaluation of the received information. The control unit checks the individual system components.

The spare wheel is not monitored as the electronic wheel module does not transmit telegrams when stationary (except for the specified post-run phase).



# TPM System Overview



Index	Explanation
1	Wheel Electronics
2	Trigger Transmitter
3	TPM Control Module
4	Instrument Cluster Display
5	Reset (initialization) Button (or via controller with CCC)
6	Central Receiving Antenna



## TPM System Components

Components of the new TPM system differ somewhat from the early TPM system. The TPM components include:

- TPM (RDC) Control Unit
- Central (Digital) Receiving Antenna (1)
- Trigger Transmitter Modules (4)
- Wheel Electronics Modules (4 +1 for spare - optional)
- Control Display (E6X vehicles)
- Instrument Cluster



## TPM (RDC) Control Unit

The TPM control unit processes the information received from the central receiving antenna and compares to the previously learned tire pressure data. When the tire pressure deviates from the specified values, the TPM control unit sends a fault telegram which is indicated in the cluster with a corresponding message in check control.

The location of the control unit varies depending upon the vehicle application. Refer to the most current ETM for exact location.



**The new RDC (TPM) module is not compatible with earlier TPM systems made prior to March 2006.**

## Central Receiving Antenna

The central receiving antenna is a digital antenna which operates on the 433 MHz frequency. The antenna is responsible for receiving the tire pressure information from the wheel electronics modules. This information is then sent to the TPM control module via the LIN interface.

Antenna location is model dependent. The antenna is waterproof which allows external mounting, usually near the center of the vehicle. The LIN bus arrangement ensures that there is no RAF wiring inside the vehicle. This eliminates any potential interference from any other systems such as CAS/EWS communication.

The antenna contains a receiving antenna, RAF receiver, a LIN bus interface and a microprocessor for demodulating and decoding.



---

### **Trigger Transmitter Modules**

The trigger transmitter modules are located behind the inner wheel well trim. There is one transmitter at each wheel. The trigger is responsible for sending command signals to the wheel electronics modules.

The trigger transmitter communicates with the wheel electronics in the 125 KHz range. In order to communicate with the TPM (RDC) module, the trigger transmitters are connected to the LIN bus.

The trigger transmitter is supplied with B+ and ground. The third connection is for the LIN bus.



---

## Wheel Transmitter Module

The wheel transmitter modules are mounted in the tire and wheel assemblies. The module is fitted to the tire valve assembly as on past models. The module is capable of measuring the tire pressure and the temperature. Acceleration is also measured as a means of determining wheel movement for various operating modes.

The wheel transmitter module transmits information to the central antenna in the 433 MHz range. However, the module receives information and commands from the trigger modules in the 125 KHz range. Therefore, the wheel transmitter module contains the necessary electronics for these two frequency ranges.



Electronic assignment of the wheel electronic modules is not carried out until movement is detected. This is to avoid any signals from vehicles in close proximity. Especially vehicles which are equipped with similar TPM systems.

Data is transmitted to the central receiving antenna via a transmit stage in the wheel transmitter module. The module at each wheel has an individual identifier (ID) which is also transmitted every time data is transmitted. The RAF transmission takes place in the 433 MHz range.

Each electronic wheel module transmits at regular intervals (approximately 30 seconds). Also, when there is a trigger request, the measured values are sent. In addition, the tire temperature is measured at regular intervals.

When the tire pressure loss exceeds 0.2 bar, the wheel transmitter module will go into a “rapid-transmit mode” immediately. In this case, the wheel transmitter module measures and sends the information from the tire at shorter intervals.

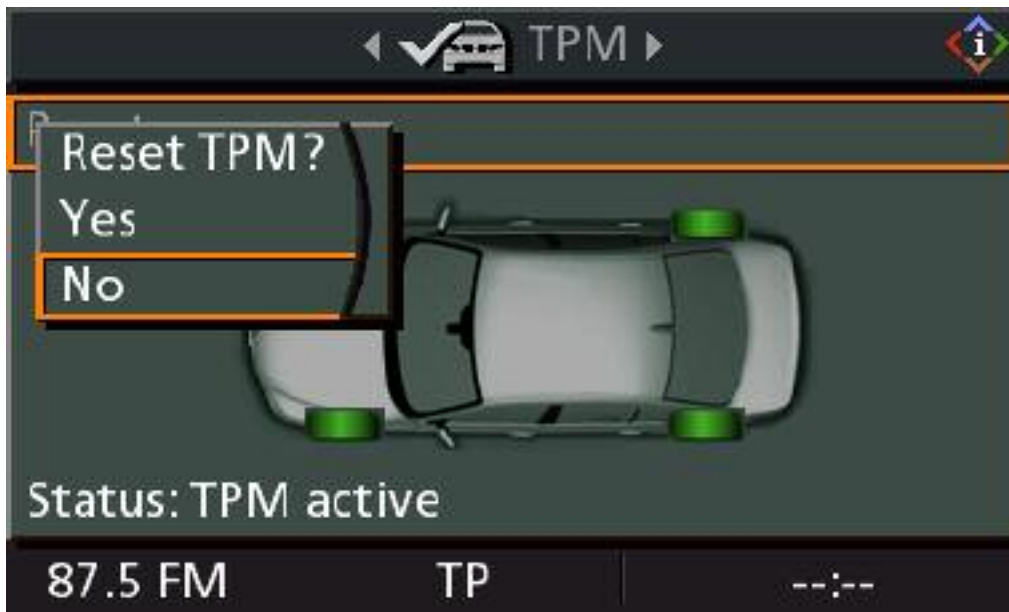
The measured data are sent from the wheel via a transmit stage in the electronic wheel module. A system with relatively few measured data transmission operations is sufficient for tire pressure monitoring if it additionally features an option for detecting fast pressure loss. The electronic module in the wheel can therefore be designed for minimum current consumption and can be battery operated.

## Control Display

On vehicle equipped with a control display, the tire status is indicated in the TPM menu. The tire pressure status is indicated by the color of the tires in the graphic. The colors are as follows:

- Green - Tire pressure is OK and matches the learned tire pressure.
- Yellow - There is a flat tire or a major drop in tire pressure has been detected.
- All wheels yellow - There is a flat tire or major tire pressure loss in several tires.
- Gray - The system cannot detect a flat tire due to a system malfunction or the system is currently in reset mode. Also, any RAF interference from other devices can cause this situation.

The system reset is also performed using the controller.

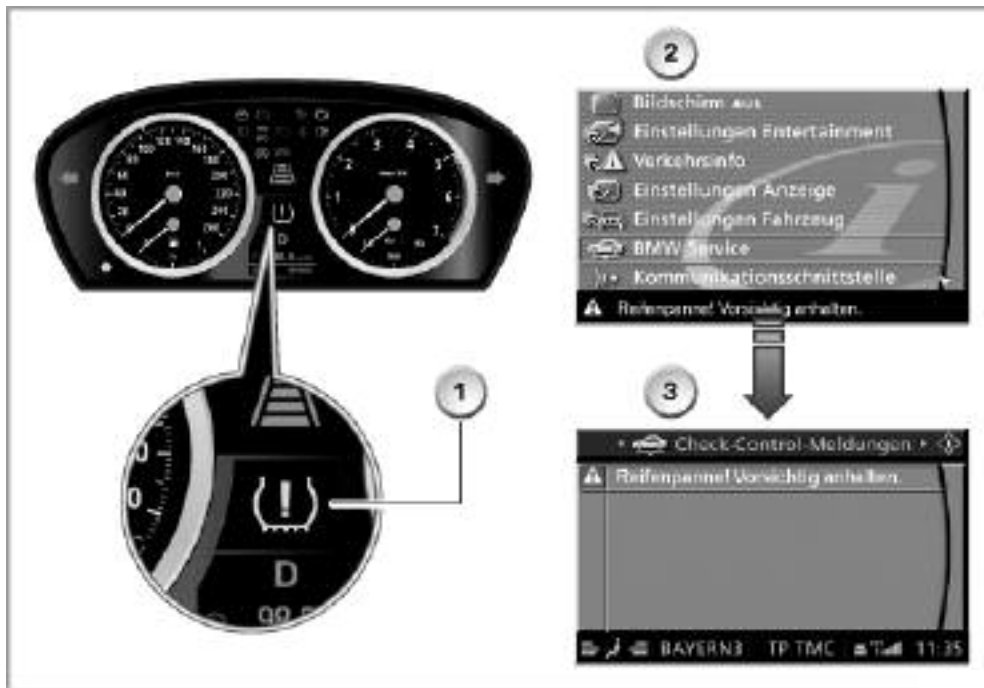


## Instrument Cluster

The TPM indicator is located in the instrument cluster. The indicator is yellow and alerts the driver to the CC message in the control display. Also, any system malfunction is indicated by a flashing yellow indicator followed by a continuous illumination.



When this occurs, the tires in the control display will be shown in gray.



Index	Explanation	Index	Explanation
1	TPM warning indicator (yellow)	3	CC Message
2	Vehicle setting menu		

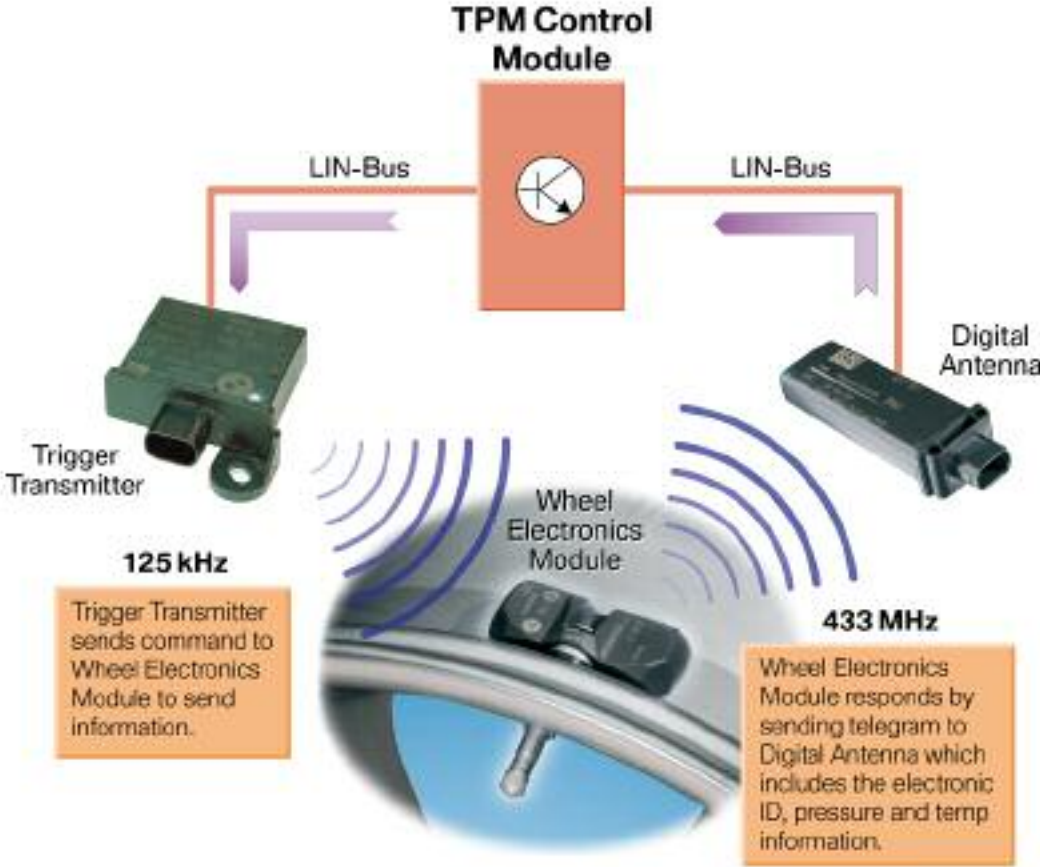
# System Operation

The primary responsibility of the new TPM system is to monitor tire pressure and warn the driver of impending flat tire situations. This new TPM system is referred to as the “trigger type” system due to the trigger transmitters installed at all four wheel well areas.

This system differs from the past “direct” systems in a few areas. There is only one centrally located digital receiving antenna. This antenna receives input from all 4 of the wheel electronics modules (5 if the vehicle has a full size spare) located in each tire and wheel assembly. The central digital receiving antenna is connected to the TPM control unit via the LIN bus.

The wheel electronics modules will transmit information when prompted by signals from the trigger transmitters. The trigger transmitters communicate to the wheel electronics over the 125 KHz frequency.

In contrast to the past wheel electronics module, the new design has the capability of bi-directional communication. In other words, the wheel electronics not only transmit information but receive information and commands from the trigger transmitter modules.



 **The wheel electronics from the previous system will not work on the new system.**

---

## **Wheel Management**

One of the important functions of the TPM system is the ability to manage wheel locations and properly report the correct wheel location. When the vehicle is NOT in motion, the system has the capability to determine where the wheel electronics are located on the vehicle. Each one of the wheel electronics module has its own unique electronic ID number which is sent to the central receiving antenna.

When an electronic wheel module receives at least 2 telegrams in response to a trigger signal, this electronic wheel module is marked as the system wheel.

The wheel position assignment of an wheel electronics module is also based on the response to the trigger signal. Once the assignment has been determined, the positions are stored in a non-volatile memory (NVRAM).

Based on the information of the acceleration sensor in the electronic wheel module, a distinction is made between the spare wheel and the remaining road wheels in the road wheel detection module for the purpose of assisting wheel position assignment.

In order to avoid any signal conflict from adjacent vehicles (with similar TPM systems), the "learning" procedure is performed only while the vehicle is driving.

The wheel management function uses a "confirmation phase" to establish whether the previous wheel assignment order is still correct or whether any new wheels have been installed or rotated for service. The confirmation phase is necessary so that the system can automatically detect changes in the mounted wheel order.

The check takes place during vehicle operation (while driving), in order to rule out any potential signal interference from adjacent vehicles.



# Control Display Screens

## One Tire with Reduced Pressure

The yellow indicator lamp in the instrument cluster is switched on permanently and an audible indication (gong) is additionally sounded as soon as a tire undershoots one of the previously specified warning limits. If the vehicle is equipped with the corresponding option, the test "Low Tire" is additionally shown together with the position in the cluster. If the vehicle is equipped with an control display (MMI), the affected tire is indicated in yellow. The unaffected wheels retain their green color.

The "Low Tire" status means that driving safety is no longer ensured. The driver is requested to stop and check the condition of the tire. It is the responsibility of the driver to decide whether he can continue the journey at low speed to the next repair workshop or whether an on-site repair is necessary.



**Several Tires with Reduced Pressure**

The yellow indicator lamp in the cluster is immediately switched on permanently and an audible indication (gong) additionally sounds as soon as several tires undershoot the previously specified warning limits. If the vehicle is equipped with the corresponding option the text "Low Tire" is additionally indicated without the position in the instrument cluster. All wheels are now shown in yellow in the MMI.

If a warning is already in effect, on the occurrence of the second warning event, a position-specific warning is replaced by the nonspecific warning. Each tire failure event is signalled audibly.



---

## Workshop Hints

### System Reset (Initialization)

The TPM system should be reset whenever any changes are made to the tire and wheel assemblies. For example, if a tire is replaced or if the tires are rotated for service. Also, the system should be reset whenever any repairs are made to the TPM system.

The driver of the vehicle is solely responsible for maintaining the correct tire pressure when in use. As per BMW recommendations, the tire pressure should be checked 2 times per month.

Before system reset (initialization), the technician (or driver) should set the tire pressure to the specified pressure (as dictated by the tire pressure placard in the b-pillar). These pressures are a cold specification and should be set as such.

Depending on the vehicle, the system reset can be carried out via a button or via the controller (on vehicles with a control display i.e 5, 6 and 7 series).



Once the reset mode is initiated, the vehicle must be driven in order to complete the process. This is to ensure that there is no RAF interference or erroneous signals from other vehicles which use similar TPM system components.

During this period, the control display will show the message “Status: Resetting TPM”. The tires on the control display will be gray in color until the process is complete. This should take only a few minutes.

When the reset is complete, the yellow TPM indicator will go out. The tire pressure and temperature values are stored in conjunction with the ID of the wheel electronics. Therefore, the wheel position is stored in the TPM control unit.



In order for the reset procedure to be completed, the tires must be at the minimum allowable pressure which is approximately 1.4 bar (20 psi) to 1.6 bar (23 psi). If the tire pressure is too low, the system will not complete the reset procedure. When complete, the control display will switch to “Status” TPM active” and the tires will switch to green.



**New target pressures are adopted solely by way of Initialization. If a wheel is exchanged and the system is not re-initialized, the newly mounted wheels will be “taught-in” and monitored to the previous target pressures.**

---

## Reset Procedure

The reset procedure is performed with KL15 ON. The engine can be OFF or ON, but do not drive off. Depending on the vehicle, the FTM is reset as follows:

### ■ Vehicles with RPA Button

Press and hold the RPA button until the RPA indicator and warning light lights up yellow for a few seconds. Then drive the vehicle through various speed ranges for at least 15 minutes.

### ■ Vehicles with BC Button (on-board computer function)

In the on-board computer function select "RPA" and "INIT" (LC display) with the rocker switch on the turn-signal/main-beam switch. Press the BC button to confirm.

Press and hold the BC button for approximately 5 seconds, until a box with a tick appears behind the "INIT" display. Then drive the vehicle through various speed ranges for at least 15 minutes.

### ■ Vehicles with Central Information Display

Initialization is performed via the Central Information Display (CID) and controller.

- Select "RPA/FTM" in the "Settings" menu and confirm.
- Select "Set" and confirm.
- Then drive the vehicle through various speed ranges for at least 15 minutes. The end of the Initialization phase is not indicated.

## Preconditions for Activation

The flat tire indicator is automatically activated when terminal 15 is switched ON. The FTM cannot be switched off manually.

## Flat Tire Indication

A flat tire is indicated as follows:

- E53, E83, E85 - Yellow FTM indicator and warning light without acoustic signal.
- E60, E61, E63, E64, E65, E66, E90, E91 - Yellow FTM indicator and warning light with acoustic signal.

An FTM system failure is indicated by a yellow FTM indicator and warning light without an acoustic signal.

## TPM Systems (from 3/11)

The latest generation of BMW tire pressure monitoring systems was introduced to the US market with the launch of the F25 and it is installed on all our current vehicles.

### Operating Principle

The direct measuring system consists of the TPM control unit with integrated reception antenna and four wheel electronics. It was possible to reduce the number of components and cost of the system by integrating the reception antenna in the TPM control unit.

The four wheel electronics transmit the tire pressure and temperature to the TPM control unit via radio communication (433 MHz). Once the wheel electronics have been woken up, (vehicle speed > 20 km/h/12mph), a total of 25 telegrams are transmitted once at two second intervals. Providing the pressure has not dropped, individual telegrams are then sent every 18 seconds from the wheel electronics to the TPM control unit. As a prerequisite for the wheel electronics to go to sleep, the wheel must be at a standstill for more than five minutes.

### Resetting the Tire Pressure Values

The tire pressure values are reset via the instrument panel or Central Information Display CID. The TPM text message appears, or the permanent TPM indicator light lights up, in the instrument panel when the teach-in process starts.

### Teach-in Process

During the teach-in process, the wheel electronics identification numbers (ID) are transmitted to the TPM control unit. The TPM control unit can identify the wheel position of the corresponding wheel electronics via the identification numbers once the teach-in process is complete.

Two acceleration sensors are installed in each of the wheel electronics in order to be able to determine their positions. The acceleration sensors determine the wheel's direction of rotation. This means that right/left differentiation of the wheel electronics positions at the vehicle is possible.

The high frequency signals received are evaluated in order to determine whether the wheel electronics are at the front or rear axle. The TPM control unit with integrated receiver is mounted in the outer area of the luggage compartment well above the rear axle. The level of the signals received by the TPM control unit from the wheels on the rear axle is higher than the level of signals sent by the wheel electronics on the front axle. This means it is possible to determine whether the wheel electronics are at the front or rear of the vehicle.

---

The entire teach-in process takes between roughly one and twelve minutes at the most. The following factors influence the duration:

- The current mode of the wheel electronics (awake/gone to sleep).
- The condition of the road (e.g. cobbles.)
- The TPM control unit already knows what the IDs of the wheel electronics are.



**F25 TPM, Teach-in Process Complete**

Once the teach-in process is complete, the TPM text message or solid TPM indicator light are cancelled. The green tire symbols subsequently appear in the CID.



**F25 TPM Pressure Drop**

Once the teach-in process is complete, the wheel electronics send the pressure, temperature and also the identification numbers of the tires to the TPM control unit at regular intervals when driving.

If a pressure change of > 20 kPa (0.2 bar, 2.9 psi) is identified within two successive pressure measurements, the wheel electronics for the relevant wheel immediately assumes a fast transmitting mode. It then sends information to the control unit at one-second intervals. If the pressure drop is higher than 25%, the TPM text message "Tire Low" appears.

**F25 System Overview of TPMS**



Index	Explanation
1	Wheel electronics (battery-operated sensor with transmitter unit 433MHz)
2	Instrument panel (KOMBI)
3	Control unit with integrated reception antenna



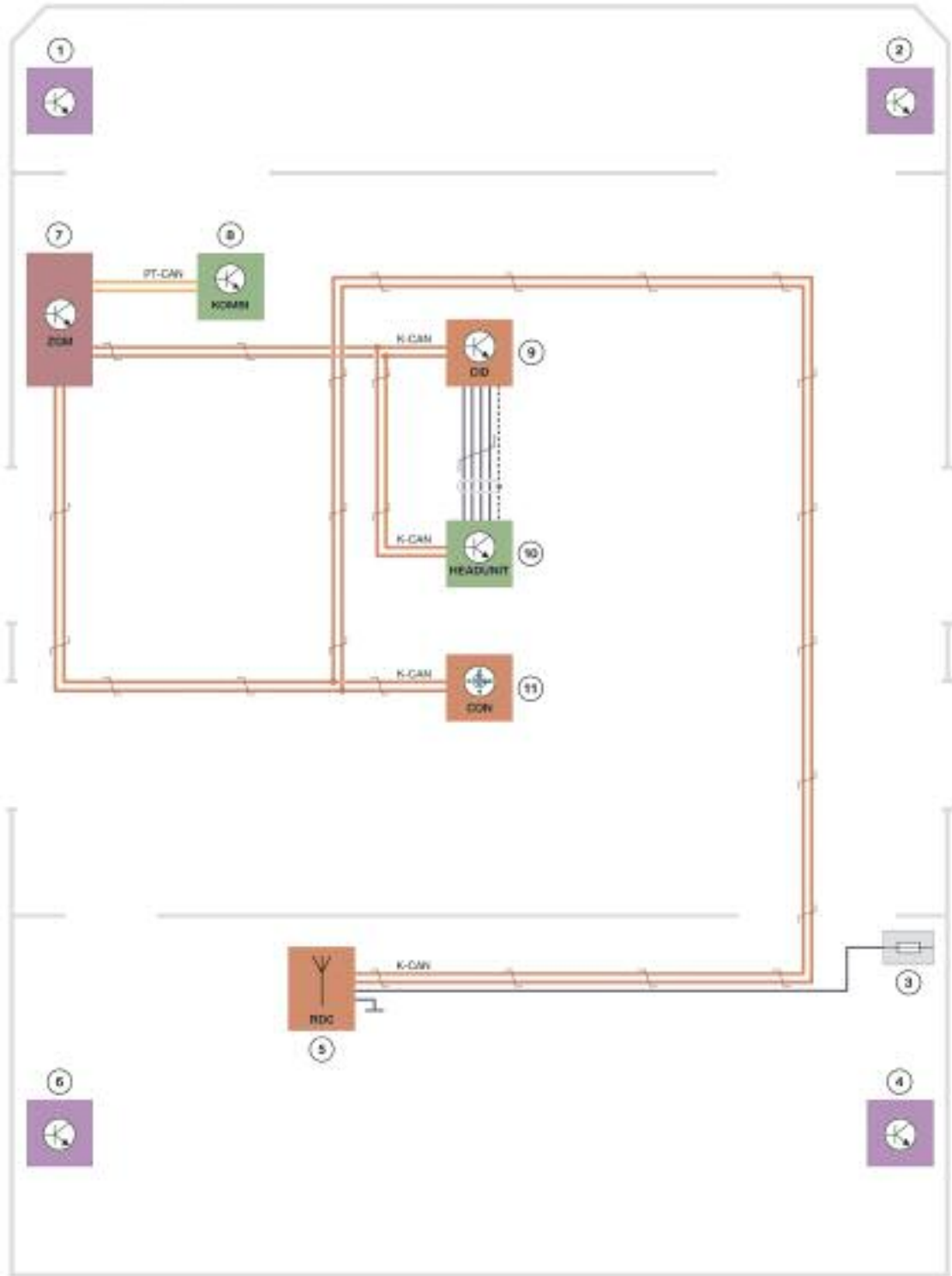
## F25 Wheel Electronics, TPM

Index	Explanation
1	Data Matrix Code
2	BMW part number
3	FCC ID = approval for wireless operation
4	Wheel electronics ID
5	Transmission frequency (433MHz)
6	Pressure sensor
7	Production date of wheel electronics
8	Tightening torque
9	Width across flats of union nut



NOTES

**F25 System Wiring Diagram, TPMS**



Index	Explanation
1	Wheel electronics, front left
2	Wheel electronics, front right
3	Power distribution box, luggage compartment
4	Wheel electronics, rear right
5	Tire pressure monitoring control (TPM)
6	Wheel electronics, rear left
7	Central gateway module ZGM
8	Instrument panel (KOMBI)
9	Central Information Display (CID)
10	Headunit
11	Central operating element
KI.30B	Terminal 30, time-dependent

---

## Service Information

### Teach-in Process

The wheel electronics must be taught in under the following circumstances:

- The tire pressure has been changed
- A tire has been changed
- Wheels are replaced axle-wise

The driver can start the teach-in process via the Central Information Display CID and the controller. For more information, refer to the vehicle Owner's manual.

### Service Life of Batteries for Wheel Electronics

The service life of the batteries installed in the wheel electronics is roughly 7.5 years. The current value of the service life counter in the batteries of the wheel electronics can be read out via the diagnosis system.

If the battery is fully discharged or defective, an TPM fault message is displayed.

### Remove / Install Wheel Electronics

The following points must be observed when removing/installing the wheel electronics of the tire pressure control (TPM):

- Do not use high pressure cleaners to clean wheel rim with the wheel electronics installed when the tire has been removed.
- Replace the wheel electronics if tire sealant has been used.
- Clean the valve and valve seat thoroughly before installing the wheel electronics.
- Do not apply solvents or cleaning agents to the wheel electronics, or clean them with compressed air.
- To clean the wheel electronics, simply wipe down with a clean cloth.

# Runflat Tire Technology

Run Flat Tire (RFT) technology has been in development by the tire industry for many years. An RFT tire allows the driver to continue safely in the event of a tire puncture or complete loss of tire pressure. The sidewalls on an RFT tire are specially reinforced to support the vehicle with zero air pressure.

The RFT tire design maximizes safety and allows the driver to maintain vehicle control in the event of sudden or slow air pressure loss. This also eliminates the need for the driver to change tires in unsafe situations. Therefore, the spare tire and jacking equipment can be deleted from some vehicles.

The first U.S. model BMW to be equipped with RFT technology was the E52 (Z8). The Z4, which has standard RFT, takes advantage of the reduced space requirement. Many current model BMW vehicles have standard RFT or they are available as an option.

## RFT Operation

If a slow or sudden pressure loss occurs in a RFT, mobility is maintained due to the additional high temperature rubber reinforcements that strengthen the sidewall.

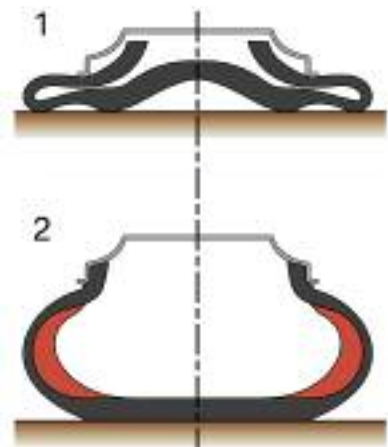
These reinforcements prevent sidewall damage when the tire is deflated and also provide support during extreme loads. In addition, the special wheel for the RFT tires “grips” the tire to maintain sufficient steering, braking and accelerating power.

## RFT Design

In the illustration to the right shows a comparison between a standard tire and one equipped with RFT self-supporting technology.

Both tires have zero pressure. The non-RFT design (1) shows that the sidewalls will be completely collapsed providing no support.

The RFT design (2), shows that the side walls will maintain limited support for the vehicle to allow the driver to get to a safe area for a tire replacement or repair.



## Tire Manufacturer Information

All “Runflat” tires, regardless of brand must carry a specific designation to indicate that the tire is a “Runflat” system component. Therefore, the tires will have an “RSC” icon on the sidewall.



---

Most of today's BMW models are fitted with the Run Flat System Component (RSC) package as standard equipment.

The BMW Group has put together a safety package with the aim of avoiding tire-related accidents and the risk involved with changing a tire in dangerous situations (e.g. by the side of the road, at night, in wet conditions, tunnels or road construction sites).

The BMW runflat safety system:

- Warns the driver in good time of imminent tire pressure loss so that countermeasures can be taken
- Allows the journey to be continued for a defined distance even in the event of complete loss of tire pressure
- Keeps the tire safely on the rim even in the event of sudden tire pressure loss at high speed.

The system consists of the RSC tires, rims with EH2+ contour and the electronic tire pressure monitoring system (TPMS).

These "self-supporting tires" incorporate reinforced side walls, additional strip inserts and heat-resistant rubber compounds. This design makes it possible to continue the journey (even when completely depressurized) for a limited distance at a maximum speed of 50 mph.

When driving with a run flat tire with no pressure, the standard VDC automatically distributes the vehicle weight over the remaining wheels so as to relieve the load on the depressurized tire with the aim of achieving the highest possible range for continued operation.



**Refer to the owners manual for the maximum driving range after puncture or deflation occurs. ABS, ASC and DSC remain fully operational even in the event of complete tire pressure loss.**



**Due to the characteristics of the self-supporting tire design, a tire which is under inflated may not appear to be low on air pressure. Therefore, always verify actual air pressure with a tire gauge. Do not assume that the tire is properly inflated. Check the tire inflation placard in the driver's side door jamb area for correct inflation pressures.**

The chart below is a breakdown of the various internal designations from the individual tire manufacturers:

Tire Manufacturer	Abbreviation/Acronym	Definition
Bridgestone	RFT	<b>R</b> un <b>F</b> lat <b>T</b> ire
Continental	SSR	<b>S</b> elf <b>S</b> upporting <b>R</b> unflat
Dunlop	DSST	<b>D</b> unlop <b>S</b> elf <b>S</b> upporting <b>T</b> echnology
Goodyear	EMT	<b>E</b> xtended <b>M</b> obility <b>T</b> echnology
Michelin	ZP	<b>Z</b> ero <b>P</b> ressure
Pirelli	PTM	<b>P</b> irelli <b>T</b> otal <b>M</b> obility

## Wheel Construction

The wheel design must be compatible with the RFT system. A self-supporting tire must be capable of gripping the rim to keep the tire beads intact. The wheels used must be of the “double-hump” design.

The “double-hump” design features 2 raised areas on the rim to help retain the tire bead.

These are referred to as EH2 wheels as opposed to the previous “H2” wheels. Standard H2 wheels will accept RFT designed tires but may not retain the tire properly in the event of a failure. This would render the safety features of the RFT system useless.



**When the Runflat tire is at zero pressure. The vehicle can be driven up to 100 miles at a maximum speed of 50 miles per hour. Always refer to the vehicle Owner’s Manual for specific guidelines.**



“EH2” Wheel

## Basic Tire Balancing

Every BMW vehicle is well known for its superior handling and ride quality. So, when this ride quality is compromised by vibration, an accurate diagnosis and timely repair is the primary goal.

To improve fuel economy and reduce emissions, many of the vehicle components have been weight optimized. Some of these weight reduction techniques involve suspension components such as strut housings and control arms. These components are now made from aluminum rather than steel or cast iron. The aluminum components work well for reducing weight, but they do not have the same dampening properties as the iron or steel components.

Therefore, procedures such as wheel balancing have become much more important in recent years. The GSP97BMW wheel balancer features “Road Force Measurement” technology which allows the tire and wheel assembly to be measured while “loaded”. This allows “radial force” variations to be measured and corrected.

This training module is designed to help the technicians understand the potential causes of vehicle vibration as well as the best methods to correct these concerns.



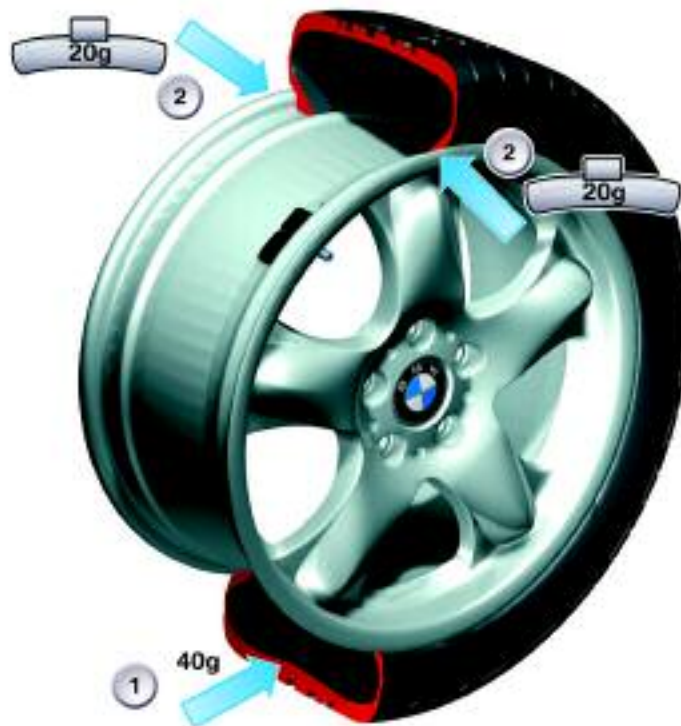


## Static Imbalance

“Static Imbalance”, as the name implies, indicates that the tire and wheel assembly is in a state of imbalance when standing still. Therefore, there is a “heavy spot” which would cause the tire to come to rest in the same position. Many years ago, tires were balanced using a “bubble balancer” and weight was added to restore the tire to a “statically balanced” condition.

When a tire and wheel assembly is statically imbalanced, the tire and wheel assembly will tend to travel in an “up and down” motion. This causes the tire and wheel to “bounce” on the pavement when the vehicle is moving. In extreme cases the wheel assembly can leave the road surface. This causes a vibration which is transferred to the driver via the chassis and suspension components. Also, the tire will wear and create a “cupping” pattern on the tire tread surface.

As far as balancing is concerned, static balancing procedures are no longer the accepted method for balancing tire and wheel assemblies. Static balancing can only correct for imbalances on one plane. This is only effective if the imbalance were only near the centerline.



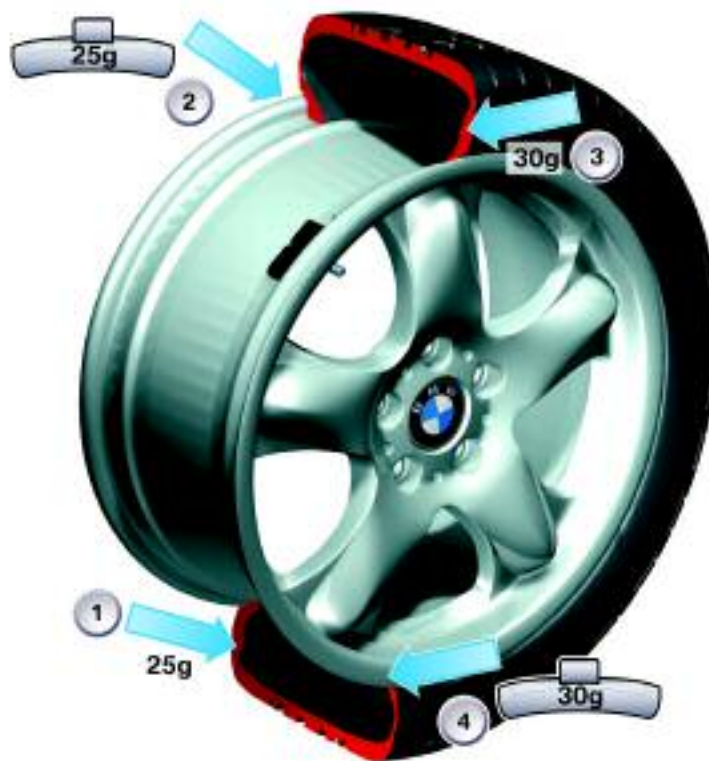
Index	Explanation	Index	Explanation
1	40 gram static imbalance	2	20gram (x2) balance weight for correction

## Dynamic Imbalance

As compared to static imbalance, dynamic imbalances pertain to situations present during vehicle movement. Also, two planes of weight correction are considered. When mass (weight) is unevenly distributed across two planes, the resulting force tends to cause the tire and wheel assembly to “wobble”. This motion is in a lateral direction which causes a steering wheel “shimmy”.

Aside from the obvious potential customer complaint, the “shimmy” caused by a dynamic imbalance can cause wear and tear on the tires and suspension components including wheel bearings and steering linkage.

If a wheel and tire assembly with a dynamic imbalance is installed on the front of the vehicle, the effect is usually noticed right away. When installed on the rear of the vehicle, the vibration is somewhat dampened by the rigidity of the rear axle.



Index	Explanation	Index	Explanation
1	25 gram dynamic imbalance	3	30 gram dynamic imbalance
2	25 gram balance weight for correction	4	30 gram balance weight for correction

## Residual Imbalance

For technical reasons, a tire and wheel assembly cannot be “perfectly” balanced. Therefore, there is a maximum allowable residual imbalance which is acceptable for smooth running performance. The maximum values are as follows:

- Less than 15 grams (1/2 ounce) for residual **static** imbalance
- Less than 7.5 grams (1/4 ounce) per plane for residual **dynamic** imbalance

These values are usually the default values programmed into most wheel balancers. Depending upon the type of wheel balancing equipment used, these values can be altered (low or high). This is usually not recommended unless required due to a specific concern.

## Balance Weights

In order to correct imbalances, balance weights must be used. Today there are many types of balance weights used due to the different wheel rim styles in use. Most wheel weights are made from lead, but due to recent legislation regarding lead safety, many wheel weights available through the BMW parts system are made from zinc.



Index	Explanation
1	One-piece clip-on (hammer-on) balance weight
2	Clip (clamp)
3	2-piece wheel weight for use with above clip (#2)
4	Adhesive Weight
5	Adhesive Weight

When installing wheel weights, be aware that there are various mounting procedures for different weights. Do not try to install incorrect wheel weights, cosmetic damage to the wheel may occur. Also, the weights may come loose and cause an unnecessary return visit.

For example, wheels which have a smooth rim flange should only use adhesive weights. Depending on the rim style and offset, the adhesive weights can be installed on the inner and/or outer area of the rim.

Clip on weights can only be used on steel wheels or aluminum wheels which have the necessary flange configuration. Two-piece weights need to be installed with a special tool to prevent rim damage.

### ■ Weight Conversion

Wheel weights available from BMW are marked in grams and range in size from 5 to 60 grams. For the purposes of weight conversion, 1000 grams is equal to 2.2 pounds (or approximately 35 ounces). The chart below represents some conversion values.

Weight in Grams	Actual Weight Conversion (decimal ounces)	Comparable Wheel Weight Fractional Ounces (rounded off)
5 grams	0.176 ounces	1/4 ounce
7.5 grams	0.2645 ounces	1/4 ounce
10 grams	0.3527 ounces	1/4 ounce
12.5 grams	0.4409 ounces	1/2 ounce
15 grams	0.5291 ounces	1/2 ounce
17.5 grams	0.6172 ounces	1/2 ounce
20 grams	0.7054 ounces	3/4 ounce
22.5 grams	0.7936 ounces	3/4 ounce
25.0 grams	0.8818 ounces	3/4 ounce
27.5 grams	0.970 ounces	1 ounce
30 grams	1.058 ounces	1 ounce
32.5 grams	1.146 ounces	1 ounce
35 grams	1.234 ounces	1 1/4 ounce
40 grams	1.410 ounces	1 1/2 ounce
45 grams	1.587 ounces	1 1/2 ounce
50 grams	1.763 ounces	1 3/4 ounce
55 grams	1.940 ounces	2 ounces
60 grams	2.116 ounces	2 ounces

## Runout

Another method for checking tire and wheel irregularities is by checking runout. Runout is an indication of an out-of-round condition or a variation in the projected movement of an object.

Runout can be checked using a dial indicator or the GSP97BMW Road Force Wheel Balancer. As far as wheel and tire assemblies are concerned, radial and lateral runout can be checked on the wheel and tire individually or as an assembly.

In order for the tire and wheel assembly to be optimized for smooth running, it is very important that the wheel (rim) is within specification. Once the tire is mounted to the rim, the tire will conform to the shape of the wheel. In other words, if the wheel is “egg-shaped”, then the tire will be egg-shaped.

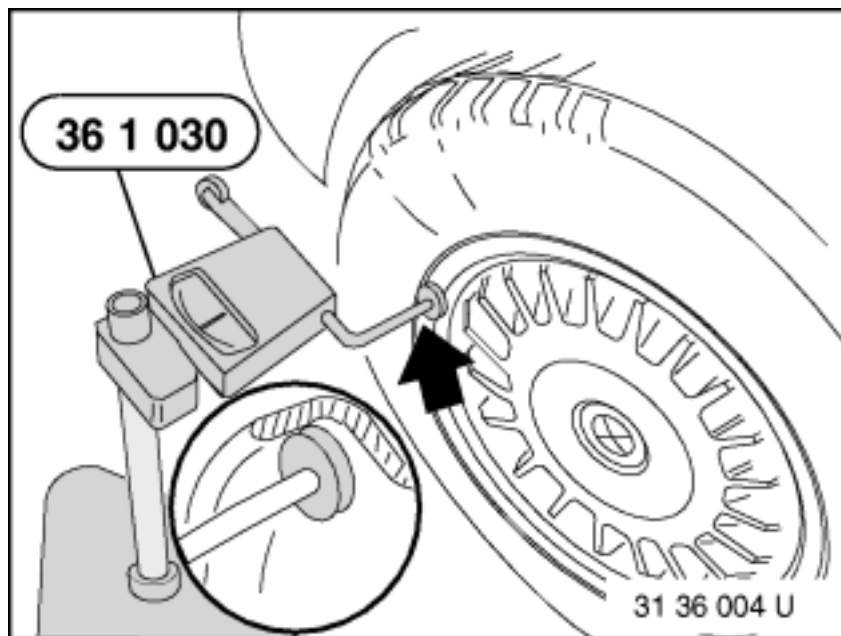
The wheel can be checked for lateral and radial runout using a dial-indicator.

### Wheel Runout

When checking for radial runout on a wheel rim, the maximum specification is 1.1 mm for one-piece aluminum wheels. The radial runout should be checked on both bead seating areas. The most accurate method for checking radial runout on a wheel is to dismount the tire. However, if the wheel has a sufficient flange area, the radial runout can be measured as shown below.



**Always check the runout specifications in WebTIS or ISTA for the most accurate specification.**

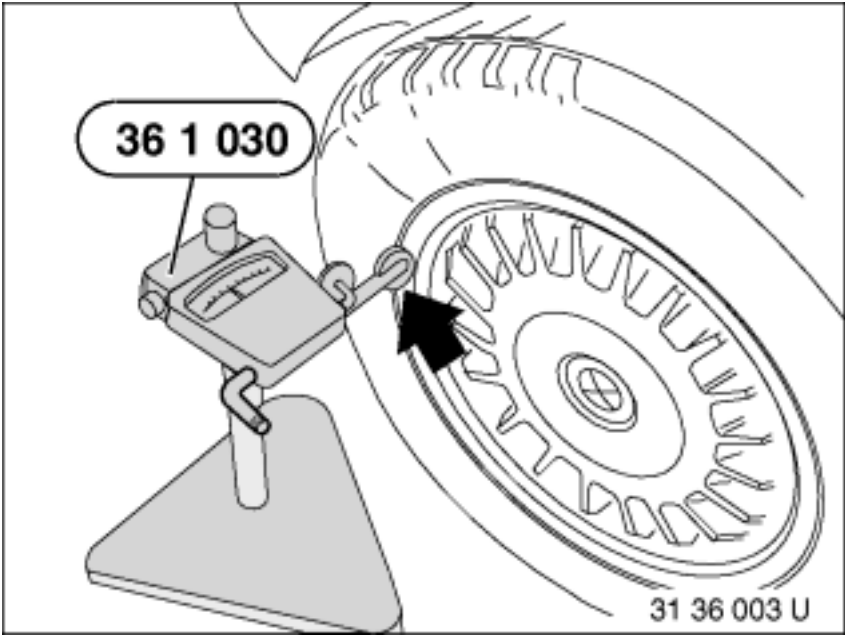


---

Excessive radial runout can caused conditions similar to a static imbalance. Radial force variations are also affected.

**Lateral Runout (Rim)**

The maximum lateral (axial) runout on a one-piece aluminum wheel is 1.3 mm. This can also be checked using a dial indicator as shown below. Refer to Technical Data and Repair Instructions in Group 36 for more information on checking wheel and tire runout.



---

## Tire Runout

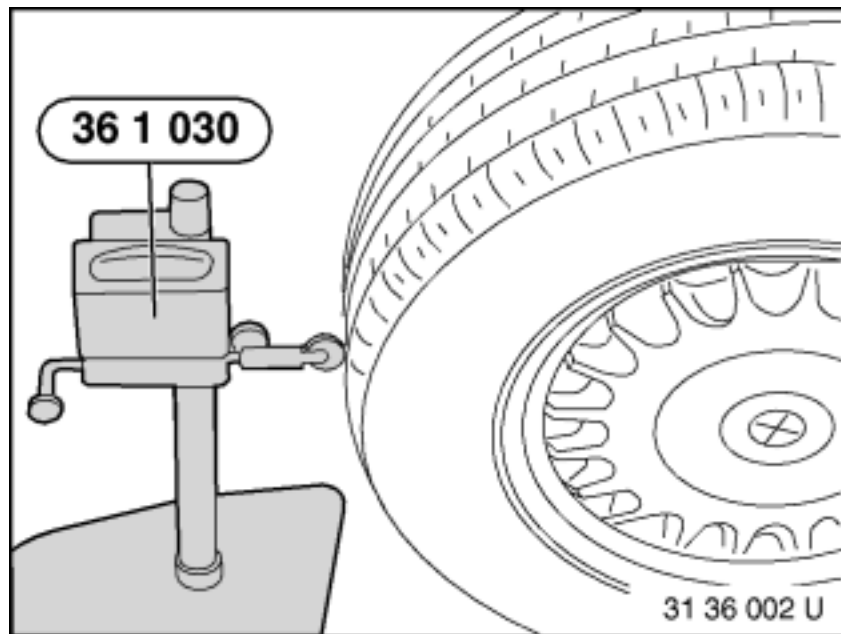
Once the tire has been mounted to the wheel, tire runout can be checked radially and laterally (axially). This is an “unloaded” measurement which does not take into account radial force variation (or lateral force variation). Radial force variations can only be measured when the tire is loaded which is only possible using the GSP97BMW wheel balancer.

### Radial Runout (Tire)

On a tire mounted on a one-piece aluminum wheel, the maximum radial runout is 1.1mm. The tire and wheel assembly should be mounted on a “spin-type” balancer or on the vehicle. Be aware that any wheel bearing or hub irregularities may affect this measurement. Be sure the check for wheel bearing play or hub runout.



**Refer to Technical Data and Repair Instructions in Group 36 for more information on checking wheel and tire runout.**

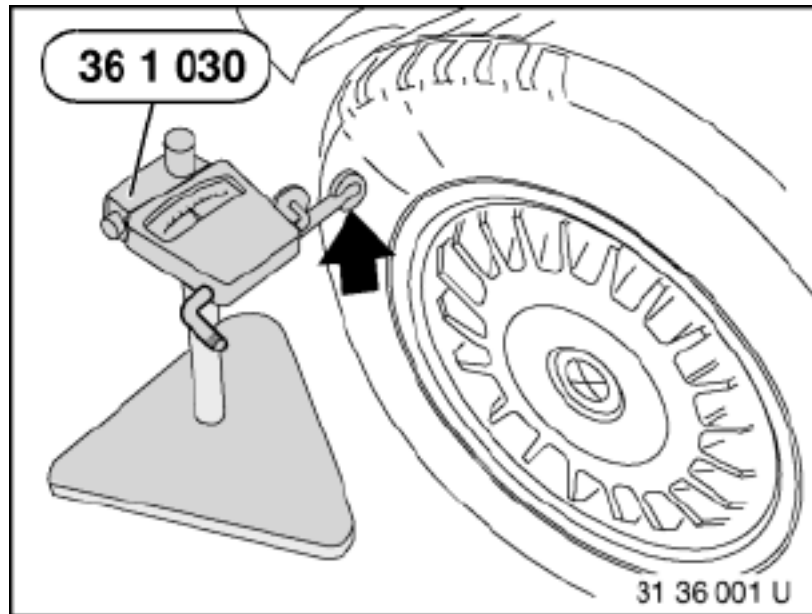


## Lateral (Axial) Runout

Lateral runout measurements are an indication of possible broken belts in the tire. Aside from possible vibration issues, excessive lateral runout can cause a pull to one side. The maximum allowable lateral (axial) runout is 1.3 mm.



**Refer to Technical Data and Repair Instructions in Group 36 for more information on checking wheel and tire runout.**



## Component Runout

In addition to tires and wheels, there are other components which can contribute to vibration issues. Wheel bearings, hub assemblies and rotors should be checked for excessive play and runout.





---

## Radial Force Variation

Radial force variations are caused by non-uniform stiffness in the tire sidewall. This variation can be best illustrated by imagining a series of springs around the circumference of the tire sidewall. If these “springs” were of equal force, the tire would roll evenly across the road surface when under load. However, if one or more of these springs were “stiffer” than the rest, the tire would not roll evenly. This would cause a noticeable vibration.



Index	Explanation	Index	Explanation
1	“Soft spots” in the tire sidewall	2	“Hard spots” in the tire sidewall

The causes of radial force fluctuation lie in the manufacturing and processing of the many different components in the tire. Components such as casing plies, belt plies and contact surfaces, etc. are combined in a tire press to make the tire blank.

Manufacturing and assembly differences arise during this process. If the differences are too large, harder and softer spots occur along the tire periphery. As a result, the tire does not flex evenly around the entire circumference.

When radial force fluctuations occur, this will have the same effect as a static imbalance. However, tire irregularities not only cause steering wheel wobble and vibrations, they also contribute to noises such as drumming, rumbling and jolting.

---

Radial force variations cannot be detected by standard wheel balancing equipment. This is due to the fact that standard wheel balancing equipment only measures the tire and wheel assembly in an “unloaded” state. When a tire and wheel assembly is dynamically balanced, this does not mean the radial force variation is within specification.



Also, checking the radial runout of the tire (when unloaded) does not give an indication of radial force fluctuations. The only method to accurately check for radial force variations is to use the GSP97BMW wheel balancer.

The GSP97BMW wheel balancer uses a load roller assembly to apply pressure to the tire and wheel assembly to simulate “on the road” conditions. The radial force variation is calculated during this process.



Lateral as well as radial force fluctuations occur. These can be traced through the sideways wobble of the wheel. Lateral means sideways. Lateral force fluctuations have less of an effect on harmonics than radial force fluctuations.

Tires which have excessive radial force variations must be replaced. However, tires which have small amounts of radial force fluctuations can be optimized by using the Hunter GSP97BMW Road Force Wheel Balancer. (This will be covered in more detail later in this training course).

---

## Vibration Diagnosis

Vibration, by definition is a recurring motion which is referenced to a central position. In the case of a tire and wheel assembly, a wheel with excessive radial runout rotates around a fixed central point (wheel bearing). If the wheel is somewhat “egg-shaped”, the tire will conform to this shape. When traveling on the road, the tire assembly will cause a vibration at a frequency proportional to road speed. For example, the vibration frequency will increase with road speed.

In automotive applications, vibrations can be classified into two basic categories:

- **Forced Vibrations** - A forced vibration is caused by an object which is rotating. An example of forced vibration is any engine driven component, the wheel and tire assemblies or any electric motors.
- **Free Vibration** - This is usually caused by an irregularity in the road surface. A pothole, crack or expansion joint in the roadway can cause a momentary jolt which stimulates an oscillation. This oscillation can affect suspension components, sheet metal in the body, exhaust system components or the steering wheel. The notable characteristic of this type of vibration is that the vibration (or noise) dissipates quickly. This type of vibration is not as common as a forced vibration.

When diagnosing forced vibrations, there are some helpful terms which pertain to how to classify the frequency or intensity of the vibration. These terms include:

- **Cycle** - A cycle is an event or disturbance. Using an example of a static imbalance, every time the imbalance creates a vibration, this is considered one cycle.
- **Frequency** - The common unit of measurement for frequency is Hertz (Hz). Hertz indicates how many cycles per second an event occurs. Therefore, an event that occurs at a rate of 50 cycles per second is otherwise known as 50 Hertz.
- **Amplitude** - The intensity or harshness level of a vibration.
- **Natural Frequency** - This is the frequency at which a given object will vibrate most easily. For example, a tuning fork will vibrate when struck at a certain frequency. This will be very consistent. A vehicle chassis can vibrate at a rate of 10 to 50 Hz. Some of the factors that contribute to the natural frequency are the type of suspension, the tires and the weight of the vehicle.

---

When diagnosing vibration complaints, there are three basic components of a vibration which should be considered. Not all vibrations are caused by imbalanced wheel and tire assemblies. Some of these vibrations could originate from engine, flywheel or driveline irregularities.

The three components of a vibration are as follows:

- **Source** - The vibration source, usually pertains to the rotating component. This includes tire and wheel assemblies, engines or engine driven accessories. Sometimes, the source is not the root cause of the complaint. For example, some engine have characteristic vibrations which should be dampened by the engine mounts. Therefore, a defective engine mount can be the root cause, not the engine itself.
- **Transfer Path** - Transfer path is the pathway between the source and the responding component. For example, the engine mount can be considered, the transfer path. As given in the example above, the transfer path must be considered during the diagnosis of a “rough” running engine. Other examples of transfer paths include; the center support bearing on the driveshaft, the strut assemblies, transmission mount or the steering column.
- **Responding Component** - The responding component is the item that the driver notices. For example, a dynamic imbalance on one of the front wheels would cause a steering wheel vibration. So, in this case, the steering wheel is the responding component.



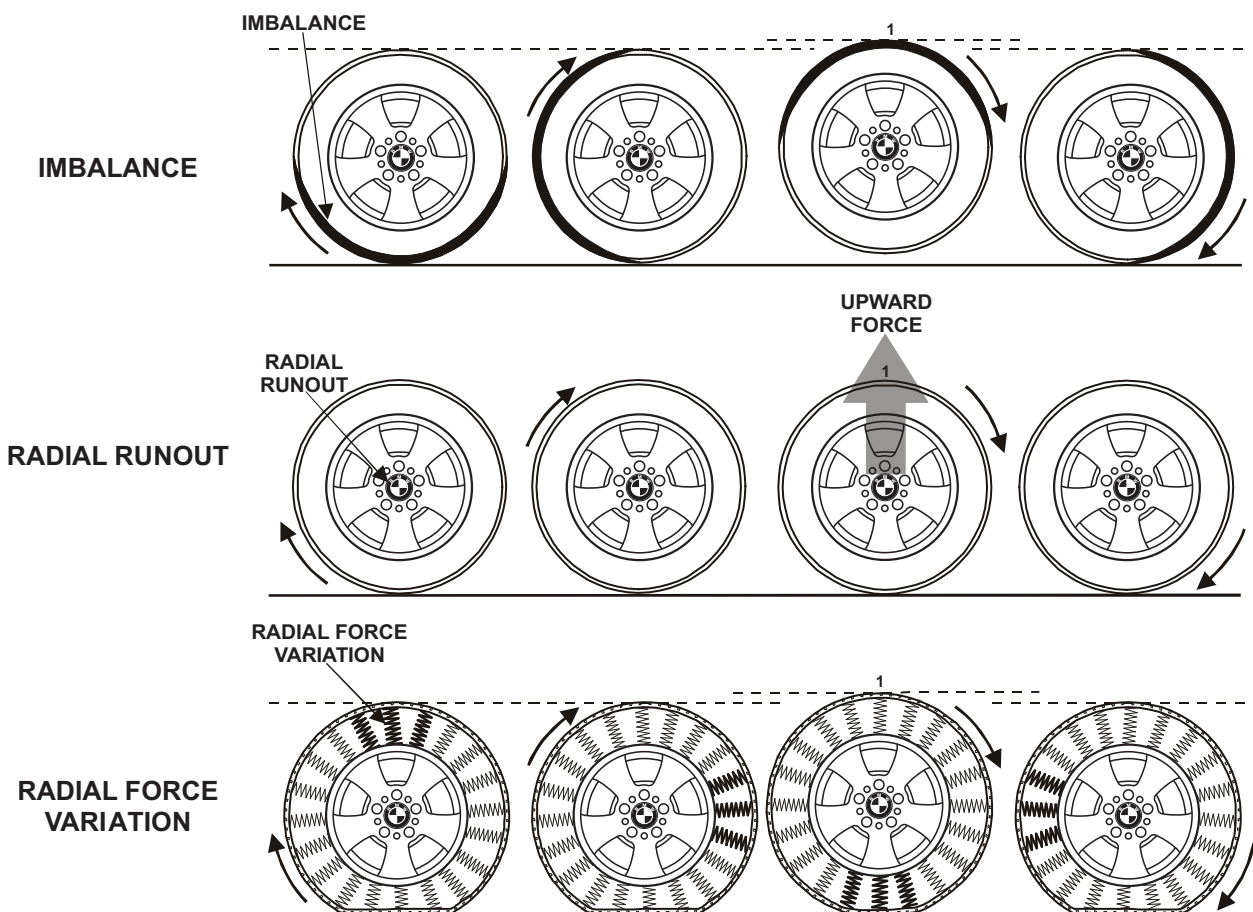
## Harmonics

Harmonics refers to the number of occurrences per revolution. They are classified as First Order (R1H), Second Order (R2H) and Third Order (R3H) harmonics.

The complete spectrum of harmonics can be measured from R1H through R15H, however this requires special equipment. For the purposes of vibration diagnosis in a workshop environment, the GSP97BMW Road Force Wheel balancer is only capable of R1H through R4H. The major source of concerns regarding vibration occur in R1H through R3H range.

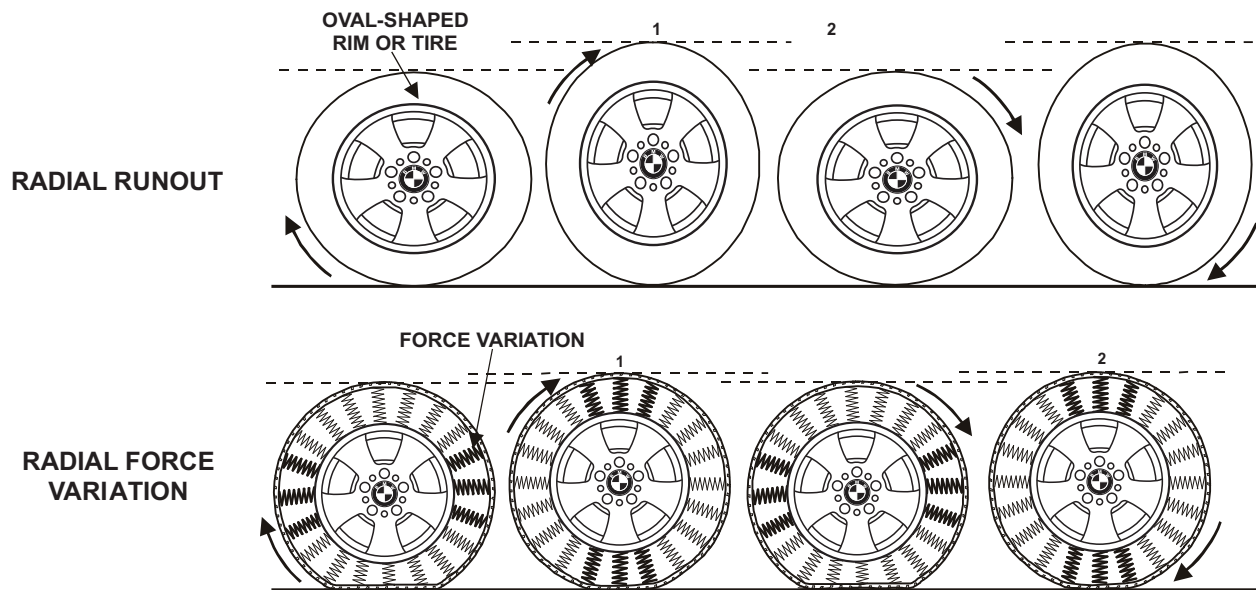
### ■ First Order Harmonics

Harmonics in the first order occur once per revolution. An example of this would be a wheel with a static imbalance or excessive radial force variation. Imagine a tire with a “hard spot” rotating on a vehicle. The hard spot would have an effect only once per revolution. A tire or wheel with an excessive “unloaded” radial runout can also influence first order harmonics.



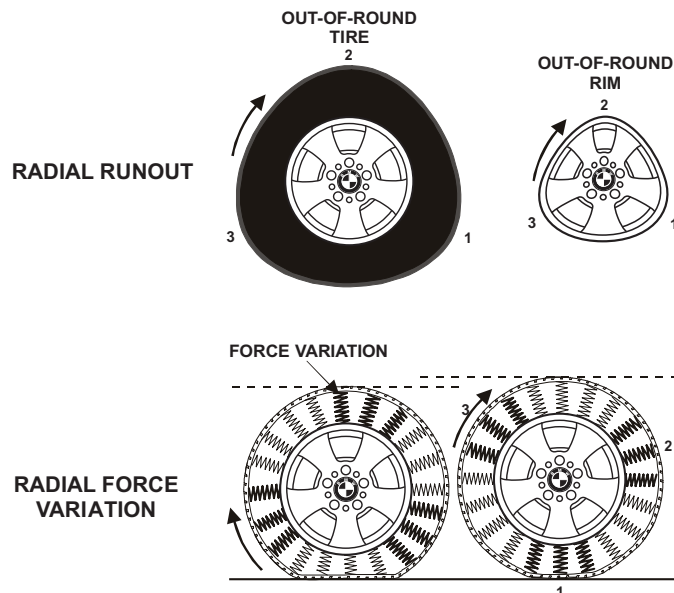
### ■ Second Order Harmonics

Second Order vibrations occur twice per revolution. For example, a tire which is “egg-shaped” would have two occurrences per revolution. This can be caused by tire and/or wheels which excessive radial runout. Also, loaded tires with excessive radial force variation (RFV) can cause 2nd order harmonics.



### ■ Third Order Harmonics

Harmonics in the third order occurs 3 times per revolution. Damaged wheels with excessive radial runout (triangular shaped) can cause this condition. Tires which are “flat-spotted” in multiple locations can show up during the Road Force balancing procedures. Usually, 3rd order harmonics are caused by damaged wheel assemblies.



---

## Tips on using the GSP9700 Wheel Balancer

The GSP 9700 BMW Road Force Wheel Balancer is capable of solving many vibration issues related to tire and wheel assemblies. However, certain concerns must be observed to get the most out of this equipment.

The following is a list of hints and tips to ensure accurate results:

- Tires should be warmed up to remove temporary flat spots prior to balancing. For example, if a vehicle is left overnight for testing, it is possible to have temporary flat spots on the tire. This would show up as excessive radial force variation. Always warm up the tires by road testing for a least 5-10 minutes at highway speed.
- Verify that the wheel is mounted on the wheel balancer properly. The balancer has a “centering check” feature if needed.
- Use the proper mounting hardware for the balancer. Use only the specified cones and adapters provided by the manufacturer.
- BMW wheels are “hub-centric”. This means that the primary reference for the wheel centering is the hub. Use of the improper wheel with excessive hub tolerance can result in an vibration which is not correctable.
- Tire and wheel assembly must be free of debris. Mud and rocks should be removed from the tire tread before balancing.
- If it is not possible to measure the runout on the bead seating area of a wheel due to wheel design, then the tire should be removed from the rim.
- Do not replace a tire based on the radial force measurements alone. Use the Force Matching and Matchmaker features of the GSP97BMW Wheel balancer to optimize the tire and wheel assemblies and reduce vibration. There is no set specification for Road Force which will condemn the tire.
- Always be sure to check for correct tire mounting. If the bead of the tire is not seated correctly, the Road Force measurements may be affected. When mounting the tire to the wheel, be sure to use sufficient lubrication. Do not use silicone, this could cause the tire and wheel to slip on the rim during hard braking.
- Make sure that the tire is inflated to the correct specification as per manufacturers guidelines. Check the b-pillar inflation placard for exact tire pressure.
- Be sure to keep the wheel balancer maintained in proper working order. Clean cones, adapters and balancer shaft according to maintenance schedule. Replace any damaged accessories with Hunter approved components.
- Periodically perform calibration checks on the wheel balancer to achieve the most accurate and consistent results.

