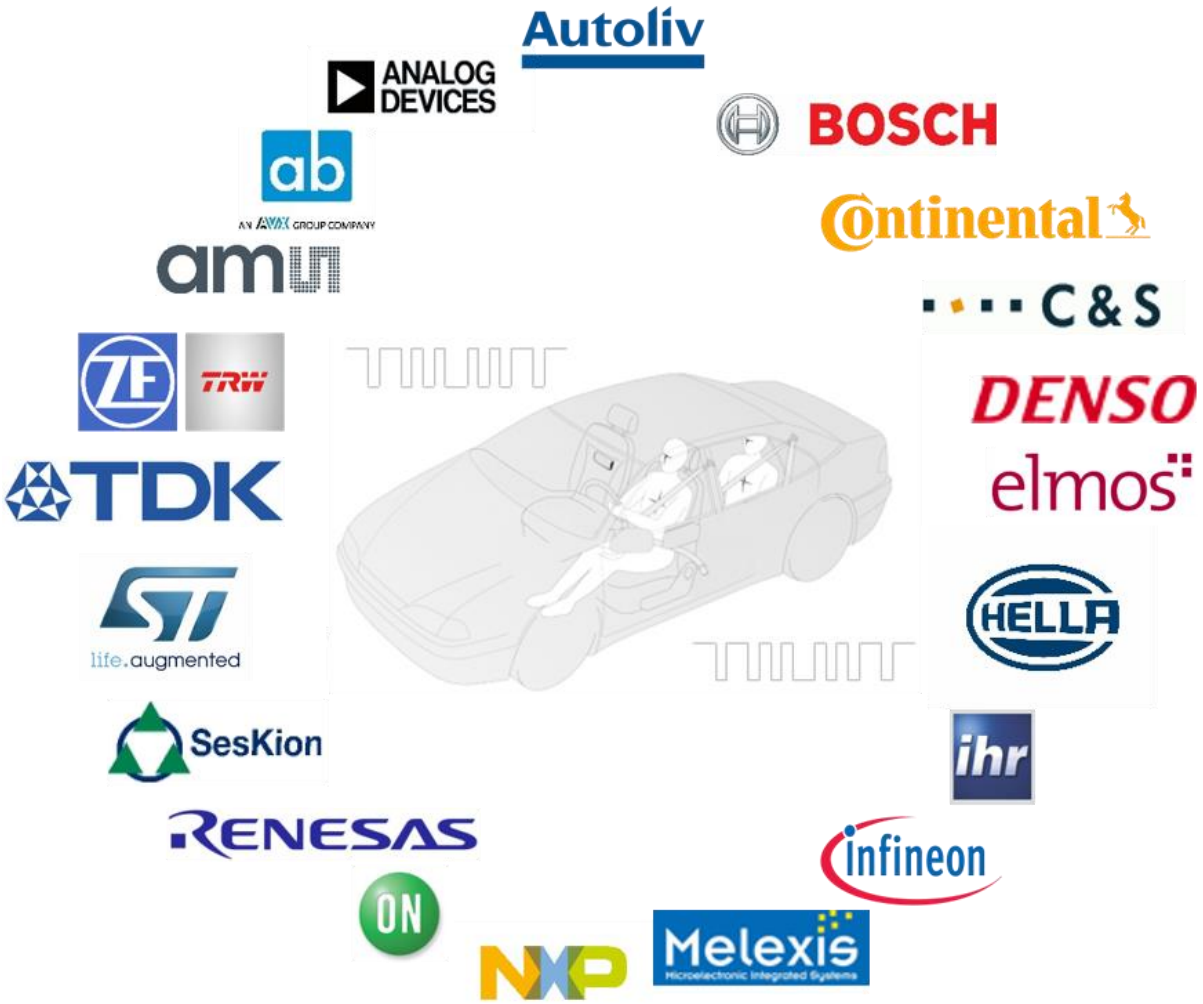
Peripheral Sensor Interface for Automotive Applications

Substandard Powertrain



Contents

1 Introduction

The Substandard Powertrain substantiates the Base Standard document with the proposed operation modes and frames formats for all sensors and transceivers used in powertrain applications.

Please be aware, that not every feature can be combined with every other one. Hence it is the responsibility of the system vendor to evaluate which features are necessary to fulfill the system requirements and ensure that the combination of features is compatible.

This substandard is effective with the PSI5 Base Specification standard V2.3 and all following versions of the PSI5 Base Specification and is valid for all powertrain components. The document is structured in a similar way to the PSI5 V2.3 Base Specification: Chapter 3.1 and 3.2 define details of the data link layer for Sensor to ECU or ECU to Sensor communication respectively. In chapter 0 specific physical layer system parameters for powertrain applications are given, chapter describes application layer implementations and in chapter 0 possible operation modes are defined.

2 Definition of Terms

12 See chapter 2 of PSI-5 V2.3 Base Standard.

3 Data Link Layer

3.1 Sensor to ECU Communication

3.1.1 Data Frame

All parts of the PSI5 Frame as defined in PSI5 Base Specification V2.3 can be applied.
An example of a payload data region for one signal transmission is given in Table 1. A 15bit payload data region, together with two start bits and three CRC bits for error detection, comprises the signal transmission.
The payload data region is composed of a 12bit Data Region A, two serial messaging bits and one status bit.

Table 1: Example of payload data region

Bits	function	Number of bits	comment
M0, M1	Messaging	2	Serial messaging channel
E0	Status	1	
A0 … A[11]	Data	12	Data Region A (Sensor Data)

3.1.2 Serial Channel

The data content definition of the serial data frame of the serial channel is according to the definitions of SAE J2716 APR2016 SENT, Appendix D.1 to D.6 with details and exceptions as described in this chapter.
The composition of a serial message with a serial data frame out of the messaging bits is according to PSI5 Base Specification V2.3, chapter 3.1.4. The PSI5 Base Specification V2.3, chapter 3.1.4 follows SAE J2716 APR2016 SENT, chapter 5.2.4.2 Enhanced Serial Message Format and ch. 5.2.4.3 Enhanced Serial Message Format CRC.
All channel definition in SAE J2716 APR2016 SENT with Channel 1 refers to Data Region A and Channel 2 refers to Data Region B of PSI5 Frame Format.

3.1.3 8bit Serial ID

The list of valid 8bit serial IDs is described in SAE J2716 APR2016 SENT, Appendix D.1.
With the message ID 0x05 the Vendor ID is transmitted in the 12bit data field with assignments given in PSI5 Base Specification V2.3, chapter 5.2.4. The assigned 8 bit values of the Vendor ID are mapped into 12 bit data field of the serial data frame starting LSB first with 4 MSB filled up with the value 0.
With the 8 bit Message ID 0x06 the protocol standard revision is transmitted with 12 bit data field definition.

3.1.4 Protocol Standard Revision

With the message ID 0x06 the protocol standard revision is transmitted in the 12 bit data field of the serial data frame. The list of 12 bit codes which shall be used is given hereafter in Table 2.
.

Table 2: List of 12bit codes for Protocol standard revision

12 bit Code	Definition	Comment
0x000	not specified	
0x001 – 0x0FF	reserved for SENT Protocol Standard Revisions	
0x100	PSI5 2.0	
0x101	PSI5 2.1	
0x102	PSI5 2.2	
0x103	PSI5 2.3	
x104 - 0xFFE	reserved	
0xFFF	not specified	

3.2 ECU to Sensor Communication

The optional ECU to Sensor Communication is realized using the “Pulse Width” method as specified in PSI5 Base Specification V2.3, chapter 4.6.2. (physical layer) and chapter 3.2.3 (data link layer).

The Frame format for the ECU to sensor communication is Frame 4 "XXLong" with configuration bit [0] according to PSI5 Base Specification V2.3, chapter 3.2.3.

Synchronization pulses with a pulse width beyond the specified range (sync signal sustain time <16µs or >62µs) are ignored by the sensor.

4 Physical Layer

4.1 General

39 See chapter 4.1 of PSI-5 V2.3 Base Standard.

4.2 Supply Line Model

40 See chapter 4.2 of PSI-5 V2.3 Base Standard.

4.3 Single Sensor, Point to Point Topologies

41 See chapter 4.3 of PSI-5 V2.3 Base Standard.

4.4 Multi Sensor, Bus Topologies

42 See chapter 4.4 of PSI-5 V2.3 Base Standard.

4.5 Sensor to ECU Communication

Table 3: Parameter specification of sensor to ECU communication (related to the sensor)

N°	Parameter	Symbol	Conditions/Remark	Min	Typ	Max	Unit
1*	Sensor clock deviation during data frame	CDs	Standard			1	%

43 1*) @ maximum temperature gradient and maximum frame length; the overall transmitter clock tolerance must not
44 be exceeded.

4.6 ECU to Sensor Communication

45 The optional ECU to Sensor Communication is realized using the “Pulse Width” method as specified in PSI5
46 Base Specification V2.3, chapter 4.6.2. (physical layer) and chapter 3.2.3 (data link layer).

4.7 General Parameters

47 The PSI5 interface implementation can be made with the following parameters by either applying the “Common
48 Mode” or the “Low Power Mode” as specified in PSI5 Base Specification V2.3, chapter 4.7.1.

Table 4: System parameter specification

N°	Parameter	Symbol	Conditions/Remark	Min	Typ	Max	Unit
1	ECU internal resistance	R_E	Standard $R_E = R_{E1} + R_{E2}$	5		9.5	Ω
2*	Supply Voltage @ Sensor	V_{SS}	Low Voltage	4.0		16,5	V

N°	Parameter	Symbol	Conditions/Remark	Min	Typ	Max	Unit
3*	Base Supply Voltage @ Sensor	$V_{SS, BASE}$	Low Voltage	4.0		11,0	V
4	Supply Voltage @ ECU	V_{CE}	Low Voltage	4.2		16,5	V
5	Base Supply Voltage @ ECU	$V_{CE, BASE}$	Low Voltage	4.4		11,0	V
6	Sink current @ Sensor	ΔI_S	Common mode; $\Delta I_S = I_{S,High} - I_{S,Low}$	22.0	26.0	30.0	mA
7			Low power mode; $\Delta I_S = I_{S,High} - I_{S,Low}$	11.0	13.0	15.0	mA

2*) In any case during normal operation VSS, min shall not be violated. This includes dynamic effects like ripple voltage.

3*) Mean voltage value at the sensor pins without communication and synchronization pulse (static)

Due to standard sensor sink signal current in combination with low supply voltage, special attention needs to be paid concerning sensor power dissipation and supply voltage ripples.

4.8 Dynamic Bus Behavior

See chapter 4.8 of PSI-5 V2.3 Base Standard.

4.9 Synchronization Signal

The synchronization signal shall be implemented using the Reduced Sync Pulse Scheme as defined in PSI5 Base Specification V2.3, chapter 4.9 with parameter values given in Table 53*) Referenced to $V_{SS, BASE}$.

Table 5: Synchronization Signal Parameters for Reduced Synch Pulse Scheme

N°	Parameter	Symbol	Conditions/Remark	Min	Typ	Max	Unit
1	Sync signal sustain voltage	V_{t2}	Reduced Sync Pulse Scheme; Referenced to $V_{SS, BASE}$	2.5			V
2	Margin for voltage variations of the signal on the interface line due to EMC effects	V_{EMC}	Reduced Sync Pulse Scheme	-0.7		+0,7	V
3*	Sensor trigger threshold	V_{TRIG}	Reduced Sync Pulse Scheme; Sensor to detect trigger	1,2	1,5	1,8	V

3*) Referenced to $V_{SS, BASE}$

4.10 Timing Definitions for Synchronous Operation Modes

See chapter 4.10 of PSI-5 V2.3 Base Standard.

4.11 Sensor Power-on Characteristics

To ensure a proper startup of the system in powertrain applications the parameters and definitions for Sensor Bus Configuration of PSI5 Base Specification V2.3, chapter 4.11.1 shall be applied except for Daisy Chain Bus which is not applicable.

An Extended Settling Time t_{SET2} as defined in PSI5 Base Specification V2.3, chapter 4.11.2 is not allowed.

4.12 Undervoltage Reset and Microcut Rejection

For powertrain sensors, an undervoltage reset is optional and should be defined component specific, if implemented.

If sensor supply voltage drops below $V_{SS, min}$ no reset of the sensor is allowed between $V_{SS} = V_{SS, min} = 4.0V$ and $V_{SS} = 3,8V$.

The functional performance within this sensor supply voltage range is defined as follows:

- Sensor can interrupt data transmission but must not restart internal initialization.
- If the sensor continues sending data it must be within the sensor specification or clearly marked as corrupt.
- Sensor must continue data transmission when voltage returns to normal operation within the next transmission period.

5 Application Layer

5.1 Data Range

73 The Data Range definition is according to PSI5 Base Specification V2.3, chapter 5.1 with the following
74 definitions specifically for the powertrain application.

5.1.1 Data Region A

Table 6 Definition of Data Region A with 10bit

Value		Definition		Range	
Dec	Hex				
+511	0x1FF	Reserved (ECU internal use) *1		Status & Error Messages	2
:	:	Reserved (ECU internal use) *1			
+504	0x1F8	Reserved (ECU internal use) *1			
+503	0x1F7	Reserved (Sensor use) *2	Powertrain Substandard		
+502	0x1F6	Reserved (Sensor use) *2			
+501	0x1F5	Free to define by OEM/Supplier *4			
+500	0x1F4	PSI5: “Sensor Defect”			
+499	0x1F3	Reserved (ECU internal use) *1			
:	:	Reserved (ECU internal use) *1			
+496	0x1F0	Reserved (ECU internal use) *1			
+495	0x1EF	Reserved *4	Powertrain Substandard		
+494	0x1EE	Reserved *4			
+493	0x1ED	Temporary sensor error indication *4			
+492	0x1EC	Sensor functionality and processing error indication *4			
+491	0x1EB	Not a valid measurement value *4			
+490	0x1EA	Initialization *4			
+489	0x1E9	“Sensor in Service Mode”			
+488	0x1E8	“Sensor Busy”			
+487	0x1E7	“Sensor Ready”			
+486	0x1E6	“Sensor Ready but Unlocked” *3			
+485	0x1E5	Reserved (Sensor use) *2			
+484	0x1E4	Reserved (Sensor use) *2			
+483	0x1E3	Reserved (Sensor use) *2			
+482	0x1E2	Bidirectional Communication: RC “Error”			
+481	0x1E1	Bidirectional Communication: RC “O.K.”			
+480	0x1E0	Maximum Sensor Data Value	Powertrain Substandard	Sensor Output Signal	1
:	:	:			
0	0x000	:			
:	:	:			
-480	0x220	Minimum Sensor Data Value			
-481	0x21F	Status Data 1111			3
:	:	:			
-496	0x210	Status Data 0000			

Value		Definition		Range	
Dec	Hex				
-497	0x20F	Block ID 16		Block ID's and Data for Initialization	
:	:	:			
-512	0x200	Block ID 1			

*1) Usage for ECU internal purpose possible (e.g. “No Data”, “Manchester Error” etc.)

*2) Reserved for future extensions of this specification. These data values may not be assigned to any other use.

*3) Indication for Sensor in “Production State” with powertrain application

*4) Specific Definition of Powertrain Substandard

The scaling of Data Range A for data words longer than 10 bit is to be done as defined with PSI5 Base Specification V2.3, chapter 3.1.3 except that the remaining unused bits are to be filled up with the value 0.

5.1.2 Data Region B

Data values in Data Region B (m bit) can be used in two different ways:

- Transparent Mode with free use of all m bits
- Measurement Data Mode with transmission of measurement data and 8 reserved values for powertrain messaging (unsigned m bits)

In the Transparent Mode all data values from 0 to 2^m-1 are available. This mode can be used for example for the transmission of rolling counter values.

In the Measurement Data Mode out of the m bits with values from 0 to 2^m-1 eight values are assigned to Error Indicators, Specific and Initialization Messages as defined in chapter 5.1.2.1. Accordingly this mode has to be defined with Data Region B with m ≥ 3 bit, however typically a definition of m = 8,10,12 bit will be done for reasonable transmission of sensor measurement data.

5.1.2.1 Data Region B: Reserved Values in Measurement Data Mode

91 Table 7 defines the assignment of the eight reserved addresses to Error Indicators, Specific and Initialization
92 Messages if the measurement data mode is applied for Data Region B.

Table 7: Error Indicators / Specific Messages / Initialization Message

Value (m=12bit Data)		Definition	Comment
2^m-1	4095	Production state	Used to indicate production state of sensor (e.g. for manufacturing purposes)
2^m-2	4094	Free to define by OEM/Supplier	
2^m-3	4093	Reserved	
2^m-4	4092	Reserved	
2^m-5	4091	Temporary sensor error indication	Generic temporary error
2^m-6	4090	Sensor functionality and processing error indication	Sensor status: Signal processing and sensor functionality errors
2^m-7	4089	Not a valid measurement value	Invalid data values, not-a-number (or measurements with reduced reliability)
0	0	Initialization	The initialization message is transmitted during the sensor initialization phase until valid measurement values are available.

5.1.3 Error Indicators, Specific and Initialization Messages in Data Region A and B

93 Table 8 shows how the powertrain application specific Error Indicators, Specific and Initialization Messages
94 are assigned to values of Data Region A and B.

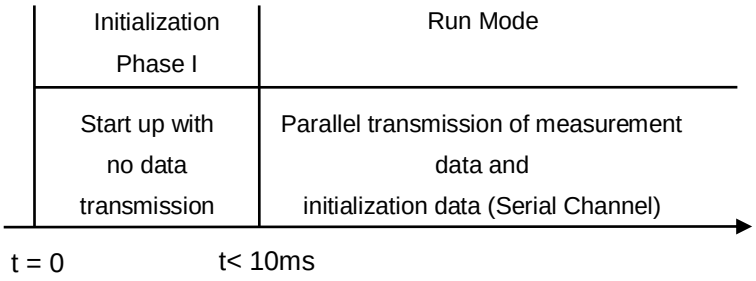
Table 8: Addresses of Error Indicators, Specific and Initialization Messages in Data Region A and B

Message Definition	Value	
	Data Region A	Data Region B
Production state	2^{n-1}-26·2^{n-10}	2^m-1
Free to define by OEM/Supplier	2^{n-1}-11·2^{n-10}	2^m-2
Reserved	2^{n-1}-17·2^{n-10}	2^m-3
Reserved	2^{n-1}-18·2^{n-10}	2^m-4
Temporary sensor error indication	2^{n-1}-19·2^{n-10}	2^m-5
Sensor functionality and processing error indication	2^{n-1}-20·2^{n-10}	2^m-6
Not a valid measurement value	2^{n-1}-21·2^{n-10}	2^m-7
Initialization	2^{n-1}-22·2^{n-10}	0
Reserved (Sensor use)	2^{n-1}-9·2^{n-10}	-
Reserved (Sensor use)	2^{n-1}-10·2^{n-10}	-

5.2 Sensor Initialization / Identification

95 Sensor Initialization and Identification is executed in Serial Channel Method according to PSI5 Base
96 Specification V2.3, chapter 5.2.

97 After power up of the system the Initialization Phase I follows where no data is transmitted and the ECU can
98 perform a connectivity test or sensor self tests can be executed.



99 *Figure 1 Initialization of the Bus*

100 With application of the Serial Channel Method some constraints and requirements as defined with SAE J2716
101 APR2016 SENT, Appendix D.7 have to be considered.

6 System Setup & Operation Modes

6.1 System Setup

102 See chapter 6.1 of PSI-5 V2.3 Base Standard.

6.2 PSI5 Operation Modes

103 Table 9 shows the possible operation modes for use in powertrain applications.

104 These selected operation modes for powertrain application exclude the use of synchronous daisy chain bus

105 mode (PSI5-D) and defines a 125kbps data rate. A maximum of six time slots per sync period can be defined.

Table 9: Powertrain operation modes

Communication Modes	
A	Asynchronous Mode
P	Synchronous Parallel Bus Mode
U	Synchronous Universal Bus Mode
V	Variable Time Triggered Synchronous Operation Mode
Error Detection	
CRC	Three Bits Cyclic Redundancy Check
Bit Rate	
L	125 kbps
Cycle time	
tttt	cycle time in µs (e.g. 500)
	or minimum allowed cycle time in µs for variable time triggered operation (e.g.. 228)

7 Interoperability Requirements

106 See chapter 7 of PSI-5 V2.3 Base Standard.

8 Document History & Modifications

Rev.N°	Chapter	Description / Changes	Date
2.0	all	First Release of Powertrain Substandard; Revision Number of corresponding PSI5 Base Document adopted	01.06.2011
2.1	all	Editorial changes	05.10.2012
	3.1	Chapter added: Data Range	
	3.2	Chapter added: Serial Channel	
	5.1	Mandatory transmission of Meta Header during initialization removed Link to SAE J2716 JAN2010 SENT added	
	6	Optional definition of sensor undervoltage reset added Supply voltage range added where no sensor reset is allowed	
	6.3	Chapter added: Data Transmission Parameters	
2.2	all	Editorial changes	18.05.2016
	div.	Reference to PSI5 Base Specification changed from V2.1 to new version V2.2	
	div.	Reference to SAE J2716 SENT changed from JAN2010 to new released version APR2016	
	3.2.2	12 bit code for Protocol Standard Revision PSI5 V2.2 added	
	6.1	Table 7 and table 8 added to replace System Parameter definitions within text body	
	6.2	Chapter added: Sensor Power-on Characteristics	
	6.4	Table 9 update due do change in Base Standard including Footnote	
2.3 draft	all	Rearrangement and editorial changes based on the structural changes in PSI5 Base Specification V2.3	15.05.2017