

Proposal for a Heavy Duty Vehicles TPMS Wireless Standard

Introduction

1. UN R141 and R13 Regulations

Under UNECE Regulation R141, a tyre pressure and temperature monitoring system (TPMS) is mandatory on heavy-duty vehicles (HDVs). Regulation R141 addresses the general safety of motor vehicles, their trailers and their systems and requires the driver of the vehicle to be informed about all tyres and any system malfunctions.

Measurement of the pressure and temperature of each tyre is also required in Regulation R13 to ensure the correct functioning of the anti-lock braking systems, ABS/EBS.

R13 Regulation also specifies the methods and protocol for data exchange between truck and trailer.

2. Micro.sp® Technology Radio frequency Standard

A wireless TPMS system that is intended to operate on heavy duty vehicles (HDV), has radio wave propagation problems, mainly due to the size and structure of the vehicle and the attenuation of radio waves due to the size of the tires. The RF standard used on automobiles, on the frequency of 433.92 MHz with FSK modulation, suffers from the very low radiated power allowed by the FCC. Positioning receivers and antennas in proximity to each group of tires is complicated and expensive.

It is therefore advantageous to use Micro.sp® Technology, a transmission system based on pulse-modulated emission, for which the FCC and ETSI standards allow a much higher radiated power, up to 100 mW RF peak.

Given the above considerations, the proposed TPMS standard is based on the Micro.sp® Wireless Connectivity Standard (1).

(1) Micro.sp® is a trademark of STE-Industries s.r.l..

Heavy Duty Vehicles TPMS Standard

Version 1.1

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1. Definitions

For the purposes of this document:

- 2.1 **“Tyre Pressure Monitoring System”** (TPMS) means a system fitted on a vehicle which can measure the pressure and the temperature of the tyres and transmit corresponding information to the vehicle.
- 2.2 **“TPS Sensor”** means a device placed inside the tire to measure pressure and temperature and wirelessly transmit the corresponding data to the Receiver Control Unit (RCU) and/or Electronic Control Unit (ECU).
- 2.3 **“Wireless”** means that data from the TPS device is transmitted according to the “Micro.sp® RF Standard” and related “WS1919 Protocol”.
- 2.4 **“TPMS ECU”** means a wireless access point consisting of a “Micro.sp® Receiver” , a Bluetooth device for remote programming and a serial data port to the vehicle CAN bus.
- 2.5 **“TPMS RCU”** means a wireless access point consisting of a “Micro.sp® WS1919 Receiver”, a Bluetooth device for remote programming and two serial data ports to the vehicle CAN bus and to Telemetry.
- 2.6 **“Micro.sp®”** refers to the wireless transmission technology , short RF pulse modulated, as specified in the “Micro.sp® Wireless Connectivity Standard”.
- 2.7 **“Protocol”** refers to the standardized data protocol structure specified in the “RF Micro.sp® Standard” and “WS1919 Communication Protocol”.
- 2.7 **“FMS”** stands for “Fleet Management System,” which in this document refers to an extension of the management that goes beyond TPMS to include telemetry from other sensors and wireless alarms.

2. UN Regulations R141 and R13

The general and functional technical specifications of the TPMS system for measuring pressure and temperature comply with the requirements of the Uniform Technical Prescription of UNECE Regulation R141.

Regulation R13 establishes the requirements for vehicle braking system, for which the pressure and temperature of each individual tire are also required.

Temperature measurement is implicitly required as tire pressure naturally varies with ambient and operational temperatures.

Below is a summary of the R141 requirements.

2.1 - R141 Specifications and tests

Par. 5 of R141 defines the "Specifications and tests" relating to the operation and minimum requirements for pressure and temperature sensors.

Annex 3 contains the "Test requirements for tyre pressure monitoring systems", where temperature measurement is used to normalize the pressure warning limits, as described in Par. 2.4 , and must correspond to the internal temperature of the tyre, preferably measured by a "Tyre Mounted Sensor".

Below is a summary of the main R141 requirements, as relevant to the application of this document.

Par. 5.2 Tyre pressure detection for incident-related pressure loss (Puncture test)

Par. 5.2.1 - 5.2.5 For all vehicle categories M, N and O the warning signal must be activated for a decrease of 20% compared to the operating pressure or if it is less than 1.5 Bar for tyre class C1 or less than 2.2 Bar for tyre class C2. The alarm must be activated within 10 minutes of cumulative driving time.

Par. 5.3 Detection for a tyre pressure level significantly below the recommended pressure for optimum performance including fuel consumption and safety (Diffusion test)

Par. 5.3.1 - 5.3.5 For all vehicle categories M,N and O, the warning signal must be activated for a decrease of 20% compared to the operating pressure or if it is less than 1.5 Bar for tyre class C1 or less than 2.2 Bar for tyre class C2. The alarm must be activated within 60 minutes of cumulative driving time.

Par. 5.4 Malfunction detection

Par. 5.4.1 - 5.4.3 The warning signal must be activated within 10 minutes of the occurrence of a TPMS malfunction. The warning signal must also be activated in the event of a malfunction of the TPMS of the towed vehicle or if no valid TPMS information is available from the towed vehicle.

2.2 - UN Regulation R13

Regulation R13 applies to M2, M3, N and O vehicles in terms of braking and defines the requirements applicable to the towing vehicle and towed vehicles, as defined in ISO 11992.

ABS and EBS braking systems require pressure and temperature to regulate braking and require monitoring the condition of each individual tire.

3. TPS - Tyre Pressure Sensor

This paragraph defines the minimum requirements that characterize the operation of the "TPS" pressure sensor used in a wireless TPMS network and which operates according to the criteria of "Micro.sp® RF Technology". These requirements are valid for vehicles of categories M2, M3, N1, N2, N3, O3 and O4.

3-1 General requirements and operating conditions

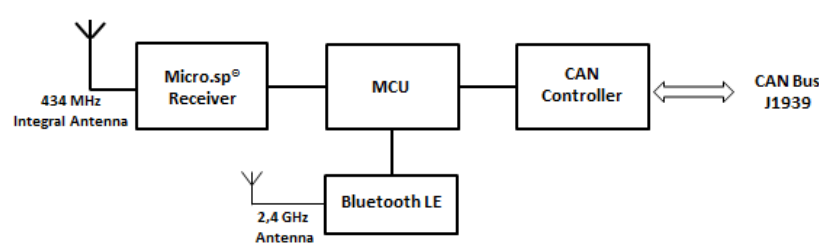
Operating Temperature	Full Spec.	-25/+125 °C
	Reduced specs	-40/+125°C
	Survival	-40/+150°C. (+150°C for 15 min.)
Storage Temperature		0/+40°C
Shelftime	1 year after date of production	
Tyre specific test	According to ECE R10 (EMC)	
Pressure Range	Rel. pressure	0 to 900 kPa (9 bar)
Accuracy of pressure meas.	0°C to 70°C	±1% of full scale – max. ±10kPa (0,1 Bar)
	Outside 0°C to 70°C	±2% of full scale – max. ±15kPa (0,15 Bar)
Survival pressure	Abs. pressure	2000 kPa (20 Bar)
Temperature range		-40°C to 120°C
Accuracy of temp. meas.	-20°C to 70°C	±3°C
	Outside -20°C to 70°C	±5°C

3-2 Functional requirements

Transmission interval	30 s
Pressure sampling interval	10 s
Minimum lifetime	7 years

4. TPMS ECU

This paragraph defines the minimum requirements that characterize the operation of a "TPMS ECU" used in a wireless TPMS network for heavy vehicles, operating according to the criteria of "Micro.sp® RF Technology". These requirements are valid for vehicles of categories M2, M3, N1, N2, N3, O3 and O4. The Micro.sp® "TPMS ECU" includes a "Micro.sp® Receiver", a J1939 CAN Bus port and a Bluetooth wireless interface. Bluetooth is mainly used for the management of the sensors "ID", their association to the tyres and their location on the vehicle.



4-1 General requirements and operating conditions

Operating Temperature	Full Spec.	-25/+105 °C
	Reduced specs	-40/+125°C
Storage Temperature		0/+40°C
Approvals	According to UN Regulation R10 (EMC)	

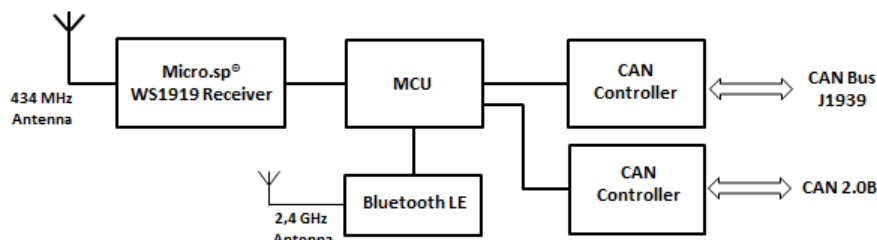
4-2 Functional requirements

Power supply	12-24 V Systems	8 - 36 VDC
TPMS Receiver	Frequency	433,92 MHz
	Selectivity t	400 kHz
	Sensitivity (integral antenna)	dB uV/V
Bluetooth	Frequency	2,4 GHz
Can 2.0B	Protocol	J1939
	PGN	65268
	Tire Pressure	SPN 241
	Tire Temperature	SPN 242
	Tire Location	SPN 929

5. TPMS RCU - Receiver Control Unit

The "Heavy Duty Vehicle TPMS Standard" defines a TPMS RCU as a wireless access point for TPMS and FMS telemetry. The TPMS RCU includes a "Micro.sp® WS1919 Receiver", a vehicle CAN J1939 port, a CAN port for telemetry and a Bluetooth wireless interface for programming.

Bluetooth is primarily used to manage TPS "IDs", their association with tires and their position on the vehicle, and is also used to manage FMS telemetry with Micro.sp® sensors and alarms.



5-1 General requirements and operating conditions

Operating Temperature	Full Spec.	-25/+105 °C
	Reduced specs	-40/+125°C
Storage Temperature		0/+40°C
Approval tests	According to ECE R10 (EMC)	

5-2 Functional requirements

Power supply	12-24 V Systems	8 - 36 VDC
TPMS Receiver	Frequency	433,92 MHz
	Selectivity t	400 kHz
	Sensitivity (integral antenna)	dB uV/V
	Sensitivity (ext. antenna)	-96dBm
Bluetooth	Frequency	2,4 GHz
Can Bus Port	J1939	PGN 65268
	Tire Pressure	SPN 241
	Tire Temperature	SPN 242
	Tire Location	SPN 929
Telemetry Port	CAN 2.0B	WS1919 Protocol

6. Micro.sp® and WS1919 Data Protocol

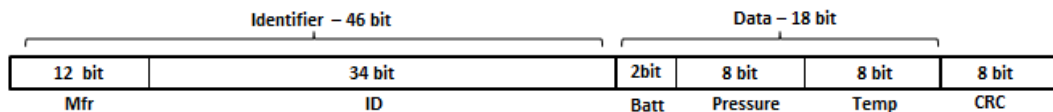
The "Tire Pressure Sensor" (TPS) uses Micro.sp® pulse transmission technology to transmit pressure and temperature measurements. In the "Micro.sp® Wireless Connectivity Standard", the "A2" Frame is specifically assigned to the "Tire Pressure Measurement System" (TPMS) on High Duty Vehicles (HDV's).

The "Tire Pressure Sensor" (TPS) uses Micro.sp® pulse modulated RF emission to transmit pressure and temperature measurements. In the "Micro.sp® Wireless Connectivity Standard", the WS1919 Data Protocol assigns the "A2" Frame to TPMS on Heavy Duty vehicles (HDV).

6-1 TPS Message - The "A2" Frame

The 72 bit "A2" frame is divided in a "Identifier" and a "Data" fields.

The "Identifier" is a unique global code with it's uniqueness guaranteed by the joint use of a "Manufacturer Code" and an "ID" serial number.



6-2 "Identifier"

Field	Lenght	Description
Mfr	12 bit	"Manufacturer code" assigned to the device "Manufacturer"
ID	34 bit	"Identity Number" programmed by "Manufacturer"

Note : The "Mfr" and "ID" joint use ensures the global uniqueness of the "Identifier" for every TPS device.

6-3 "Data" field - Pressure and Temperature

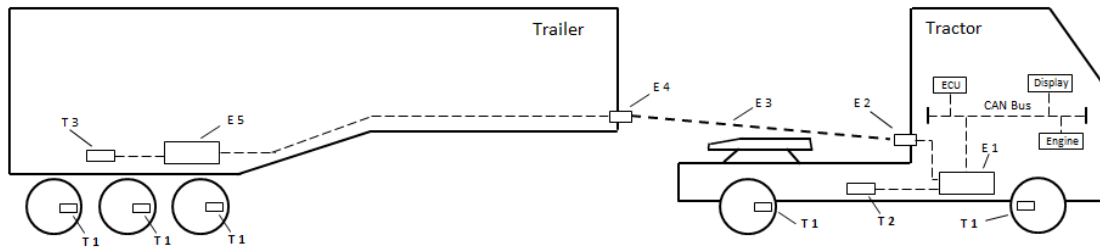
Field	Lenght	Range	Resolution	Offset
Pressure	8 bit	0 to 14 Bar	0,1 Bar / bit	no offset
Temperature	8 bit	-40°C to +125°C	1°C / bit	- 40

6-4 "Data" field - Battery

MSB	LSB	Battery Voltage	Battery charge level (1)
1	1	$\geq 3\text{ V}$	Full charge
1	0	$>2,6\text{V} < 3\text{V}$	Operative charge level
0	1	$>2,4\text{V} < 2,6\text{V}$	Residual charge
0	0	$< 2,4\text{ V}$	End of life

Annex 1

Examples of TPMS on Tractor and Trailer (1)



LEGEND

ELECTRICAL

- E1 ISO 11992-2 node in Tractor, e.g. ECU ABS/EBS
- E2 Tractor ISO 7638 socket
- E3 ISO 7638 coiled cable
- E4 Trailer ISO 7638 socket
- E5 ISO 11992-2 node in Trailer, e.g. ECU ABS/EBS

TPMS

- T1 TPS - pressure and temperature sensor on wheels
- T2 TPMS ECU in Tractor
- T3 TPMS ECU in Trailer

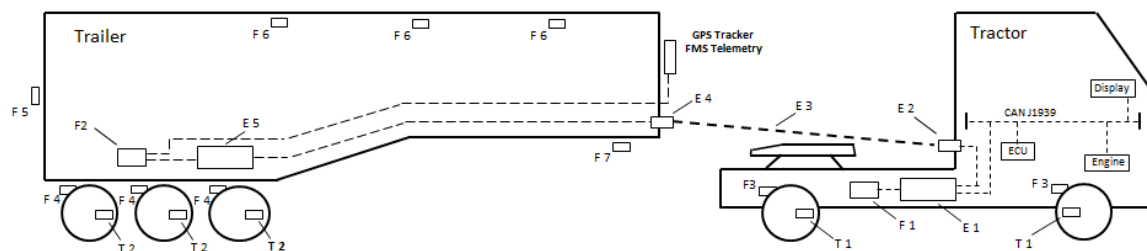
(1) Reference UNECE R13 Regulation , Annex 22 – Appendix 1

Annex 2

Fleet Management System and Telemetry on Heavy Duty Vehicles

The FMS Standard is an open CAN interface developed by several truck manufacturers, to make manufacturer-independent applications for telematics possible. Annex 2 contains information on the extension of the "Fleet Management System", intended as a remote management system for vehicle fleets, to telemetry of a wide range of Micro.sp® wireless sensors and alarms. This is made possible by the TPMS RCU which features the "Micro.sp® WS 1919 Receiver" and can therefore receive and decode messages from TPS and other wireless sensors and alarms, according to the "Micro.sp® Wireless Connectivity Standard".

Below a possible implementation of the system on tractors and trailers



LEGEND

ELECTRICAL

- E1 ISO 11992-2 node in Tractor, e.g. ECU ABS/EBS
- E2 Tractor ISO 7638 socket
- E3 ISO 7638 coiled cable
- E4 Trailer ISO 7638 socket
- E5 ISO 11992-2 node in Trailer, e.g. ECU ABS/EBS

TPMS

- T1 TPS-1 - pressure and temperature sensor on tractor wheels
- T2 TPS-2 - pressure and temperature sensor on trailer wheels

FMS Telemetry

- F1 TPMS RCU in tractor
- F2 TPMS RCU in trailer
- F3 Brake pad wear wireless sensor in tractor
- F4 Brake pad wear wireless sensor in trailer
- F5 Door open wireless sensor
- F6 Temperature wireless sensor
- F7 Asset wireless sensor