Peripheral Sensor Interface for Automotive Applications

Substandard Powertrain

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

Contents

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

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 V2.1. and all following versions of the PSI5 Base Specification and is valid for all power train components.

The document is structured in a similar way to the PSI5 V2.1 Base Specification: chapter 2 gives recommended operation modes, whereas chapter 3 and 4 define details of the Sensor to ECU, or the ECU to Sensor communication respectively. Chapter 5 describes Application Layer Implementations and in chapter 6 specific system parameters for powertrain applications are given.

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

14 # 2 Operation Modes

15 Table 1 shows the possible operation modes for use in powertrain applications.

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)

16 *Table 1 Powertrain operation modes*

17 The above selected operation modes exclude the use of synchronous daisy chain bus mode (PSI5-D) and
18 defines a 125kbps data rate.

19 A maximum of six time slots per sync period can be defined.

20

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

3 Sensor to ECU communication

All parts of the PSI5 Frame as defined in PSI5 Base Specification V2.1 can be applied.

An example of a payload data region for one signal transmission is given in Table 2. 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.

Bits	function	Number of bits
M0 … M1	Serial messaging channel	2
E0	status	1
A0 … A11	Sensor Data [Data region A]	12

Table 2 Example of payload data region

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

3.1 Data Range

The Data Range definition is according to PSI5 Base Specification V2.1, chapter 3.3 with the following definitions specifically for the powertrain application.

3.1.1 Data Region A

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			
+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	Powertrain Substandard		
+494	0x1EE	Reserved			
+493	0x1ED	Temporary sensor error indication			
+492	0x1EC	Sensor functionality and processing error			
+491	0x1EB	Not a valid measurement value			
+490	0x1EA	Initialization			
+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		Block ID's and Data for Initialization	3
:	:	:			
-496	0x210	Status Data 0000			
-497	0x20F	Block ID 16			
:	:	:			
-512	0x200	Block ID 1			

Table 3 Definition of Data Region A with 10bit

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

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

(*2) Reserved for future extensions of this specification, usage not recommended.

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

The scaling of Data Range A for data words longer than 10 bit is to be done as defined with PSI5 Base Specification V2.1, chapter 3.3.2 except that the remaining unused bits are to be filled up with the value 0.

3.1.2 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 3.1.2.1. 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.

3.1.2.1 Data Region B: Reserved Values in Measurement Data Mode

Table 4 defines the assignment of the eight reserved addresses to Error Indicators, Specific and Initialization Messages if the measurement data mode is applied for Data Region B.

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.

Table 4 Error Indicators / Specific Messages / Initialization Message

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

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

Table 5 shows how the powertrain application specific Error Indicators, Specific and Initialization Messages are assigned to values of Data Region A and B.

Message Definition	**Value**	
	Data Region A	**Data Region B**
Production state	$2^{n-1}-26\cdot2^{n-10}$	$2^{m}-1$
Free to define by OEM/Supplier	$2^{n-1}-11\cdot2^{n-10}$	$2^{m}-2$
Reserved	$2^{n-1}-17\cdot2^{n-10}$	$2^{m}-3$
Reserved	$2^{n-1}-18\cdot2^{n-10}$	$2^{m}-4$
Temporary sensor error indication	$2^{n-1}-19\cdot2^{n-10}$	$2^{m}-5$
Sensor functionality and processing error indication	$2^{n-1}-20\cdot2^{n-10}$	$2^{m}-6$
Not a valid measurement value	$2^{n-1}-21\cdot2^{n-10}$	$2^{m}-7$
Initialization	$2^{n-1}-22\cdot2^{n-10}$	0
Reserved (Sensor use)	$2^{n-1}-9\cdot2^{n-10}$	-
Reserved (Sensor use)	$2^{n-1}-10\cdot2^{n-10}$	-

Table 5 Addresses of Error Indicators, Specific and Initialization Messages in Data Region A and B

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

3.2 Serial Channel

The data content definition of the serial data frame of the serial channel is according to the definitions of SAE J2716 JAN2010 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 V2.1, chapter 3.4.
The PSI5 Base Specification V2.1, chapter 3.4.follows SAE J2716 JAN2010 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 JAN2010 SENT with Channel 1 refers to Data Region A and Channel 2 refers to Data Region B of PSI5 Frame Format.

3.2.1 8bit Serial ID

The list of valid 8bit serial IDs is described in SAE J2716 JAN2010 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 V2.1, chapter 5.1.3. 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 given in chapter 3.2.2.

3.2.2 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 is given hereafter in Table 6.

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

Table 6 List of 12bit codes for Protocol standard revision

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

4 ECU to Sensor (bidirectional) communication

The optional ECU to Sensor Communication is realized using the “Pulse Width” method as specified in PSI5 Base Specification V2.1, chapter 4.1.2.

The Frame format for the ECU to sensor communication is Frame 4 "XXLong" with configuration bit [0] according to PSI5 Base Specification V2.1, chapter 4.2..

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

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

5 Application Layer Implementations

5.1 Sensor start up an identification

Sensor start up and identification is executed in Serial Channel Method according to PSI5 Base Specification V2.1, chapter 5.1.

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

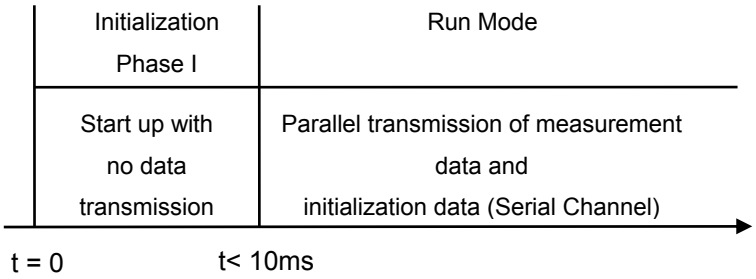

Figure 1 Initialization of the Bus

With application of the Serial Channel Method some constraints and requirements as defined with SAE J2716 JAN2010 SENT, Appendix D.7 have to be considered.

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

6 Physical Layer - Parameter Specification

6.1 System Parameters

The PSI5 interface implementation can be made with the following listed selected parameters by either applying the “Common Mode” or the “Low Power Mode” as specified in PSI5 Base Specification V2.1, chapter 6.1.2.

Common Mode

- Supply Voltage: $V_{CE,\,min}$ = 4.2V; $V_{SS,\,min}$ = 4.0V
- Sync signal sustain voltage : V_{t2} = 2.5V
- Internal ECU Resistance: $R_{E,\,max}$ = 9.5Ω

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.

Low power mode

- Supply Voltage $V_{CE,\,min}$ = 4.2V; $V_{SS,\,min}$ = 4.0V
- Sync signal sustain voltage V_{t2} = 2.5V
- Internal ECU Resistance $R_{E,\,max}$ = 9.5Ω

6.2 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} = 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.

6.3 Data Transmission Parameters

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

Table 7 Data transmission parameters for powertrain applications

3*) @ maximum temperature gradient and maximum frame length

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.

128 7 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	Editoral 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	

All rights including industrial property rights and all rights of disposal such as copying and passing to third parties reserved.