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Development Of Testing Tool For PSI5 Sensors

For Automotive Applications

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Abstract — *Peripheral Sensor interface (PSI5) is one of the emerging communication protocol for automotive sensor applications. There is a need to develop the testing tool for PSI5 sensors which eases the development of sensors.The testing tool for PSI5 sensors is an interface box which provides fast data acquisition and has the capacity respond to the circumstance utilizing simulated data.In this project, for the purpose of evaluating the PSI5 sensors the testing tool is developed. In the testing tool ,the simulated sensor data is fed as the input to the PSI5 module where the data gets converted to PSI5 frame format and Manchester encoded. For the purpose of data transfer between sensor and PSI5 module Automotive Electronics Interface (AEI) is chosen. The encoded data from PSI5 module is given to the Manchester decoder module .This decoded data is compared with the input simulated sensor data for sensor evaluation. All the modules required for the development of testing tool are coded using VHDL and further simulated using Modelsim ALTERA starter edition 10.1d.The testing tool for PSI5 sensors verifies all the sensor mode data and thus helps in evaluation.*

Keywords- *peripheral sensor interface(PSI5);Automotive electronics interface(AEI);Manchester encoding;PSI5 sensors;electronic control unit(ECU);sensor data;PSI5 frame;*

I. INTRODUCTION

Today's vehicles have become exceedingly perplexing modern electronic control frameworks and the major share of advancements have been exclusively attained to through electronics and the utilization of cutting edge sensors.The pattern towards perpetually expanding utilization of electronically controlled electrically impelled frameworks on vehicles (for instance, electrically powered steering, semi-active ride control, slip control systems and adaptive cruise control) has made new difficulties and open doors for sensor designers. Customary sensors have been supplemented by the expansion of new sensors for new applications. Sensors are crucial part of automotive electronic control systems.Sensors are characterized as the devices that transform (or transduce) physical quantities such pressure or acceleration (called measureands) into output signals (usually electrical) that serve as inputs for control frameworks.The need for sensors is evolving and is progressively growing. Automotive engineers are challenged by a huge number of stringent prerequisites.. Hence sensor needs to provide fast and accurate information in automotive applications. This data is required for deciphering driving qualities. The reliability and continued advancement of sensors and their cutoff points must be guaranteed by experiencing tests, optimization and quality controls. Data from the sensor and control unit must be assessed and test circumstances need to be simulated.

Communication protocols in-vehicle systems administration is a technique for exchanging information from sensors to different appropriated modules via a serial data bus or by mean of wireless. Automotive communication protocols are changing rapidly as users and systems are demanding more information to be available in-vehicle.Embedded system predominantly utilizes serial communication to exchange information with peripherals. Therefore serial communication plays significant role in embedded system design. Numerous communication protocols are used like Universal Asynchronous Receiver Transmitter (UART), Control Access Network (CAN), Peripheral Sensor interface (PSI5), Universal Serial Bus (USB), Serial Peripheral Interface (SPI) and Inter IC Protocol (I2C).Serial communication protocol have characteristic of high speed and low information loss and it simplifies system level design and guarantee information exchange. Peripheral Sensor interface (PSI5) is one of the emerging communication protocols for automotive sensor applications. For the evaluation and test simulation of PSI5 sensors, there is a greater need to develop a testing tool for the same. With the help of PSI5 sensors testing tool the development of PSI5 sensors becomes easy. The testing tool can be considered as an interface box which provides fast data acquisition and has the capacity respond to the circumstance utilizing simulated data.

II. OVERVIEW OF PERIPHERAL SENSOR INTERFACE(PSI5)

The Peripheral Sensor Interface (PSI5) is a current interface mainly used for automotive sensor applications. PSI5 is an open standard in view of existing sensor interfaces mainly utilized for the peripheral airbag sensors, effectively demonstrated in numerous airbag systems. PSI5 standardizes the low level data exchange between peripheral sensors and electronic control units. The specialized technical attributes, the low implementation overhead and also the alluring cost make the PSI5 additionally suitable for some other automotive sensor applications. Improvement objective of the PSI5 is an adaptable, reliable communication standard for automotive sensor applications that can be utilized and executed free of cost. PSI5 is a current interface which uses the modulation of the sending current for the transmission of information on the power supply lines. The relatively high sending current and the utilization of a Manchester code for bit encoding result in high resistance against obstruction from radiated emanations. The utilization of a less expensive twisted pair cable is hence adequate for a large portion of the applications, However, in automotive more extravagant cabling is utilized.

A. Main Features of Peripheral Sensor Interface(PSI5)

Primary highlights of the PSI5 are high speed and high reliability information exchange at least implementation overhead and expense. PSI5 covers the prerequisites of the low-end section of advanced digital automotive interfaces and offers an all inclusive and adaptable solution for numerous sensor applications.It is characterized by the following features:

- PSI5 is a current interface which is two-wire
- Data transmission is digital where the bits are Manchester encoded.
- PSI5 supports high speed of 125kbps or optional 189kbps
- High ElectroMagnetic Compatibility (EMC) strength and low radiation
- Extensive variety of sensor supply current
- Flexible data word span (10 to 28 bit with one bit granularity)
- Asynchronous or synchronous operation and diverse bus modes
- Bidirectional communication

B. Operational modes of Peripheral Sensor Interface(PSI5)

The different PSI5 operation modes define various topologies and parameters of the communication between sensors and the peripherals such as communication mode, number of data bits, error detection, cycle time, number of time slots per cycle and bit rate are shown in the Figure 1 and the modes are specified in Table 1.

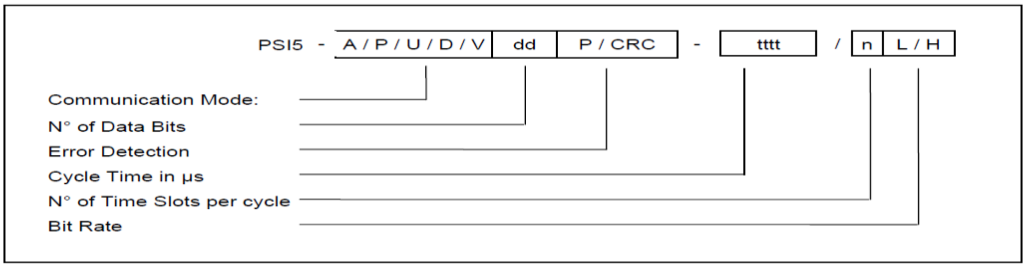

Figure 1. PSI5 operation modes illustration

Communication Modes	
A	Asynchronous Mode
P	Synchronous Parallel Bus Mode
U	Synchronous Universal Bus Mode
D	Synchronous Daisy Chain Bus Mode
V	Variable Time Triggered Synchronous Operation Mode
Error Detection	
P	One Parity Bit
CRC	Three Bits Cyclic Redundancy Check
Bit Rate	
L	125 kbps
H	189 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)

Table 1.Various PSI5 communication modes

C. Sensor to ECU Communication using Peripheral Sensor Interface(PSI5)

PSI5 consists of two wires which are used for both power supply to the sensors and transmission of the data. A pre-regulated voltage is provided by ECU to the sensor. PSI5 uses current modulation on the power supply lines for the data transmission from sensor to Electronic control unit .Current oscillations are restrained by the ECU and the sensor's input impedances.

D. Frame Format of Peripheral Sensor Interface(PSI5)

The data frames which are in the PSI5 frame format are sent periodically to the ECUfrom the sensor. The frame format is given in the Figure 2. A minimum gap time T-Gap which has to be large compared to one maximum bit duration.A gap pf T-Bit is necessary between two consecutive data frames. Each PSI5 data frame consists of *p*number of bits which contains:

- Two bits at the beginning of the frame called as start bits (S1 and S2), which are always coded as "0"
- one parity bit (P) which is calculated as even parity or alternatively 3 CRC bits (C0, C1, C2) calculated using the polynomial $1+x+x^3$ and
- a payload data region (D0 … D[n-1]) with n = 10.. 28 bit where n is the number of bits.

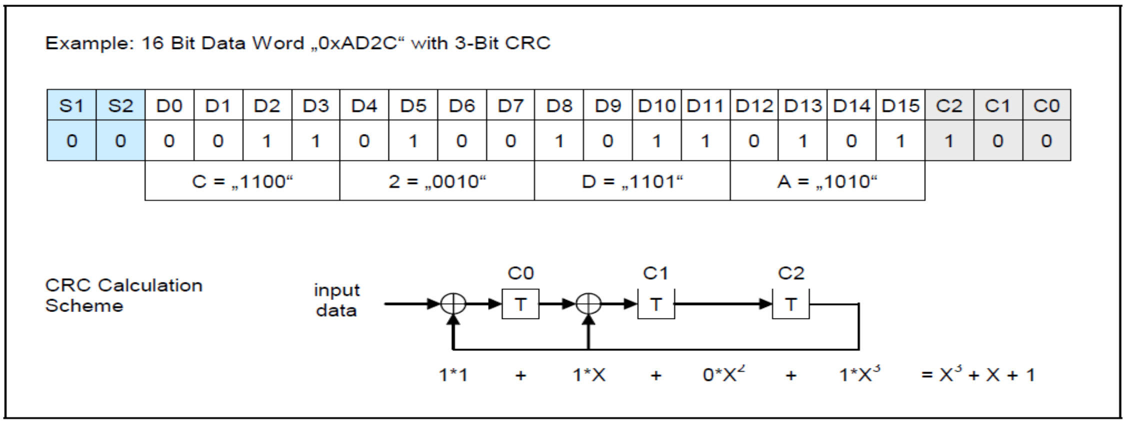

Figure 2.PSI5 Frame Format with start bits, payload data and 3-Bit CRC

E.Automotive Electronics Interface(AEI)

The AEI is a parallel synchronous master / slave address / data bus. Synchronous means, the complete bus has to be located in a single (same) clock domain. If a clock domain crossing is necessary e.g. for a single node, an AEI Clock Domain Crossing Bridge has to be used or the crossing has to be implemented between the AE- Interface and the dedicated module.

III. DESIGN AND IMPLEMENTATION

A. The Overview Of Working Of PSI5 Sensor Testing Tool

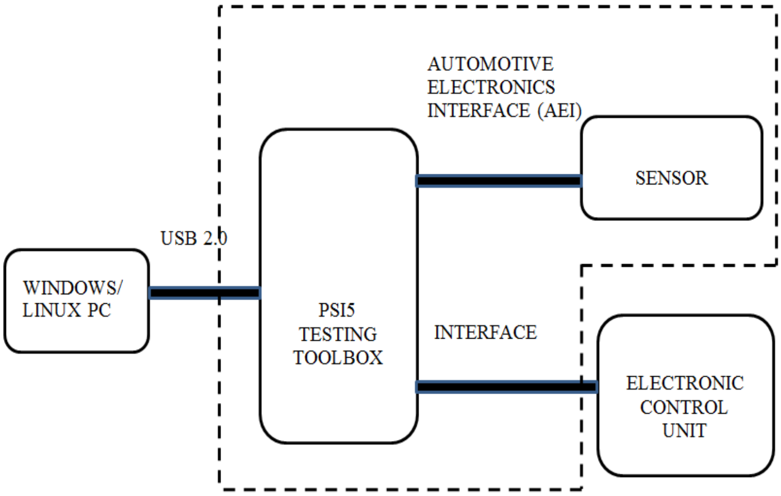

Figure 3.Block diagram for PSI5 testing tool

The testing tool for PSI5 sensors consists of various components as specified in the Figure 3. The working of testing tool for the PSI5 sensors is as follows.

- The software application of the PSI5 sensor testing tool is installed on Windows/Linux PC.
- Upon starting the program the connection to the PSI5-Simulyzer will be automatically detected.
- Before starting the program the initial configuration of the PSI5-Bus has to be done.
- The connection between windows/linux pc and testing tool is done through USB 2.0 interface.
- The data transfer between sensor to the testing tool is done through Automotive electronics interface.
- The sensor data is given to the testing tool for the validation of sensor working.
- The same way ECU condition can be evaluated by sending the ECU data over other interface.

B. The Working Of Integrated PSI5 Block

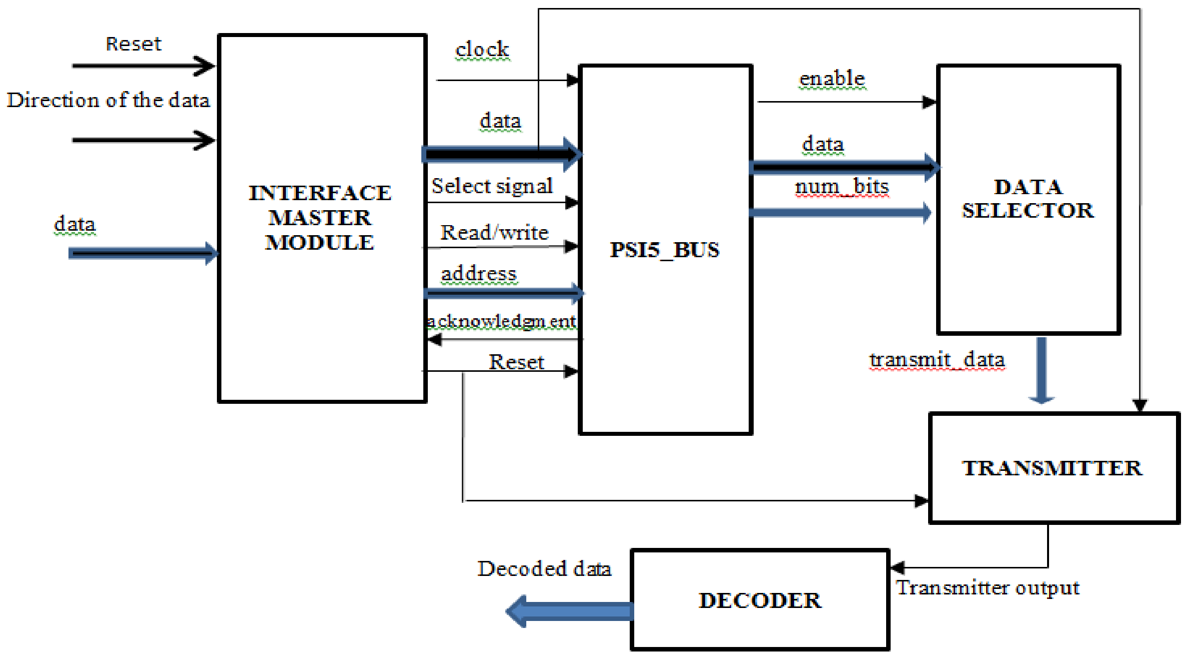

Figure 4.Block diagram for Integrated PSI5 module

The Integrated PSI5 module works as follows:

- The primary inputs to the testing tool are clock and the active low reset signal as shown in the Figure 4. When the reset signal is made low, all the signals, registers and the variables are initialized with their default values.
- The 16 bit data is given to the master from the sensor and the direction of the data whether the operation is data read or data write is given by the application running on the PC.
- InterfaceMaster sends the 16 bit data to the PSI5 bus and specifies the address of the register to which the data has to be written.
- The PSI5 bus stores the data in one of the 16-registers and computes the cycle time, bit half time and start slot time from the data available.
- When the PSI5 bus is enabled the sensor data and the number significant of bits in the data is sent to the data selector which sends the data to the transmitter.
- The transmitter converts the 16 bit data into PSI5 frame by appending two start bits and three bit CRC.
- The data along with the start bits and the CRC is Manchester coded finally the output from the transmitter is given to the decoder module which decodes the PSI5 frame and the data is extracted from the PSI5 frame.
- The 16 bit output from the decoder module is compared with the incoming data in order to ensure that all the blocks mentioned above are working desired.

IV.SIMULATION RESULTS

The integrated PSI5 top module, Interface master module and decoder module are validated for various inputs in the simulation process. All these specified modules required for the simulation are coded using VHDL and further simulated using Modelsim ALTERA starter edition 10.1d. The simulated sensor data is the input to the Interface master module which is further processed and encoded in PSI5 module. These encoded data bits is fed as input to the decoder block. As a final result the decoded data bits has to be matched with the input simulated sensor data. For the simulation purpose various range of simulated sensor data are considered. Each of this simulated sensor data signifies the different states/modes of sensor such as hex'01E9' for sensor in diagnostic mode, hex'01E8' for sensor busy mode, hex'01E7' for sensor ready mode, hex'01E6' for sensor ready but unlocked mode,hex'021' for data offset and hex'020' for id offset.

A. Simulation Results

The simulation results of integrated PSI5 module and the sub modules involved in it are illustrated.For the different sensor data the simulation results of each module are shown.Each of the individual modules is coded using VHDL and simulated using Modelsim ALTERA starter edition 10.1d.

B.Simulation Results for Sensor ready mode (Hex"01E7")

The simulation results of sensor ready mode is shown in the Figure 5.
Input: Sensor data: 0000000111100111
Output: Manchester encoded data: 0101(start bits)
0101010101010110101010100101101010(payload data) 101010 (CRC)

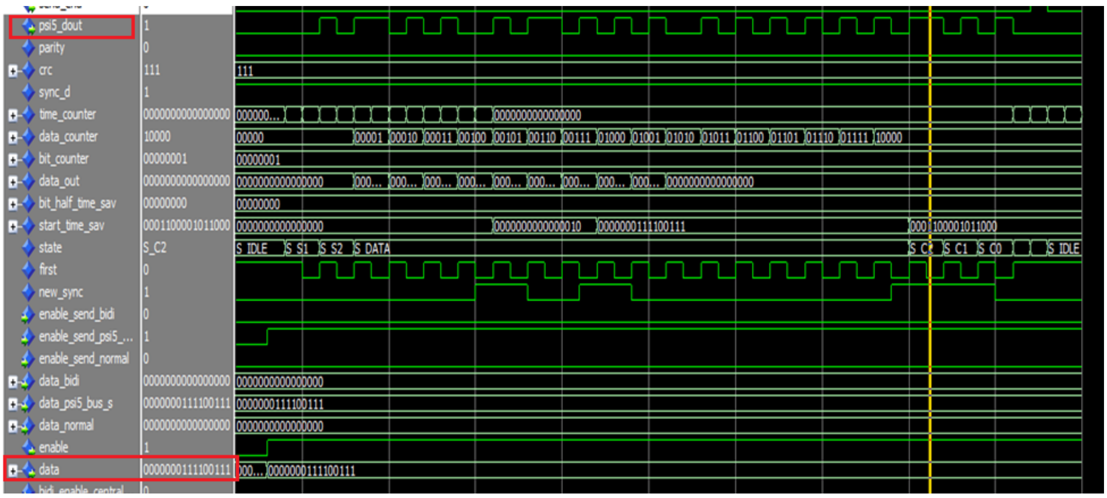

Figure 5.Simulation results for sensor ready mode

C.Simulation Results for decoded output for Sensor ready mode (Hex"01E7")

The simulation results of decoder output for sensor ready mode is shown in the Figure 6.
Input- Manchester encoded data: 0101(start bits)
010101010101011010101001011011010 (payload data) 101010 (CRC)
Output: Manchester decoded data: 0000000111100111

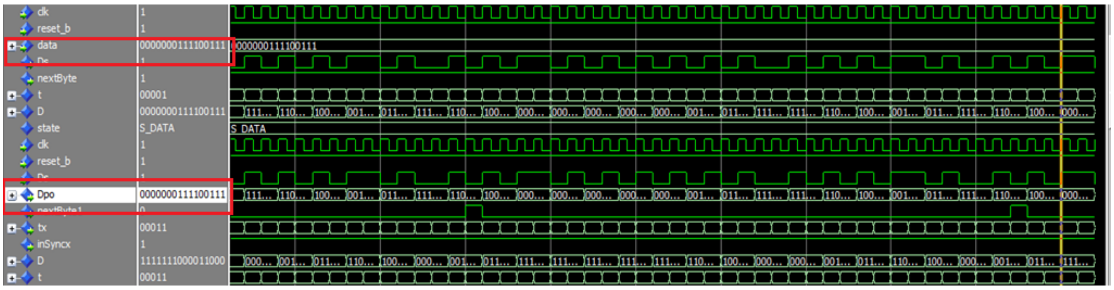

Figure 6.Simulation results for decoded output for sensor ready mode

V. CONCLUSIONS AND FUTURE SCOPE

The PSI5 sensor testing tool is a hardware interface box which finds its application in the manufacture of sensors used in the automotive applications such as Airbags,Power-rain,chassis and safety systems and vehicle dynamics control. Managing the wellbeing of automotive electronics, wrong information may bring about a non-deployment of an Airbag amid an accident or an airbag deployment without an accidentor failure in power-trains. data reliabilty is the main focus during the development of the PSI5 sensors. The important aspect for the design the PSI5 testing tool is "The failure prevention is better than the failure detection".

The development of the testing tool for the PSI5 sensor includes designing of different modules such as AEI master module ,PSI5 bus module,Data selector module ,Transmitter module and decoder module and integrating them to the PSI5 top module. All these modules design were coded using VHDL and simulated using Modelsim ALTERA starter addition 10.d. as an input to the PSI5 sensor testing tool the simulated sensor data was given at the InterfaceMaster module which was further processed into PSI5 data format and manchester encoded at the transmitter module of the PSI5 top module. These encoded bits were fed to the decoder block and finally compared the decoded output with the input simulated sensor data.The simulation results are obtained for the individual modules of the PSI5 top module and various results were observed by giving the various sensor mode data.

Future work in the domain would include the FPGA implementation of the integrated PSI5 module. Further the end product of the PSI5 sensor testing tool will be the hardware interface box which can be connected to the windows/Linux PC which has PSI5 simulyzing software. Upon running the PSI5 simulyzing software the status of the sensor can be analysed through various simulyzing graphs.

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