E521.41 - 4 Channel Multi-Mode PSI5 Transceiver

1 What you get

1. Demoboard E521.41
2. PSI5 pressure sensor E524.40 Eval Board with 2 wire interconnecting cable
3. USB cable
4. CD with software, documentation and driver

2 What you need in addition

1. PC with Windows operating system and USB interface
2. A 12V power supply

3 Connectors

1. Connect the 12V supply to the connector AK1, see PCB print for the proper connection of VBAT and GND
2. Connect the USB cable to the X1 connector. The USB voltage supplies only the FTDI chip.
   Data transfer between FTDI chip and microcontroller is galvanically isolated.
3. Connect the PSI5 sensors to X2 (Chan 1), X3 (Chan 2), X4 (Chan 3) or X5 (Chan 4)
4. Connector X6 is the programming connector for the microcontroller. This is only needed at the very first programming, software updates are possible with just the USB cable and suitable software on the PC.

4 Features of the Demoboard

1. Integrated microcontroller
2. Galvanically isolated USB-socket
3. Four independent operating channels for up to 24 Sensors
4. Deselectable LDO- Power MOS for external VBUS supply
5 Start of Operation

1. Connect the sensor plugs to connector X2...X5
2. Connect the PC with an USB Mini-B cable to the demo board, the green USB LED will light up
3. Connect the power supply to connector AK1, the green VDD LED and the green SPI LED will light up
4. Start Hterm.exe from the CD for first communication.

6 Start of Operation

1. Start Hterm.exe from the Hterminal folder on the CD. It looks like the figure below:

![Figure 2. Main window](image)

2. Choose right COM-Port number in the top left place of Hterm, it is usually the highest COM-Port Number. The proper COM-Port number is also visible in the system settings / hardware / connections – USB Serial Port (COMxx)

3. Press the “Connect Button”

4. Optionally press the button “S1” on the E521.41 Demo Board to see the command interpreter version

5. Type “?” in the ‘Input control’ window and then press the return key on the keyboard, all available commands will be printed in the ‘Received Data’ window. To use further commands, type in the command in the ‘Input control’ window and finish always with pressing the return key on the keyboard.

6. The command SPI_WCONF <adr> <data> writes the configuration register <adr> with <data> - CAUTION, all values are interpreted hexadecimal!

7. The command SPI_RCONF <adr> reads the configuration register at address <adr>

8. The command SPI_TESTMODE send the testmode entry command.
9. Sync Pulses can be generated either with the command SYNC or with SPI_SYNCPULSE <ptype>. The command SYNC just sets the E521.41 input pin TRIG for 15µs high to generate a short SYNC pulse. With the command SPI_SYNCPULSE short or long sync pulses can be generated. The upper nibble of <ptype> chooses the channel (Bit 7 sets channel 4, Bit 6 sets channel 3, Bit 5 sets channel 2 and Bit 4 sets channel 1). If no bit in the lower nibble is set, a short sync pulse will be generated on the selected channel(s). If the corresponding bit in the lower nibble is set, a long sync pulse will be generated. For example, b10010000 generates a short SYNC pulse on channel 4 and channel 1. For example, b10101010 generates a long SYNC pulse on channel 4 and channel 2.

10. The command SPI_RCHANTS <chan> <ts> reads only the content of the 16 Bit receive buffer of the selected channel and the selected timeslot. To read valid sensor data generate a SYNC pulse before.

11. The command SPI_TR16CHAN <chan> <rep> will generate a short SYNC pulse and will then read the 16Bit sensor data of the selected channel in timeslot 0, 1 and 2. This will be done <rep> times in a 500µs cycle (generating SYNC pulse and read 16Bit sensor data of all 3 timeslots). The maximum <rep> value is 2000d = 0x07D8. The complete sensor data will be latched in the controller. Afterwards the data is transmitted to the PC.

   A typical output of this command is like this:

   :SPI_TR16CHAN 4 5
   :SPI_TR16CHAN 4 005
   0 07FF 1 07FF 2 0401 0 07FF 1 07FF 2 0401 0 07FF 1 07FF 2 0000 0 07FF 1 07FF 2 0000
   spi_tr16chan 4 5 is typed (chan 4 selected and the repeat value is 5). First the command is acknowledged by printing #SPI_TR16CHAN 5 005.

   The first digit represent the timeslot.
   The second value shows the sensor data.

   The above output shows no connected sensor in time slot 0 and 1 because of output 07FF. Only in timeslot 2 a sensor answered with sensor data 0000.

   The default setting of the SPI buffer is 16Bit reading. Changing again to read 16Bit sensor requires a correct setting of the SPI buffer. Use command SPI_BUF_CONF <chan> <type> for this purpose. Valid values for <chan> are [1..4], valid values for <type> are [0..3] (type=0:48Bit type=2:32Bit type=3:24Bit type=3:16Bit)

12. The command SPI_BUF_CONF <chan> <type> configures the SPI buffer. The command writes the Bits D10 and D11 in the register Chx_CFG7 for the correct SPI buffer length. Valid values for <chan> are [1..4], valid values for <type> are [0..3] (type=0:48Bit type=2:32Bit type=3:24Bit type=3:16Bit). For example SPI_BUF_CONF 1 3 sets the SPI Buffer for channel 1 to 16Bit.

13. The command SPI_TR24CHAN <chan> <rep> will generate a short SYNC pulse and will then read the 24Bit sensor data of the selected channel in timeslot 0, 1 and 2. This will be done <rep> times in a 500µs cycle (generating SYNC pulse and read 24Bit sensor data of all 3 timeslots). The maximum <rep> value is 1000d = 0x03E8. The complete sensor data will be latched in the controller. Afterwards the data is transmitted to the PC.

   Use command SPI_BUF_CONF once if the SPI buffer do not match with the sensor data bit width.

14. The command SPI_TR32CHAN <chan> <rep> will generate a short SYNC pulse and will then read the 32Bit sensor data of the selected channel in timeslot 0, 1 and 2. This will be done <rep> times in a 500µs cycle (generating SYNC pulse and read 32Bit sensor data of all 3 timeslots). The maximum <rep> value is 1000d = 0x03E8. The complete sensor data will be latched in the controller. Afterwards the data is transmitted to the PC.

   Use command SPI_BUF_CONF once if the SPI buffer do not match with the sensor data bit width.
15. The command SPI_TR48CHAN <chan> <rep> will generate a short SYNC pulse and will then read the 48Bit sensor data of the selected channel in timeslot 0, 1 and 2. This will be done <rep> times in a 500µs cycle (generating SYNC pulse and read 48Bit sensor data of all 3 timeslots). The maximum <rep> value is 1000d = 0x03E8. The complete sensor data will be latched in the controller. Afterwards the data is transmitted to the PC.
   Use command SPI_BUF_CONF once if the SPI buffer do not match with the sensor data bit width.

16. The command SPI_TR16CHAN4 <chan> <rep> will generate a short SYNC pulse and will then read the 16Bit sensor data of the selected channel in timeslot 0, 1 and 2. This will be done <rep> times in a 4ms cycle (generating SYNC pulse and read 16Bit sensor data of all 3 timeslots). The maximum <rep> value is 65535d = 0xFFFF. Sensor data of timeslot 0, 1 and 2 will be read and instantly transmitted to the PC.
   Use command SPI_BUF_CONF once if the SPI buffer do not match with the sensor data bit width.

17. The command SPI_RASYNC16 <rep> is for reading sensors in asynchronous mode every 228µs. This command read 16 Bit data of channel [1..4] in timeslot 0. The maximum <rep> value is 1500d = 0x05DC. The complete sensor data will be latched in the controller. Afterwards the data is transmitted to the PC.

7 Features

- Compliant to PSI5 specification V1.3 and V2.0 (configurable via UART/SPI)
- Supports synchronous and asynchronous operation modes
- Provides four independent master channels with up to 6 physical sensors each
- Bidirectional communication supported
- Input voltage range for sensor supply of 4.6V to 11V
- Single or dual power supply for sensor (optional)
- LDO control circuit for VBUS generation (ext. NMOS is used)
- 3 selectable LDO output voltages (range VBUS=5.15V ... 7.7V)
- VSYNC can be generated internally (charge pump) or supplied externally
- Supports variable SYNC period
- Dedicated time slots for PSI5 frames with different length
- Interface diagnosis and protection features
- Leakage to battery, leakage to GND and open load detection
- Overcurrent detection and protection (Short to GND, Short to Battery)
- Over temperature detection and protection
- Reverse polarity protected bus outputs up to 40V
- Low and high power mode provided
- Supports UART/SPI Interface
- Support of 125Kbaud and 189Kbaud protocols
- Automatic adaption to sensor quiescent current and adjustment of trigger level (Ibase tracking)
8 Application Circuits

Figure 1 shows a possible system setup for peripheral sensors connected to an ECU with PSI5.

The sensors are connected to the ECU by just two wires, using the same lines for power supply and data transmission. The transceiver IC provides a pre-regulated voltage to the sensors and reads in the transmitted sensor data. The example above shows a point-to-point connection for sensor 1 and 2 and two different bus configurations for sensor 3 and 4, and 5 to 8, respectively.
9 Supply Voltage Concept

9.1 Application Circuit with LDO

Figure 4. Application circuit with LDO and external mosfet
9.2 Special Configuration VBUS = VSUPPLY

Disconnect the external LDO Mosfet by open the Jumper SJ1, SJ2 and SJ3. Connect test pin VBAT with test pin VBUS.

Figure 5. Application Circuit with VBUS Supplied from VBAT
9.3 Special Configuration, VSYNC external

The voltage VSYNC, which is necessary for providing the sync pulse, is normally generated in the internal charge pump. This voltage is available at pin CSYNC. Alternatively, VSYNC can be supplied directly at the pin CSYNC with an external voltage supply. The internal charge pump must be disabled therefore.

Figure 6. Application Circuit with external VBUS and external VBAT

Overview of possible supply voltage concepts, which can be chosen via SPI or UART commands.

Table 1. Overview Supply Voltage Concepts

<table>
<thead>
<tr>
<th>Config Options</th>
<th>V_DD</th>
<th>V_BAT</th>
<th>V_BUS</th>
<th>V_SYNC</th>
<th>LDO enabled</th>
<th>CP enabled</th>
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<td>A</td>
<td>V_DD SUPplied directly</td>
<td>V_SUPPLY supplied directly</td>
<td>Generated by LDO</td>
<td>Generated by charge pump</td>
<td>YES</td>
<td>YES</td>
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<tr>
<td>B</td>
<td>V_DD SUPplied directly</td>
<td>V_SUPPLY supplied directly</td>
<td>Generated by LDO</td>
<td>V_SYNC supplied from ECU</td>
<td>YES</td>
<td>NO</td>
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<tr>
<td>C</td>
<td>V_DD SUPplied directly</td>
<td>V_BUS supplied directly</td>
<td>V_BUS supplied directly</td>
<td>Generated by charge pump</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>D</td>
<td>V_DD SUPplied directly</td>
<td>V_BUS supplied directly</td>
<td>V_BUS supplied directly</td>
<td>V_SYNC supplied from ECU</td>
<td>NO</td>
<td>NO</td>
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</table>
10 Communication Modes

10.1 Sensor to ECU Communication

Data transmission from Sensor to ECU is done by current modulation with a data rate of 125kbps or 189kbps (Manchester coded).

10.2 ECU to Sensor Communication

Data transmission from ECU to sensor is done by voltage modulation in all synchronous operation modes.

Two methods are defined:

Tooth gap method
- Logical „0“ = no sync pulse
- Logical „1“ = short sync pulse (<35µs)

Pulse with method
- Logical „0“ = short sync pulse (<35µs)
- Logical „1“ = long sync pulse (43µs < t < 62µs)

11 Bus Configurations

A Asynchronous Mode
P Synchronous Parallel Bus Mode (star topology)
U Synchronous Universal Bus Mode
D Synchronous Daisy Chain Bus Mode
V Variable Time Triggered Synchronous Operation Mode (sensor cluster/multichannel)

Asynchronous Operation (PSI5-A)
PSI5-A describes a point-to-point connection for unidirectional, asynchronous data transmission. Each sensor is connected to the ECU by two wires. After switching on the power supply, the sensor starts transmitting data to the ECU periodically. Timing and repetition rate of the data transmission are controlled by the sensor.

Synchronous Parallel Bus Mode (PSI5-P)
PSI5-P describes a bus configuration for synchronous data transmission of one or more sensors. Each sensor is connected to the ECU by a separate pair of wires (star topology).

Synchronous Universal Bus Mode (PSI5-U)
PSI5-U describes a bus configuration for synchronous data transmission of one or more sensors. The sensors are connected to the ECU in different wiring topologies including splices or pass-through configurations.

Synchronous Daisy Chain Bus Mode (PSI5-D)
PSI5-D describes a bus configuration for synchronous data transmission of one or more sensors connected in a daisy chain configuration. The required addressing of the sensors during start up is specified.

Sensor Cluster / Multichannel (PSI5-V)
Sensor cluster / multichannel operation modes can be combined with both, asynchronous and synchronous data transmission and furthermore with different bus configurations. In a sensor cluster configuration, one physical sensor contains two or more logical channels. For example, a two channel acceleration sensor or a combined temperature and pressure sensor. The data transmission of the different channels can be realized by splitting up the data word of each data frame into two or more blocks. Another kind for transmitting the data for the different channels in separate data frames is using the time multiplex.
12 Schematic

Figure 7. Board schematic
13 Top overlayp print of PCB

Figure 8. PCB layout
# 14 Bill of Material (BOM)

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Designator</th>
<th>Value</th>
<th>Device/Package</th>
<th>Package</th>
<th>Description</th>
<th>Supplier</th>
<th>Part No.</th>
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Usage Restrictions

Elmos Semiconductor AG provide the E521.41 Demonstration Board simply and solely for IC evaluation purposes in laboratory. The Kit or any part of the Kit must not be used for other purposes or within non laboratory environments. Especially the use or the integration in production systems, appliances or other installations is prohibited.

The pcb’s are delivered to customer are for the temporary purpose of testing, evaluation and development of the Elmos IC’s only. Elmos will not assume any liability for additional applications of the pcb.

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