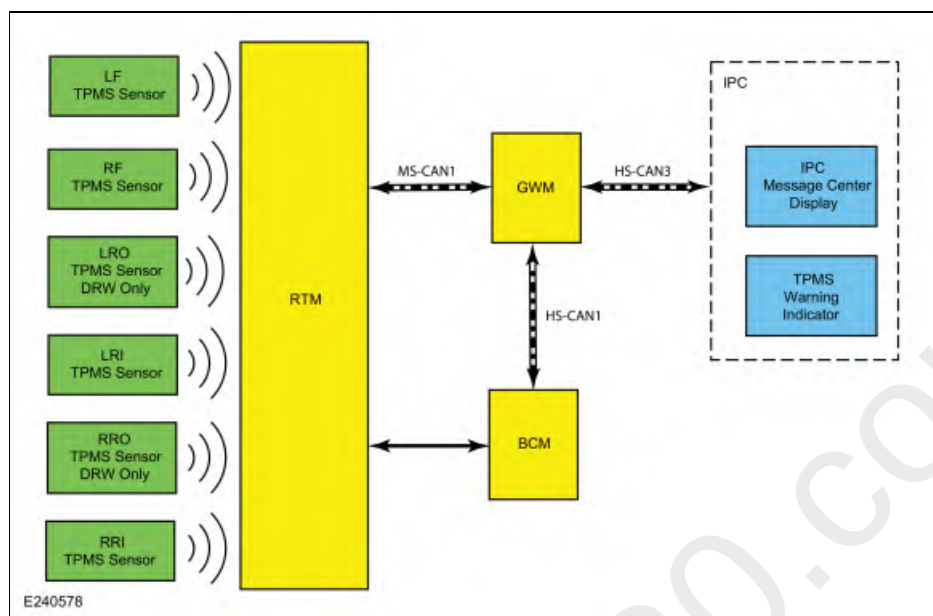


Tire Pressure Monitoring System (TPMS) - System Operation and Component Description

System Operation

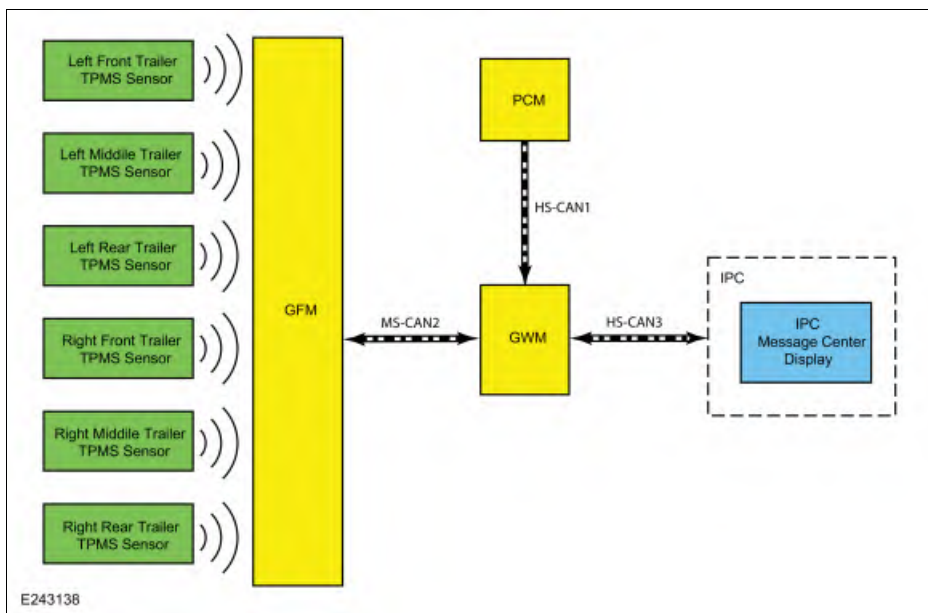
System Diagrams

Vehicle Tire Pressure Monitoring System (TPMS)



Item	Description
1	IPC
2	IPC message center display
3	TPMS warning indicator
4	BCM
5	GWM
6	LH front TPMS sensor
7	RH front TPMS sensor
8	LH rear-outer TPMS sensor dual-rear wheel only
9	LH rear TPMS sensor (rear-inner on dual-rear wheel vehicles)
10	RH rear TPMS sensor (rear-inner on dual-rear wheel vehicles)
11	RTM
12	RH rear-outer TPMS sensor dual-rear wheel only

Trailer Tire Pressure Monitoring System (TPMS)



Item	Description
1	IPC
2	PCM
3	IPC message center display
4	LH front trailer TPMS sensor
5	GFM
6	GWM
7	LH middle trailer TPMS sensor
8	LH rear trailer TPMS sensor
9	RH front trailer TPMS sensor
10	RH middle trailer TPMS sensor
11	RH rear trailer TPMS sensor

Network Message Charts

RTM TPMS Network Input Messages

Broadcast Message	Originating Module	Message Purpose
TPMS status	BCM	This message is sent to the GWM and then to the RTM. Communicates tire pressure system status to the RTM; system fault, sensor fault, low pressure, system active, training active, training complete and tires not trained.
TPMS sensor status	BCM	This message is sent to the GWM and then to the RTM. Communicates the status of each tire pressure sensor individually to the RTM; unknown, normal, low or fault.
TPMS warning indicator	BCM	This message is sent to the GWM and then to the RTM. This message informs the RTM of the TPMS warning indicator status; on, off, or flashing.

GFM Network Input Messages

Broadcast Message	Originating Module	Message Purpose
Ambient air temperature	PCM	This message is sent to the GWM and then to the GFM. The GFM uses the information in this message for determining TPMS sensor faults and for system operation.
Trailer learn mode	IPC	This message is sent to the GWM and then to the GFM. This message lets the GFM the operator or diagnostic scan tool has requested activation of the TPMS learn mode.
Trailer tire count	IPC	This message is sent to the GWM and then to the GFM. This message contains the number of road wheels on the trailer as set by the operator. The minimum number of allowable road wheels is 2 and the maximum number is 6. This information is used for determining TPMS sensor faults and for system operation.
Trailer tire pressure threshold	IPC	This message is sent to the GWM and then to the GFM. This message contains the pressure threshold of the trailer tires as set by the operator. This information is used for determining TPMS sensor faults and for system operation.
Vehicle speed	PCM	This message is sent to the GWM and then to the GFM. The GFM uses the information in this message for determining TPMS sensor faults and for system operation.

TPMS Function

NOTE: When directed to train any **vehicle** TPMS sensors, use **only** the sensor training procedure outlined in this manual. Do not use the TPMS reset procedure outlined in the Owner's Literature as this procedure **does not** program new sensors to the module.

Vehicle TPMS

The vehicle TPMS uses 4 valve stem mounted sensors to monitor tire pressure. These sensors wirelessly transmit tire pressure data to the RTM. The RTM is a radio signal receiver which collects the tire pressure data and sends the information to the BCM along a LIN.

All TPMS functions are controlled by the BCM. The BCM compares the tire pressure data sent by the RTM with a programmed tire pressure. This programmed pressure is specified on the VC label and cannot be changed. If the actual tire pressure is less than the programmed tire pressure, the BCM sends a low tire pressure message to the IPC along the MS-CAN. The IPC responds by illuminating the TPMS warning indicator and displaying a low tire pressure message in the message center. The TPMS sensors are trained (calibrated) to the BCM which records the unique identifier for each TPMS sensor and records the location of each sensor based on the training (calibration) order. The BCM sends messages to the RTM by first sending the information along the HS-CAN1 to the GWM which then sends the information to the RTM along the MS-CAN.

It is necessary to train (calibrate) the TPMS sensors after a tire rotation on vehicles with different front and rear tire pressures. The BCM does not automatically recognize the sensor identifiers have been moved to different positions and retains the original position information for each sensor. Refer to: Tire Pressure Monitoring System (TPMS) Sensor Location Calibration (204-04B Tire Pressure Monitoring System (TPMS), General Procedures).

The diagnostic scan tool is useful in diagnosing TPMS concerns and may be used to verify the accuracy of the tire pressure data transmitted by the TPMS sensors. This is accomplished by comparing the BCM tire pressure PID data to the actual tire pressure using a digital tire pressure gauge.

Trailer TPMS

If equipped, the trailer TPMS uses 2, 4 or 6 valve stem mounted sensors to monitor trailer tire pressure. These sensors wirelessly transmit tire pressure data to the GFM. The GFM contains a radio signal receiver which collects the tire pressure data and the GFM determines what actions to take based on the data from the sensors.

All trailer TPMS functions are controlled by the GFM. The GFM compares the tire pressure data sent by the trailer TPMS sensors against a programmed tire pressure. This tire pressure is programmed during GFM installation. If the actual tire pressure is significantly less than the programmed tire pressure, the GFM sends a low tire pressure message to the GWM along the MS-CAN2. The GWM relays the message to the IPC along the HS-CAN3. The IPC responds by displaying a low tire pressure message in the message center. The TPMS sensors are trained (calibrated) to the GFM which records the unique identifier for each TPMS sensor and records the location of each sensor based on the training (calibration) order.

For information on training (calibrating) the trailer TPMS sensors and programming the GFM with the number of TPMS sensors and the tire pressure threshold, refer to the Owner's Literature.

TPMS Sensor Training Techniques

Wheel Rotation and Sensor Training Techniques

Training known good sensors from another vehicle can help determine whether the concern is with a sensor, the RTM or GFM. This technique cannot help determine whether the concern is due to RFI as some RFI source could be preventing the RTM or GFM from receiving the tire

pressure status from the known good sensors as well as the original sensors.

If the RTM or GFM in the suspect vehicle cannot train any of the original sensors and, likewise, cannot train known good sensors from another vehicle, then the concern is with the module or RFI and not with the original sensors. The original sensors should not be replaced. If a sensor in a certain location has caused several events, yet the sensor trains and seems to operate normally, moving that particular wheel to a different location on the vehicle is a good way to isolate the concern to a certain sensor/wheel location. Rotate the wheels and road test the vehicle. This can be done in an attempt to replicate the concern and help determine if the concern followed the sensor or remained in the original sensor location.

If the vehicle has been stationary for more than 30 minutes, the sensors go into a "sleep mode" to conserve battery power and need to be "woken up" so they transmit the latest tire pressure information to the RTM.

Refer to: Tire Pressure Monitoring System (TPMS) Sensor Activation (204-04B Tire Pressure Monitoring System (TPMS), General Procedures).

Training Sensors in a Different Order

If the first sensor fails the TPMS training procedure, the BCM or GFM aborts the entire procedure. Starting the training procedure at a different wheel is a technique which can be used to determine if the remaining sensors can train to the module. This can help save time determining if one sensor is damaged, other sensors are having concerns or the BCM or GFM is experiencing training difficulties with a certain TPMS sensor location.

TPMS Warning Indicator

The TPMS warning indicator is used to indicate both a **vehicle** low tire pressure event and a possible **vehicle** TPMS fault condition. The message center displays additional information associated with the low tire pressure event or the system fault condition. Occasionally, the warning indicator and message center indicate faults the customer cannot resolve. Treat these as serviceable TPMS faults.

The trailer TPMS **does not** use the TPMS warning indicator to notify the vehicle occupants of low trailer tire pressures or trailer TPMS fault conditions. The trailer TPMS uses only the message center for low tire pressure and fault notifications.

TPMS Warning Indicator Illuminates Continuously

The TPMS warning indicator remains on continuously and the message center displays LOW TIRE PRESSURE when any of the **vehicle** tire pressures fall below the low pressure limit. When this condition exists, adjust the tire pressure to the recommended cold tire pressure indicated on the VC label.

TPMS Warning Indicator Flashes

The TPMS warning indicator flashes for 70 seconds and then remains on continuously when the ignition is set to ON and the **vehicle** TPMS is malfunctioning. The TPMS status (TPMS_STATUS) PID can be used to determine why the TPMS warning indicator is flashing.

- Tire Pressure Sensor Fault – The message center displays TIRE PRESSURE SENSOR FAULT when a TPMS sensor is malfunctioning.
- No communication with the BCM – The TPMS warning indicator illuminates when the IPC has not received any signals from the BCM for more than 5 seconds. The message center displays TIRE PRESSURE MONITOR FAULT.
- Tire Pressure Monitor Fault – The message center displays TIRE PRESSURE MONITOR FAULT when the TPMS is malfunctioning.

TPMS PID Definitions

The BCM or GFM monitors the TPMS status. Use the diagnostic scan tool to view the current status of the TPMS status (TPMS_STATUS) PID. This helps identify the current system status and may aid in diagnosing the system. The PID has 4 valid states:

- TPMS_STATUS PID displays SENSOR FAULT if the BCM or GFM has not received the tire pressure data from a **single** TPMS sensor for 20 minutes when vehicle speed is above 32.2 km/h (20 mph).
- TPMS_STATUS PID displays SYSTEM FAULT if the BCM or GFM has not received the tire pressure data from **all** TPMS sensors for 20 minutes when vehicle speed is above 32.2 km/h (20 mph).
- TPMS_STATUS PID displays LOW if the BCM or GFM has detected at least 1 TPMS sensor is reporting low tire pressure.
- TPMS_STATUS PID displays SYSTEM ACTIVE if the TPMS is functioning normally.

Last Warning Event PID Definitions

The TPMS uses the TPMS last warning event Parameter Identifications (PIDs) to store detailed information about the last 5 times the TPMS warning indicator was activated or a TPMS fault message was displayed in the message center. These Parameter Identifications (PIDs) can be used to acquire more information about a particular TPMS event, but must be used carefully.

PID	Definition

PID	Definition
EVT1_AGE_IGN through EVT5_AGE_IGN	The number of key cycles since the TPMS was activated. This PID cycles from zero to 255 and then starts over from zero again. This can be used to determine how long ago a TPMS event occurred and the time (in key cycles) between events.
EVT1_TR_LOC through EVT5_TR_LOC	This is the last programmed location for the TPMS sensor identifier causing each TPMS event. Due to tire rotation, the sensor may no longer be at the original location. It is suggested that all the Parameter Identifications (PIDs) be recorded, the system retrained, and then the sensor identifier Parameter Identifications (PIDs) be used to pinpoint the actual location of each sensor.
EVT1_PRES_BP through EVT5_PRES_BP	This is the tire pressure associated with each TPMS indicator event. This can be used along with the function code to clearly identify the TPMS events that were strictly due to low pressure. It can also be used to determine when a sensor is transmitting inaccurate tire pressure.
EVT1_SNSR_ST through EVT5_SNSR_ST	- Describes the warning status of each TPMS event by using the information received from the TPMS_STATUS PID. If there is a communication concern, the status could be NORMAL. - UNKNOWN - NORMAL (normal operation) - LOW (low pressure event) - FAULT (sensor fault or system fault)
EVT1_SNSR_ID through EVT5_SNSR_ID	This is the identifier of the sensor involved in each TPMS event. EVT1 is the most recent event triggering the TPMS warning indicator or displaying a fault message.

Radio Frequency Interference (RFI)

RFI can be caused by:

- Video equipment has been found to cause RFI especially when the video and power supply lines are near the TPMS.
- Anti-theft alarms (even those installed by the dealership) have been found to create enough RFI to cause the TPMS to malfunction or lose considerable range. These anti-theft alarms can be difficult to locate, as they are usually hidden somewhere out of the way for reduced accessibility.
- Many in-vehicle cell phone chargers have been found to cause considerable RFI. The vehicles with the power point closest to the RTM or GFM are the most affected. It must be noted that most cell phone chargers do not produce high levels of RFI all the time. This depends on the state of charge of the cell phone battery. The phone battery must be almost completely discharged in some cases.
- Power supplies and DC/ AC inverters typically create a lot of RFI. Most consumer grade equipment has very little filtering or shielding.

Using Hit Rate Parameter Identifiers (PIDs) to Determine the Presence of RFI

If an intermittent RFI issue is suspected, the information contained in the last 5 TPMS warning event Parameter Identifiers (PIDs) can be combined with specific Parameter Identifiers (PIDs) from the BCM to determine which TPMS sensors are being affected and if a RFI source is currently present in the vehicle.

The BCM or GFM contains Parameter Identifiers (PIDs) to keep track of the number of TPMS messages received from the trained TPMS sensors. These Parameter Identifiers (PIDs) can provide insight on the performance of the TPMS, and can help establish the presence of an Frequency Interference (RFI) source.

The rear inner and rear outer locations are also used for the trailer middle and rear locations, depending on how the trailer TPMS was programmed.

- TPM_HITS_LF (Tire Pressure Monitor Hit Rate Left Front) – The number of TPMS messages received by the BCM module from the LH front sensor
- TPM_HITS_RF (Tire Pressure Monitor Hit Rate Right Front) – The number of TPMS messages received by the BCM module from the RH front sensor.
- TPM_HITS_LRO (Tire Pressure Monitor Hit Rate Left Rear Outer) – The number of TPMS messages received by the BCM module from the LH rear outer sensor
- TPM_HITS_LRI (Tire Pressure Monitor Hit Rate Left Rear Inner) – The number of TPMS messages received by the BCM module from the LH rear inner sensor
- TPM_HITS_RRO (Tire Pressure Monitor Hit Rate Right Rear Outer) – The number of TPMS messages received by the BCM module from the RH rear outer sensor.
- TPM_HITS_RRI (Tire Pressure Monitor Hit Rate Right Rear Inner) – The number of TPMS messages received by the BCM module from the RH rear inner sensor.

Method for determining if RFI issue has been affecting the TPMS:

1. Collect the last 5 TPMS events and determine if they were due to system faults or low tire air pressure.
2. Collect the TPMS Hit Rate PID counters and compare them to the last 5 TPMS events.
3. If the TPMS Hit Rate PID counters are significantly different from each other or if the locations with lower hit rate values show up as fault locations in last 5 TPMS events and DTC B124D:02 (Tire Pressure Sensor: General Signal Failure) is present, an intermittent RFI source is most likely preventing the signals from these TPMS sensors from reaching the RTM or GFM.
4. An intermittent RFI source can also be the case when **all** TPMS sensors show up in the last 5 fault events and DTC B1182:00 (Tire Pressure Monitoring System (TPMS): No Sub Type Information) is present. The possible cause would be a strong source of RFI noise.

Original Equipment Manufacturer (OEM) Modules

In some cases the RFI may actually be caused by a module or ground on the vehicle. Depending on the severity of the concern, a dirty ground, improperly built ground shield or module can disable the system. Modules which have micro-controllers using clock circuits to create timing pulses for the microprocessor may radiate RFI.

Using Customer Electronics to Pinpoint RFI

This method can be a way to determine the cause of a concern before the sensors and module are replaced with little or no effect on system performance. Discuss with the customer what types of devices were being used when the event occurred. Determine which power points were being used and, if necessary, ask the devices be activated to determine their affect on the TPMS.

Options for Eliminating Intermittent TPMS Operation Caused by RFI

- If an Original Equipment Manufacturer (OEM) component or customer device is causing a RFI concern, replace the device.
- If a phone charger is causing a RFI concern, the customer should consult with their cell phone provider to acquire a different battery charger.
- If a device such as a dealer installed anti-theft alarm is causing a RFI concern, move the device to another location in the vehicle. In the case of a portable device move the power cord to another power point location.

In summary, if the RFI source is present and cannot be moved or replaced, the intermittent concern remains. The TPMS must accept the unwanted system operation the RFI can cause.

Ambient Temperature Change and Tire Pressure

Tire pressures fluctuate with temperature changes. For this reason, tire pressures must be set to specification when tires are at outdoor ambient temperatures. If the vehicle or trailer is allowed to warm up to shop temperatures, and the outside temperature is less than shop temperature, the tire inflation pressure must be adjusted accordingly.

If the tires are inflated to specification at shop temperatures, and the vehicle or trailer is moved outdoors when the outdoor ambient temperature is significantly lower, the tire pressure may drop enough to be detected by the TPMS and illuminate the TPMS warning indicator or display a TPMS fault message in the message center.

Tire pressure decreases by 6.9 kPa (1 psi) for every drop of -12.2°C (10°F) of outside ambient temperature. Similarly, as the ambient temperature decreases by a delta of 5.6°C (42°F), tire pressure decreases by 6.9 kPa (1 psi). Adjust the tire pressure by 6.9 kPa (1 psi) per -12.2°C (10°F) (6.9 kPa [1 psi] per 5.6°C [42°F] delta) of outside ambient temperature change as necessary to keep the tire at the specified VC label pressure. To adjust the tire pressure indoors for colder outside temperatures, refer to the following table.

Table 1. Use Table to Adjust Tire Pressure Inside Garage for Colder Outside Temperature¹

**** Do Not Inflate Tire Higher than Maximum Pressure Stamped on Tire Sidewall. ****

Outside Temperature (°F)	Tire Placard Pressure (PSI)																	
	30	32	34	35	38	40	41	42	45	50	55	60	65	70	75	80	85	90
70	30	32	34	35	38	40	41	42	45	50	55	60	65	70	75	80	85	90
60	31	33	35	36	39	41	42	43	46	51	56	61	67	72	77	82	87	92
50	32	34	36	37	40	42	43	44	47	53	58	63	68	73	79	84	89	94
40	33	35	37	38	41	43	44	45	49	54	59	64	70	75	80	86	91	96
30	34	36	38	39	42	44	46	47	50	55	61	66	72	77	82	87	92	97
20	35	37	39	40	43	46	47	48	51	57	62	67	72	77	82	87	92	97
10	36	38	40	41	45	47	48	49	52	57	62	67	72	77	82	87	92	97
0	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97
-10	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97
-20	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97
-30	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97
-40	37	39	41	42	45	47	48	49	52	57	62	67	72	77	82	87	92	97

Table 2. Use Table to Adjust Tire Pressure Inside Garage for Colder Outside Temperature (Metric Units)¹

**** Do Not Inflate Tire Higher than Maximum Pressure Stamped on Tire Sidewall. ****

Outside Temperature (°C)	Tire Placard Pressure (kPa)																	
	205	220	235	240	260	275	285	290	310	345	380	415	450	485	515	550	585	620
21	205	220	235	240	260	275	285	290	310	345	380	415	450	485	515	550	585	620
16	215	230	240	250	270	285	290	295	315	350	385	420	460	495	530	565	600	635
10	220	235	250	255	275	290	295	305	325	365	400	435	470	505	545	580	615	650
4	230	240	255	260	285	295	305	310	340	370	405	440	485	515	550	595	625	660
-1	235	250	260	270	290	305	315	325	345	380	420	455	495	530	565	600	635	670
-7	240	255	270	275	295	315	325	330	350	395	425	460	495	530	565	600	635	670
-12	250	260	275	285	310	325	330	340	360	395	425	460	495	530	565	600	635	670
-18	255	270	285	290	310	325	330	340	360	395	425	460	495	530	565	600	635	670
-23	255	270	285	290	310	325	330	340	360	395	425	460	495	530	565	600	635	670
-29	255	270	285	290	310	325	330	340	360	395	425	460	495	530	565	600	635	670
-34	255	270	285	290	310	325	330	340	360	395	425	460	495	530	565	600	635	670
-40	255	270	285	290	310	325	330	340	360	395	425	460	495	530	565	600	635	670

¹When Outside (Ambient) Temperature is greater than 21°C (70°F), Inflate tires to placard pressure.

²Use the table to adjust tire pressure for P-metric and LT tires only.

³Do NOT use table for Commercial Truck Tires (i.e. 19.5 inch tires for F450 & F550). See F-Super Duty Service Manual for tire inflation procedure.

E142982

Component Description

BCM

The BCM is a multifunction module which monitors all sensor inputs and all CAN messages relating to the TPMS. The BCM records and retains the unique sensor identifier of each TPMS sensor.

The BCM retains the previous sensor location information following a tire rotation. For the BCM to learn the new sensor location, the sensors must be trained (calibrated) to the BCM. Additionally, the sensors must be trained when a new BCM is installed.

For information on training (calibrating) the **vehicle** TPMS sensors,

Refer to: Tire Pressure Monitoring System (TPMS) Sensor Location Calibration (204-04B Tire Pressure Monitoring System (TPMS), General Procedures).

For information on training (calibrating) the **trailer** TPMS sensors, refer to the Owner's Literature.

When installing a new BCM, several procedures must be carried out in the order listed for the module to function correctly. These procedures include, but are not limited to; PMI, anti-theft parameter reset, programming keyless entry remote and setting customer preferences.

Refer to: Body Control Module (BCM) (419-10 Multifunction Electronic Modules, Removal and Installation).

Additionally, the sensors must be trained when a new BCM is installed. TPMS pressure data is cleared from the BCM when the module is flashed or reconfigured. When the data is cleared, the tire pressure DID's reset to the factory default of 1033 kPa (149.96 psi) and the IPC displays dashes for the tire pressures. The sensors must be activated to transmit the latest tire pressure information.

GFM

The GFM is the controlling ECU for the trailer TPMS and contains a radio signal receiver which collects the tire pressure data from the trailer TPMS sensors. When a new GFM is installed, the number of wheels on the trailer and the upper pressure limit for the tires must be programmed into the GFM using the message center menu and the buttons on the steering wheel. For additional information on programming the GFM with the number of TPMS sensors and the tire pressure threshold, refer to the Owner's Literature.

RTM

The RTM is a radio signal receiver which collects the tire pressure data from the vehicle TPMS sensors.

TPMS Sensor

Each TPMS sensors contains a battery, a tire pressure sensor and a radio transmitter. The TPMS sensor radio transmissions are sent

approximately once every 60 seconds when the vehicle speed exceeds 32.2 km/h (20 mph).

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