

# 1. Introduction

## 1.1 Purpose

The purpose of this specification, is to relay the main characteristics of the Schrader-Bridgeport International Incorporated (SBII) RTPMS transmitter. This information is important for the design of either a stand-alone receiver or integration with the vehicle's Remote Keyless Entry (RKE) receiver.

## 1.2 Scope

This document applies to all customers who will be designing the RTPMS into part of their vehicular monitoring system. Schrader Bridgeport will supply the tyre pressure transmitters. The receiver may also be supplied by SBII to form a complete "stand alone" system, or the vehicle manufacturer may decide on integration with the vehicle's RKE receiver. This document does not intend to restrict or specify any hardware or software. The intent is only to relay the transmission format of the tyre pressure monitoring data, the data protocol, the functionality and the key points of the RTPMS transmitter.

## 1.3 Overview

The system has been developed to monitor a vehicle's tyre pressures whilst driving or stationary. An electronic unit inside each tyre, (referred to as the RTPMS transmitter) mounted to the valve stem, periodically measures actual tyre pressure. By means of RF communication, this pressure information is transmitted to a receiver/decoder. The receiver is used to decode the incoming radio frequency signals, format the data, and transfer the data to the proper display locations within the vehicle as required by the customer/supplier.

## 1.4 Definition

**ASIC-** Application Specific Integrated Circuit. Generally, a custom designed integrated circuit (IC) manufactured for a unique application for a specific customer.

**Bit-** Acronym for binary digit. A unit of information that can be represented by either logic zero (0) or a logic one (1).

**Bit width-** The time set for one unit of information (bit).

**Block-** In this document, a block is referred to as a group of eight transmitted words or frames.

**Check sum-** Usually several bits of a word that signify the authenticity or correctness of the information (data) being sent. The check sum is usually compared against a calculated value in binary form.

**Customer-** The person, or persons, who pay for the product and usually (but not necessarily) decide the requirements.

**Data Rate-** The speed with which the data is transmitted or sent, usually in bits per second.

**Frame-** One complete transmission of information. In this document, frame and word are used interchangeably and refer to the same thing. For this message, each frame contains one and only one message. A frame is delineated by the start of frame (SOF) mark.

EXHIBIT 12

Page 1-6 of 6

U of Mich file 41503- 024

**LF-** Low Frequency 125 kHz.

**Low Battery Fault-** A fault associated with a wheel transmitter, which indicates that a low battery function code has been sent.

**Low Pressure Threshold-** Pressure level below which a low pressure alarm shall be generated by the receiver.

**Protocol-** A set of conventions that govern the interaction of processes, devices, and other components within a system.

**Receiver-** Device, supplied by the customer, that decodes the RTPMS data and then converts the data into information that can be used by the vehicular system.

**RF-** Radio Frequency

**RTPMS-** Remote Tire Pressure Monitoring System

**Supplier-** The person, or persons, who produce a product for a customer.

**Start of Frame-** The start of frame (SOF) mark is used to uniquely identify the start of a frame. In the case of the PWM (Pulse Width Modulation) version it is four high bits followed by a low bit.

**Transmitter-** The device that is mounted in the tyre that senses the tyre pressure and then sends the information via RF to the vehicle receiver.

**UHF-** Ultra High Frequency 315 / 433.92 MHz.

**Vehicle Trip-** The period during which the roll switch is closed

**Word-** A sequence of bits or characters that is stored, addressed, transmitted, and operated on as a unit within a given computer or processor. A sequence of bits or characters that has meaning and is considered an entity. Within this document, word and frame are used interchangeably.

## 2. Overall Description

### 2.1 Product Perspective

#### 2.1.1 System Interface

The RTPMS transmitter is one part of the RTPM System. The RTPMS requires an interface decoder (receiver).

#### 2.1.2 Block Diagram

See Appendix A "RTPMS Transmitter Block Diagram"

### 2.2 Product Functions

#### 2.2.1 Major Functions

The main functions, which the RTPMS transmitter has to perform, are:

- Monitor and transmit tyre pressure.
- Determination of a temperature compensated pressure value.
- Inform the receiver of any low battery condition.
- Determine if there are abnormal pressure variations in the wheel.

### 2.3 Constraints

#### 2.3.1 ETSI 300/220

The 433.92 MHz version meets the requirements of the European Telecommunications Standard Institute 300/220 regulations. Individual country approvals need to be applied for. Division of cost to be negotiated.

#### 2.3.2 FCC Regulations

The 315 MHz version meets the requirements of the Federal Communications Commission regulations Part 15.

The environmental conditions, including ESD (electrostatic discharge), EMC (electromagnetic compatibility), temperature, vibration etc. which the transmitter must be able to withstand are described in the "Schrader-Bridgeport RTPM Generic Validation Specification" document.

### 2.4 Assumptions and Dependencies

#### 2.4.1 AM versus FM

The standard Schrader Bridgeport RTPMS transmitter transmits using amplitude modulation (AM). An FM version can also be supplied.

#### 2.4.2 Carrier Frequency

In the USA, the transmission frequency is 315 MHz. In the European Community, the transmission frequency is 433.92 MHz.

## 3. Specific Requirements

### 3.1 Functions

#### 3.1.1 Operational Description

The function of the receiver is to decode the information sent by the RTPMS transmitter and indicate the pressure to the end user. It is the responsibility of the customer to determine how the information is displayed to the end-user and what levels of warnings are given. SBII can however offer advice in this area. The display can be in the form of a display, bulbs, buzzer, or even voice synthesis to warn the driver of the abnormal pressures. Dependent on the state of the vehicle, the RTPMS transmitter will sense the actual tyre pressure and transmit the information in a specified format to the receiver. (See Appendix B Schrader RTPMS Protocol). The RTPMS transmitter is a transmit only device and cannot accept information or other stimuli other than for the "Learn" or "Roll" inputs. The RTPMS transmitter will always transmit the tyre pressure, but in addition, it will transmit the function of the particular word and transmitter identification. The functions are: Stationary, Wake, Drive, Low battery, Learn, Re-measure, Normal, Sleep and Off (See next section).

### 3.2 Transmitter System Modes

#### 3.2.1 Stationary Mode

The RTPMS transmitter may transmit over a regular interval while the vehicle is parked, this option is set at the Schrader factory. The block of data will use the normal pressure function code. The transmission rate while stationary is given in Section 3.3 (see also Appendix D Transmitter Functional Timing). This stationary mode is exited by a roll switch input to the custom ASIC. The RTPMS transmitter is considered to be in stationary mode if the roll switch has de-activated the ASIC input (open roll switch) for at least the duration of the Service Period (See Section 3.3) and has recognised at least one wake mode since system activation.

#### 3.2.2 Wake Mode

Once the vehicle has begun movement, a roll switch activates (closed roll switch) an ASIC input to activate the transmitter. The roll switch closes with a centrifugal acceleration of between 2 and 17 G. The speed at which the roll switch closes varies with each vehicle's wheel running diameter. As a guideline this will typically be between 11 and 32 km/h (7 and 20 mph). For the first transmission after the ASIC receives the signal, the data block will contain the function code for "Wake" mode (see Appendix B 4.2.6 Function Codes). All the other data will remain consistent within the format (start, ID, check sum). This will only be transmitted once, after the RTPMS transmitter has been in stationary mode and then "awakened". This is an extra transmission.

#### 3.2.3 Drive Mode

The RTPMS transmitter increases its rate of sampling and transmission when the vehicle is moving (roll switch closed). See Section 3.3 for exact values. The transmitter will remain in drive mode for a period of time known as the Service Period after the vehicle comes to rest (roll switch open). After the Service Period time has elapsed the transmitter returns to Stationary Mode.

### 3.2.4 Low Battery Mode

Battery life is designed to be 10 years or 160,000 km (100,000 miles), whichever comes first.

The circuit within the RTPMS transmitter monitors the battery every time a pressure measurement is taken. A "Low Battery" function code will be sent when the battery voltage within the transmitter is below a pre-selected level. Under typical conditions, the transmitter will remain active for at least 3 months after the first Low Battery transmission. During the 3 month period neither the RF power output nor the pressure measurement accuracy degrade in any way.

Note that battery voltage is a function of temperature. When approaching the end of the battery life, a Low Battery transmission may occur because of low ambient temperatures at the start of a trip. However, once the tyre starts rolling, the internal temperature rises and the battery voltage rises above the function code threshold.

### 3.2.5 Learn Mode

The receiver/decoder shall be able to distinguish this learn code and store the transmitter ID within its memory for future identification purposes. The memorisation or "learning" of the ID codes of the transmitters on the vehicles means that the receiver is capable of filtering out information coming from transmitters on adjacent vehicles. There are two types of Learn Mode response, depending on ASIC type.

**Magnetic Learn Activation Selected :** When the learn input on the transmitter ASIC is activated the next UHF transmission which follows 5 s after input activation will contain the function code for the "Learn" mode. While in this mode, the RTPMS transmitter will transmit five data blocks, 40 frames. When the transmission is complete, the RTPMS transmitter returns to the stationary mode. When the roll switch closes (i.e. the vehicle is moving) after the learn mode is complete, the transmitter goes into wake mode.

Note, the learn mode input is ignored until after a transmission or measurement if they are coincident. Once in the learn mode, the roll switch input is ignored. (see Appendix F)

**Transponder Learn Activation Selected :** When the learn input on the transmitter ASIC is activated the next transmission will consist of a 4 s LF frame burst, followed by a 5 s UHF transmission as described in Appendix F.

### 3.2.6 Re-measure Mode

This mode only occurs if the pressure is changing. The pressure in the tyre is periodically measured and transmitted at a pre-set interval (See Section 3.3 for values). If, during any measurement period, the current pressure sample is different by +/- 84 mbar (1.2 psi) from the last transmitted pressure value, a re-measure will occur immediately. This re-measure is done to verify the change in pressure. If the pressure has indeed changed, an additional transmission ( $\Delta P$ ) will be sent with the re-measure function code (see Appendix H). If the re-measure cycle occurs coincident with a regular transmission, the re-measure takes precedence and the regular transmission will be replaced by the re-measure transmission.

### *3.2.7 Normal Pressure*

Normal mode is considered a supervisory mode. During normal rolling and stationary (if applicable) operation, the transmitters will send out regularly scheduled pressure data associated with each wheel as a "state of health" of the system.

Unless in Wake, Low Battery, Learn, or Re-measure mode, all block data transmissions will contain the function code for Normal Pressure. Note, the transmitter does not make the decision of low pressure.

### *3.2.8 Sleep Mode*

Sleep mode is a low power mode during transmitter activation. It occurs in the time period between transmissions and measurements.

### *3.2.9 Off Mode*

This is a minimum power mode, mainly used for shipment and storage of the RTPMS transmitter units. Not all units will be shipped in this mode.

During the Off mode, all internal circuitry is disabled.

To exit the Off mode, activate the learn or roll switch continuously for four seconds (putting the transmitter into learn mode).

If the Off mode is inadvertently entered, the transmitter will send a one-second block of eight frames of Off code and then the transmitter will go off completely. This mode should only be entered by Schrader Bridgeport personnel.