Application Note 006/A

SPI Communication with PHPS-85xx

1. Introduction

This document describes the basic SPI communication process with the APSP pressure sensor series PHPS-85xx.

2. Sensor Connection

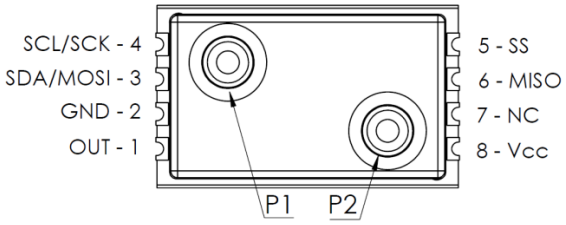

***Figure 1**: PHPS-85xx pinout (top view)*

Pin assignment with alternate functions		
Pin	**Name**	**Function**
1	Out	Analog output or PWM2 output
2	GND	Ground
3	SDA/MOSI	I²C data I/O or SPI data in (MOSI)
4	SCL/SCK	I²C clock or SPI clock (SCK)
5	SS	SPI slave select (SS)
6	MISO	SPI data out (MISO) or PWM1 Output
7	NC	Not connected
8	Vcc	Positive power supply

***Table 1**: Pin assignment of PHPS-85xx*

3. SPI – SERIAL PERIPHERAL INTERFACE

3.1 General Description

The pressure sensors present a digital output signal. The device runs a continuous program, which will store a corrected sensor value in the output registers of the internal ASIC. This cyclic program runs independently from the bus communication.
The SPI protocol specifies four signals as shown in Figure 2:

1. The clock (SCK) is generated by the master and input to all slaves.
2. MOSI carries data from master to slave.
3. MISO carries data from slave back to master.
4. A slave select line (SS) allows individual selection of a slave device.

Timing requirements for these signals are shown in Table 2 and Figure 3.

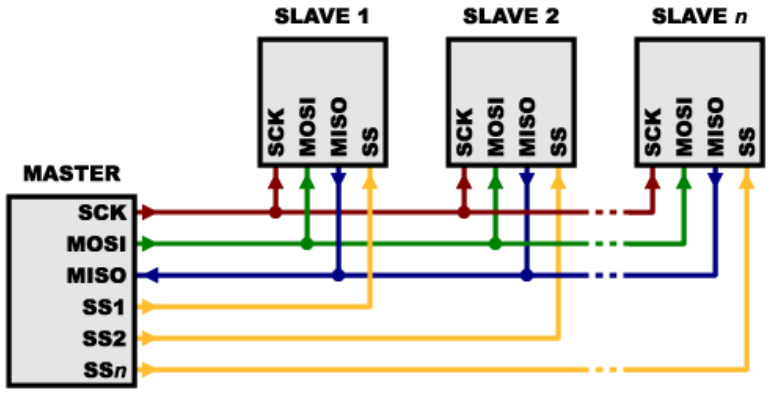

***Figure 2**: SPI connection*

Characteristics	Min.	Typ.	Max.	Unit
SPI-clock frequency			400	kHz
Input - high level	0.9		1	Vs
Input - low level	0		0.1	Vs
Output - low level			0.1	Vs
Pull-up resistor	500			Ω

***Table 2**: Timing requirements of data signals*

3.2 SPI Modes

A pair of parameters called clock polarity (CPOL) and clock phase (CPHA) determine the edges of the clock signal on which the data are driven and sampled. Each of the two parameters has two possible states, which allows for four possible combinations, all of which are incompatible with one another. The PHPS-85xx series supports clock phase (CPHA)=0 and polarity (CPOL)=0, which means that SCK is low when idle and data is sampled on the rising edge.

3.3 Slave Select

The falling edge of the SS line indicates the beginning of the transfer. Additionally, the SS line must not be negated and reasserted between the three bytes to be transmitted.

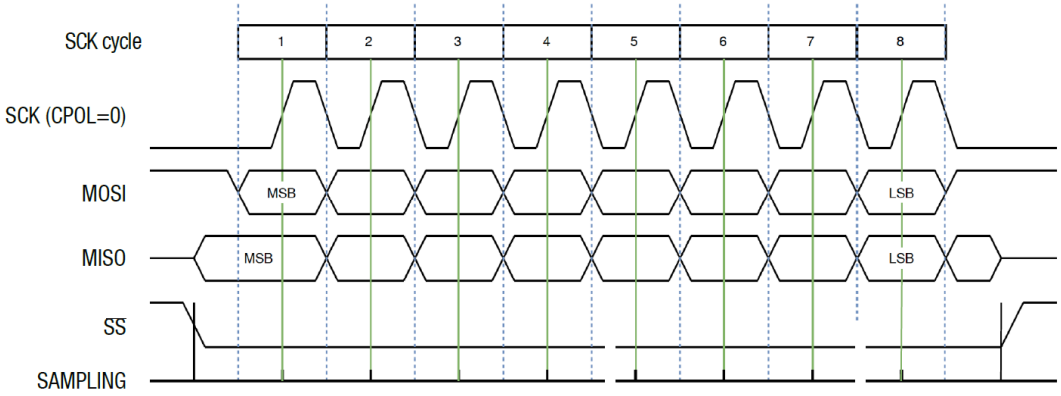

***Figure 3**: Example of a standard 1 byte SPI data transfer for CPHA=0 and CPOL=0*

3.4 Read and Calculate Pressure Value

The MOSI line should always be set to a high level. Because of internal configuration, the slave will answer the first byte with a value of 0xFF. The second and third byte contains the 15 bit pressure information (see Table 3).

	Data Byte 1								Data Byte 2								Data Byte 3							
MOSI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MISO	x	x	x	x	x	x	x	x	x	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
									Pressure data															

***Table 3:** 3 bytes data stream between the pressure sensor and master containing the pressure value as a 15 bit information*

The sensor can be configured to additionally return information about ambient temperature. This data is contained in bytes 4 and 5 (see Table 4).

	Data Byte 4								Data Byte 5							
MOSI	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
MISO	x	E14	E13	E12	E11	E10	E9	E8	E7	E6	E5	E4	E3	E2	E1	E0
		Temperature data														

***Table 4:** Additional 2 bytes inside the same Slave Select cycle containing the temperature value as a 15 bit information*

A digital pressure signal range is from 0 to 32767. The pressure and temperature values are calculated using the equations below.

$$SP = \frac{DPmax - DPmin}{Pmax - Pmin}$$

SP... Pressure sensitivity
DPmax... Max. digital pressure (counts)
DPmin... Min. digital pressure (counts)
Pmax... Max. pressure (mbar, bar)
Pmin... Min. pressure (mbar, bar)

$$P = \frac{DPvalue - DPmin}{SP} + Pmin$$

P ... Pressure (mbar, bar)
DPvalue... Digital pressure value (counts)

$$ST = \frac{DTmax - DTmin}{Tmax - Tmin}$$

ST... Temperature sensitivity
DTmax... Max. digital temp. (counts)
DTmin... Min. digital temp. (counts)
Tmax... Max. temp. (°C)
Tmin... Min. temp. (°C)

$$T = \frac{DTvalue - DTmin}{ST} + Tmin$$

T ... Temperature (°C)
DTvalue... Digital temperature value (counts)

4. Code Example

4.1 Programming Language MicroPython

```
from machine import Pin, SoftSPI, Timer
import time

# Define pressure range range
Pmin = 0                                    # Min. pressure (mbar, bar)
Pmax = 10.0                                 # Max. pressure (mbar, bar)
DPmin = 3277                                # Min. digital pressure
DPmax = 29491                               # Max. digital pressure

# Define temperature range
Tmin = 0.0                                  # Min. temperature (°C)
Tmax = 70.0                                 # Max. temperature (°C)
DTmin = 8192                                # Min. digital temperature
DTmax = 24576                               # Max. digital temperature

class PHPS85xx_SPI:  # Communication protocol: SPI
    def __init__(self, Pmin, Pmax, DPmin, DPmax, Tmin, Tmax, DTmin, DTmax, spi, ss):
        self.Pmin = Pmin                                                    # Min. pressure (mbar, bar)
        self.Pmax = Pmax                                                    # Max. pressure (mbar, bar)
        self.DPmin = DPmin                                                  # Max. digital pressure
        self.DPmax = DPmax                                                  # Min. digital pressure
        self.S_P = (self.DPmax - self.DPmin) / (self.Pmax - self.Pmin)      # Pressure sensitivity
        self.Tmin = Tmin                                                    # Min. temperature (°C)
        self.Tmax = Tmax                                                    # Max. temperature (°C)
        self.DTmin = DTmin                                                  # Min. digital temperature
        self.DTmax = DTmax                                                  # Max. digital temperature
        self.S_T = (self.DTmax - self.DTmin) / (self.Tmax - self.Tmin)      # Temperature sensitivity
        self.spi = spi                                                      # SPI instance
        self.ss = ss                                                        # Slave Select

    def read(self):
        self.ss(0)                                                          # Set Slave Select signal LOW
        raw_data = spi.read(5, 0xff)                                        # Read 5 bytes while outputting
                                                                              0xff on MOSI
        self.ss(1)                                                          # Set Slave Select signal HIGH

        data = [int (x) for x in bytearray (raw_data)]

        DPvalue = data[1] << 8 | data[2]                                    # Convert pressure data
                                                                              (bytes to integer)
        DTvalue = data[3] << 8 | data[4]                                    # Convert temperature data
                                                                              (bytes to integer)

        press = round ((DPvalue - self.DPmin) / self.S_P + self.Pmin, 2)    # Calculate pressure
        temp = round ((DTvalue - self.DTmin) / self.S_T + self.Tmin, 2)     # Calculate temperature
        return press, temp

spi = SoftSPI(baudrate=100000, polarity=0, phase=0, sck=Pin(25), mosi=Pin(26), miso=Pin(27))
ss = Pin(14, mode=Pin.OUT, value=1)

sensor = PHPS85xx_SPI(Pmin, Pmax, DPmin, DPmax, Tmin, Tmax, DTmin, DTmax, spi, ss)# Module control instance
while True:
    Press, Temp = sensor.read()                                             # Read pressure and temperature

    print(f'T: {Temp:.2f} °C P: {Press:.2f} mbar')


    time.sleep(0.2)
```

Revision History

Revision Letter	Date	Description / Changes
A	20.07.2022	Initial Creation

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