bf1systems IRTPTMS V3 System Description

1 Modifications

Date	Modifications	Author	Version	Modified Sheets	Approved		
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4 Conformity to FCC-Rules

Electronic wheel sensors within the IRTPTMS system contains Transmitter Module FCC ID: xxx-xxxxxxxxx

4.1 United States of America

4.1.1 Statement FCC 15.19: Labelling requirements

This device complies with Part 15 of the FCC Rules.
Operation is subject to the following two conditions:

(1) This device may not cause harmful interference, and
(2) This device must accept any interference received, including interference that may cause undesired operation.

4.1.2 Statement FCC 15.21: Information to the user

The user manual or instruction manual for an intentional or unintentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

5 System and Functional Description

5.1 System Description

The Infrared Tyre Pressure & Temperature Monitoring System (IRTPTMS) monitors vehicle tyre pressures and temperatures.

A typical system is comprised of the following components:

- 1 Motorsport DigiTyre ECU (MDE)
- Up to 4 wheel electronics including mounting system
- Up to 4 digital antennas
- Up to 4 trigger transmitters

The wheel electronic mounted on the wheel rim measures tyre pressure ambient temperature and tyre carcass temperature at regular intervals and transfers the values wirelessly to the reception antenna(s). The current pressure and temperature values can be requested specifically via the LF trigger function. In the digital antenna, the radio data telegram is decoded and transferred to the ECU unit as a digital signal. The ECU unit evaluates the received data and forwards the information as required.

5.2 Functional Description

The wheel electronic is mounted on the wheel rim and measures tyre pressure, temperature and wheel electronic status. The measured data is sent from the wheel via a transmit stage in the wheel electronics. A system with relatively seldom-measured data transfer is adequate for tyre pressure monitoring, provided it features the additional option of detecting sudden pressure loss. This enables the electronics in the wheel to be designed for minimal power draw and thus maximize battery life.

All wheel electronics have a unique ID code that is forwarded along with data at each transfer. The HF transfer occurs in the 433MHz range, referred to as the ISM range. The trigger functionality is achieved by the use of a 125 kHz LF channel.

The control unit calls up the wheel electronics via the trigger transmitters when power is supplied to the MDE. When a pressure loss > 0.2 bar on the previously measured pressure value is detected, the wheel electronics switch immediately to fast-transmit mode. In this situation, the wheel electronics measure and transmit every 0.8 seconds.

The IRTPTMS measures and transfers considerably more data than is necessary to ensure reliable basic function. It can therefore use a data transfer path this is not assigned for the error-free transfer of each individual data protocol. Using the trigger function, an implausible and/or non-received data message can be requested again from the corresponding wheel electronics.

The data sent by the wheel electronics is received via the digital antenna and is subsequently decoded. The decoded data is transferred onwards to the MDE unit via a digital interface (LIN interface). The MDE unit evaluates the received data and forwards the information to the driver information system as required. This provides the driver with information on the necessary tyre pressure or temperature.

The main functional characteristics of the control unit are:

- A central warning algorithm and an algorithm for the wheel manager.
- The vehicle-specific connection for the power supply system and manufacturer-specific operation and display philosophy.

6 Warning Algorithm

The system monitors a nominal pressure, which is set automatically when the tyre speed exceeds 30kph, and a fixed set minimum warning pressure. The higher value in each case is used to generate the deflation warning.

6.1 Warning Limit “Minimum pressure”

At this warning limit, a check is made against the minimum warning pressure $Abs_{Pressure}$ Minimum, which is programmed into the system as a fixed value.

The corresponding warning bit is set, if the measured pressure lies below this threshold twice in succession.

6.2 Warning Limit “Nominal pressure minus relative deviation” (Nominal Pressure – 25%)

This warning limit is calculated from the nominal pressure less a relative deviation of 25% of the nominal pressure. The nominal pressure is specified by the driver. An accuracy reserve of 0.1 Bar is added to the warning limit.

The corresponding warning bit is set if the measured pressure lies below this threshold twice in succession.

7 System Components

The system components of the IRTPTMS are described in the following sections.

7.1 Motorsport DigiTyre ECU (MDE)

The MDE control unit consists of a printed circuit board with a microcontroller and interfaces for CAN, RS232 and TPMS-LIN.

The tyre information received from the digital antennae is recorded and evaluated in the control unit. The pressure information and, if applicable, the warning information, is forwarded via the CAN bus to the display systems in the vehicle.

The information from the digital antennae is transferred to the control unit via a LIN bus communication link. The control unit is the master here, while the antennae and/or the trigger transmitters work as slaves. The control unit interrogates the digital antennae at set intervals with respect to radio messages. The trigger transmitters are contacted in sequence. The control unit also provides the supply voltage to the trigger transmitters and the antennae. The most important details of the control unit are described below.

7.1.1 Installation Area

The control unit is intended to be installed in the interior of the vehicle. If not stated otherwise, the values stated in the following chapters relate to a temperature of 25°C and to the current sample control units based on the HCS12 processor.

7.1.2 Temperature Range

Operating temperature: -40°C to +80°C
Storage temperature: -40°C to +85°C

7.1.3 Voltage Range

Nominal voltage: 12V
Operating voltage: 9V to 16V
Maximum voltage: 0 to +18V, with polar protection
Under voltage switch off: The control unit is switched off when V_{batt} < 7.5V
No. of Antennas / triggers that can be supplied: 6

7.1.4 Current Consumption

Normal operation: < 200 mA @ 12V (without antennae or trigger)

7.1.5 MDE Pin Description

System Connection (8STA2-10-35PN, Male, Circular)			
Pin	Description	Pin	Description
1	Protected Ignition, +12 V	8	CAN L (DASH), BLUE
2	GND, LIN GND, RS232 GND	9	RS232 DATA TX / Configure Input A
3	LIN V RL TRIGGER Switched	10	RS232 DATA RX / Configure Input B
4	LINV TRIG FR/RR ANT FRT/REAR	11	LIN DATA RL TRIG/FRT ANT
5	LIN V FL TRIGGER Switched	12	LIN DATA FL TRIG/REAR ANT
6	LIN DATA FR TRIGGER	13	LIN DATA RR TRIGGER
7	CAN H (DASH), RED		

Secondary Connection (8STA2-10-35SA, Female, Circular)			
Pin	Description	Pin	Description
1	Configure Input C	8	N/C
2	Configure Input A / RS232 DATA TX	9	N/C
3	Configure Input B / RS232 DATA RX	10	N/C
4	Daughterboard Out 2	11	N/C
5	GND Sense	12	N/C
6	RS232 GND	13	N/C
7	N/C		

7.1.6 CAN Bus Connection

Vehicle bus: High speed CAN, transfer rate 1Mbits/sec
TPMS bus messages: Programmable to customer requirements
Start-up behaviour: Power applied to the MDE

CAN interface data:
Driver module: TJA1050T
CAN H / CAN L – line: Resistant to short circuits against GND and +V_{batt}

7.2 Wheel Electronics

The wheel electronics measure the pressure, the air temperature inside the tyre, plus the tyre carcass temperature and transmit this data via a HF radio route, together with its residual battery life and ID code to the digital antenna.

7.2.1 Installation Area

The wheel electronics are mounted on the inside of the wheel rim.
During assembly, the bf1systems assembly guidelines must be noted.

7.2.2 Versions

The working frequency of 433MHz is used exclusively.

7.2.3 Temperature

	Min	Max	Units
Working temperature	0	+125	°C
Storage temperature > 50°C max. 30 days	+50	+70	°C
Storage temperature (6 months)	0	+50	°C
Temperature gradient in the working temperature range	-16	+16	K/s

7.2.4 Pressure

Pressure overload	Maximum 2000 kPa
Measurement range	50 kPa to 732.5 kPa

7.2.5 Environmental Requirements

Vibration with overlying temperature	
Temperature profile	0°C to 125°C
Vibration profile 1	20Hz to 2000Hz: 2 g^2/Hz to 0.035 g^2/Hz
Acceleration	
Static acceleration (vertical to PCB)	12 x half sine shock pulses of 80g pk acceleration, pulse width 6ms
Evaluation criteria	No malfunction during and after the test

7.2.6 Mechanical specification

Dimension	70.1mm x 33.4 x 26.8mm
Wheel Sensor Assembly Weight	45g ±1g

7.2.7 Measurement specification

Pressure	**Comment**	**Min**	**Nom**	**Max**	**Units**
Measurement range	Nominal	0.882	-	4.631	bar
Accuracy	0°C to +50°C	-29.4	-	+29.4	mbar
Resolution	LSB	-	14.7	-	mbar
Pressure Sensor Temperature	**Comment**	**Min**	**Nom**	**Max**	**Units**
Measurement range	-	-40	-	215	°C
Accuracy	0°C to +50°C	-1	-	+1	°C
Resolution	LSB	-	1	-	°C
IR Sensor Temperature	**Comment**	**Min**	**Nom**	**Max**	**Units**
Measurement range	-	-2	-	125	°C
Accuracy	-	-0.5	-	0.5	°C
Resolution	LSB	-	0.125	-	°C

Tyre Carcass Surface Temperature (±17.5° & ±45° Field of view)					
	Comment	**Min**	**Nom**	**Max**	**Units**
Measurement Range	-	-40	-	215	°C
Resolution	10-bit	-	0.25	-	°C
Accuracy (Under isothermal conditions)	Ambient temp of 0 - 50°C and target temp of 0 - 60°C	-	±0.5	-	°C
	Ambient temp of 0 - 50°C and target temp of 61 – 180°C	-	±2	-	°C
	Ambient temp of 0 - 50°C and target temp of 181 – 215°C	-	±3	-	°C
	Ambient temp of 0 - 100°C and target temp of 0 – 120°C	-	±1	-	°C
	Ambient temp of 0 - 125°C and target temp of 0 – 180°C	-	±2	-	°C
	Ambient temp of 0 - 125°C and target temp of 181 - 215°C	-	±3	-	°C

Acceleration	**Comment**	**Min**	**Nom**	**Max**	**Units**
Recognition threshold for turning wheel (RS == 1)	-40°C to +90°C	2	11	20	g
	> 90°C	2	14	26	g
Recognition threshold for resting wheel (RS == 0)	-40°C to +90°C	1	10	19	g
	> 90°C	1	13	25	g

7.2.8 Byte format

Start bit	None
Data bits	8, MSB first
Stop bit	None
Code specification	Conditioned diphase code
Description	• flank at the start of a bit interval • no flank in the middle of a "1" interval • flank in the middle of a "0" interval
Data format	Binary
Transmission rate	9.6 kbps +/- 10%

7.2.9 Specification for HF transmitter

7.2.9.1 Frequency

433 MHz Version		
Modulation		Frequency shift keying (2-FSK)
Frequency f_{nom} @ 25°C		433.920 MHz ± 35 kHz
Frequency drift overall (aging, temperature)		f_{nom} ± 85 kHz
Logic levels	Data = 0	f_{nom} - $\Delta f/2$
	Data = 1	f_{nom} + $\Delta f/2$

7.2.10 Transmission		
Marking for type approval	433 MHz Version	
Tolerance transmitted power		+/- 3 dB @ 25°C
Tolerance transmitted power over lifetime		- 3 dB
Tolerance transmitted power over working temperature range		- 5 dB

7.2.11 Block diagram wheel electronics

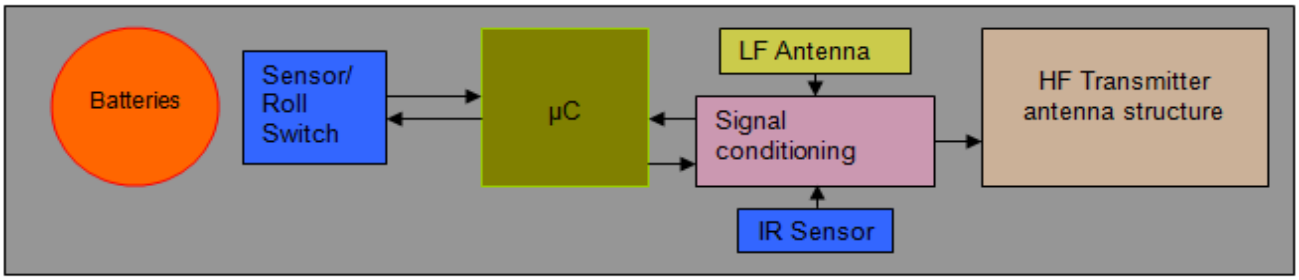

Figure 1: Wheel electronics block diagram

7.3 Digital antenna

The digital antenna has integrated signal conditioning (decoding processor) to receive and decode the HF signal sent by the wheel electronics. The conditioned information is transferred to the MDE control unit via a LIN communication.

7.3.1 Installation area

The digital antennae are mounted on the outside of the vehicle. The area directly subject to being hit by stones from the road must be avoided. The antennae should therefore be installed in a protected position behind a plastic trim (wheel housing shell, or similar).

7.3.2 General dimensions and values

Dimensions:	See Chapter on “Assembly”
Frequency range of the receiver:	550kHz @ -85dBm / 20°C
Type of modulations:	FSK, hard keyed
Sensitivity within bandwidth @ 25°C	>5nT <8nT
Reduction of Sensitivity over frequency	max. 1nT
Reduction of Sensitivity over temp	max. 1nT
Reception to wake-up:	5 dB +/-1dB
RSSI signal:	Start of climb typically 16dBµV @ 25°C
	Saturation typically 56dBµV @ 25°C
Radio data rate:	9.6kBaud +/- 10%
Radio reception frequency:	433.92 MHz +/-200kHz

7.3.3 Temperature ranges

Operating temperature:	0°C to + 125°C
Storage temperature:	0°C to + 70°C

7.3.4 Voltage supply

Supply line: Two wire circuit, V_{batt}, GND
for each digital antenna
Supply voltage: > (V_{batt} – 2V)
Switch type: High side switch

7.3.5 Current consumption

Supply current, digital antenna: At HF reception < 30mA permanently

7.3.6 Environmental conditions

Protection class: IP 69K in line with test according to DIN 40050
Salt spray: 144h in line with test according to DIN 50021-SS
Pressure balance: Climate membrane 2 mm ∅

7.3.7 LIN communication with MDE/Combined Antenna ECU control unit

The LIN communication of the antennas with the MDE/Combined Antenna ECU control unit fulfils the specification of the LIN Consortium Version 1.1. The MDE control unit is in master operation here, while the antennas are in the slave condition.
The following details apply:

LIN bit rate: 10k Baud +/-2%
LIN driver: Infineon TLE 6259-2G
Bus coupling: EMC network
Signal reference: Ground

7.3.8 Connection occupancy, sleeve strip

Manufacturer: Tyco electronics AMP GmbH
Type, plug connector: MQS in line with Tyco drawing 114-18063-014
Contact system: Micro-Quad-Lock
Version: Pin shell
Number, contact pins: 4 Pins
Pin version: Sealed, gold-plated
(sealed; selectively gold-plated),
Sealing system: Primary sealing: Lamellar sealing in the housing
Secondary sealing: Individual seam sealing
Distance between pins (Pitch): 2.54x2.54mm

Pin:	Signal:	Description:
1	LIN_GND	LIN Ground
2	LIN_V1	LIN Supply voltage
3	LIN_DATA	LIN Data
4	SCREEN_GND	Ground for Screen Connection (optional)

Figure 2: Antenna pinout

7.3.9 Block diagram

The basic electrical structure of the antenna electronics is outlined below.

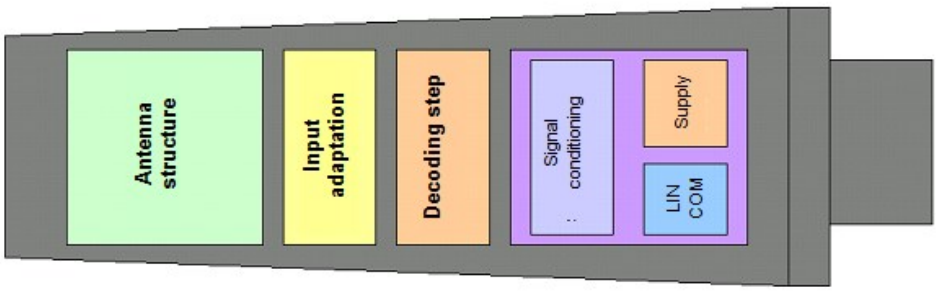

Figure 3: RF Antenna structure

7.3.10 Assembly

The digital antenna can be mounted in the vehicle in line with the following sketch.

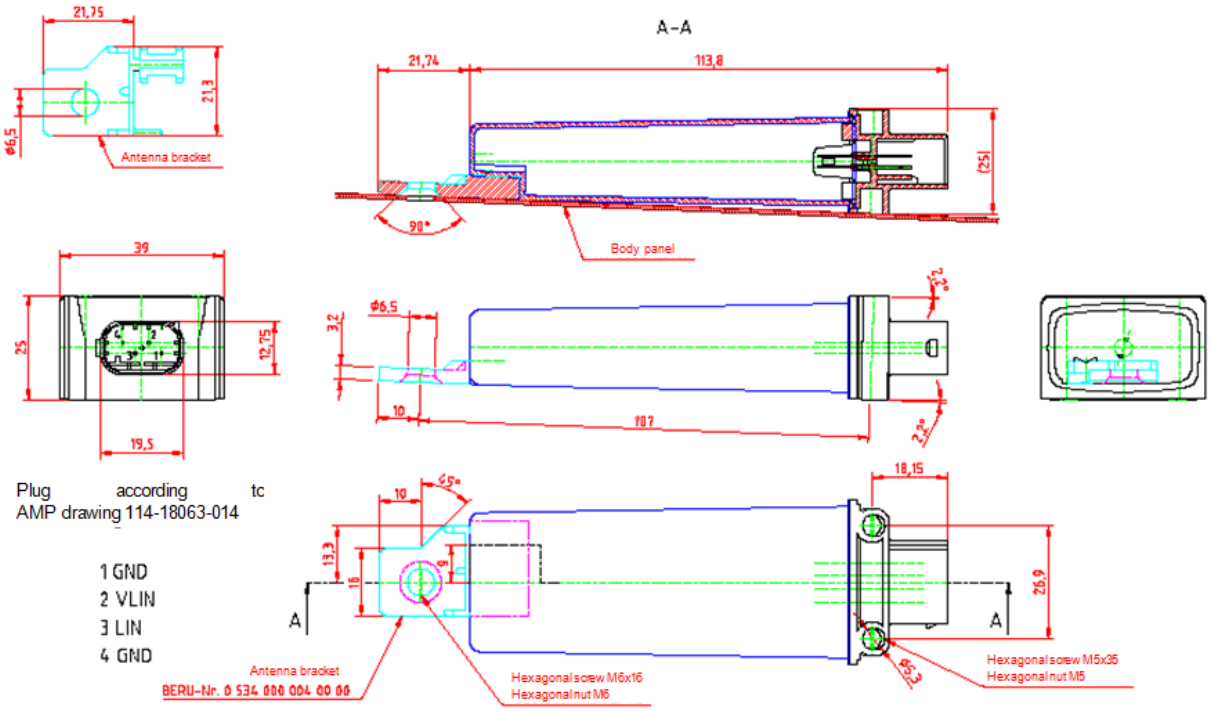

Figure 4: RF Antenna dimentions

7.4 Trigger transmitters

7.4.1 Temperature	
Operating temperature	-40°C to +105°C
Storage temperature	-40°C to + 90°C
7.4.2 Mechanical requirements	
Dimensions	90.5mm x 65.0mm x 27mm
4 vibration loading capacity	3533 41 202 001 C
Shock loading capacity	3533 41 202 001 C
Free fall	1000 mm falling height, concrete (EN 60068-2-32)
Plug push thru strength	≥ 55N
Soundness	IP 69K
Pressure balance	Climate membrane 2 mm ∅

7.4.3 Voltage range	
Static voltage strength	+20V / -2.8V limited by control unit
Dynamic voltage strength	Interference pulses Type 3a, 3b via coupling clamp
ESD strength	8 kV (human body model)
Operating voltage	+7.0V to +18V
7.4.4 Current consumption	
Passive operating current	≤ 10 mA @ 12V
Active operating current (transmitting)	≤ 230 mA @ 12V

Ground current	≤ 230 mA @ 12V

7.4.5 Frequency	
Frequency	125 kHz +/-5 kHz @ -40°C to +105°C (In condition installed in vehicle)
Field strength	≤ 21 dBµV/m @ 3m, 16V
Duration of transmission	< 10 s
Keying ratio	< 0.1
Field orientation	Field of a magnetic dipole, symmetrical axis transverse to the housing
7.4.6 Modulation	
Modulation	Duration of impulse
Baud rate	< 0.5 kBaud
Report	See specification for the corresponding WE

7.4.7 Physical link	
Data interface	LIN specification Rev. 1.1
7.4.8 Protocol	
Data report	LIN specification Rev. 1.1 LIN_SPDPS.doc LIN_Master.doc LIN_Slave.doc

7.4.9 Diagnostics	
Current monitor in the antenna circuit	$V_M \geq 0.5$ V (in the transmission impulse)
Diagnostics response	Set diagnostics status (see LIN_Slave.doc)
7.4.10 Connector	
Type	Mini-timer, 4-pole
Pin 1	LIN_GND
Pin 2	LIN_V1 (Voltage supply)
Pin 3	LIN_DATA
Pin 4	SCREEN_GND
7.4.11 Environmental qualification	
	3533 41 202 001 C

7.4.12 Schematic representation of the trigger transmitters

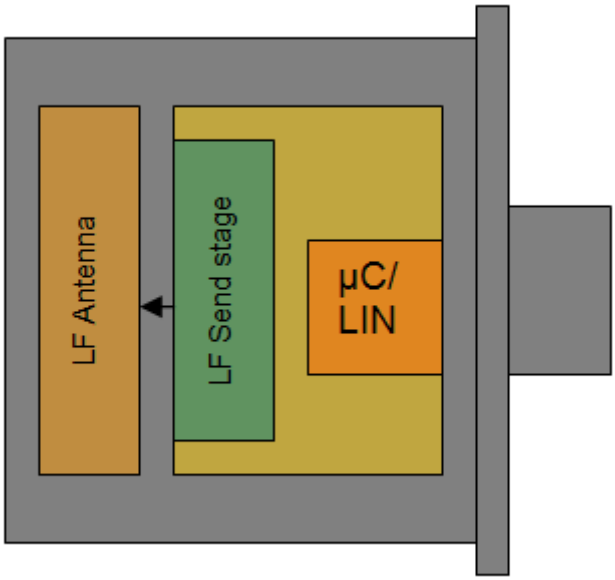

Figure 5: LF Satellite Trigger