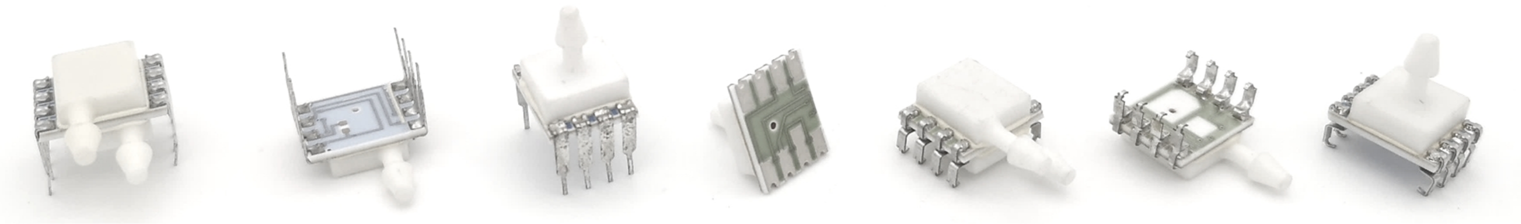
Senther P2101R



DIP/Differential | DIP/Side port | DIP/Top port | SMT/Top port | SIP/Differential | SIP/Side port | SIP/Top port

Features

- Piezoresistive MEMS element
- I²C or SPI Interface protocols
- ASIC fully calibrated
- Gas and non-corrosive fluids
- Low cost OEM
- Range: 1 to 75 mbar
- Temperature compensated
- Various package
- Small size
- Energy efficient
- Excellent long-term stability
- Industry-leading TEB
- RoHS compliant.

TEB=Total Error Band
ASIC=Application Specific Integrated Circuit

Application

- Anesthesia machines
- Spirometers
- Hospital room air pressure
- Nebulizers
- VAV control
- Static duct pressure
- HVAC transmitters
- Clogged HVAC filter detection

VAV=Variable Air Volume
HVAC=Heating, Ventilation, Air Conditioning

Digital output MEMS pressure sensor

Performance

Pressure range(FS) .... 1~75 mbar
Accuracy(BFSL typical).. ±0.25% FS
Span stability(typical) .... ±0.5% FS/1000H
Total error band(>5mbar) .... ±1% FS
Total error band(≤5mbar) .... ±3% FS
Interface type .... I²C/SPI
Output type(A type) .... 10%~90%
Output type(B type) .... 5%~95%
Resolution(14bits) .... 0.008% FS
Response frequency(typical) 2KHz
Load resistance .... >10KΩ

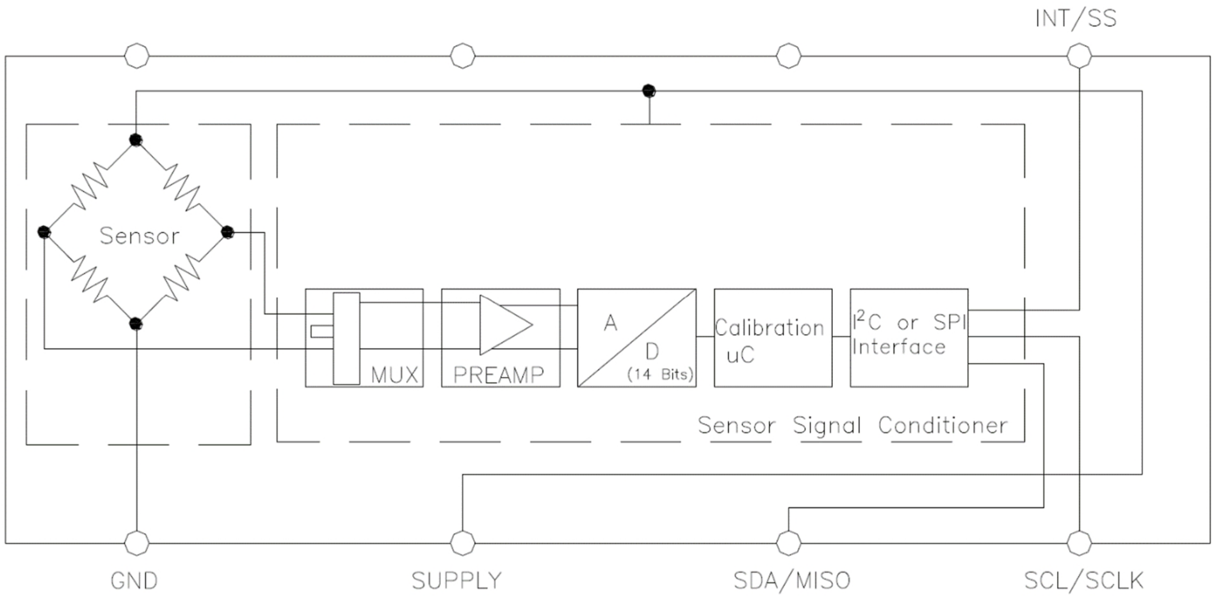
Electrical

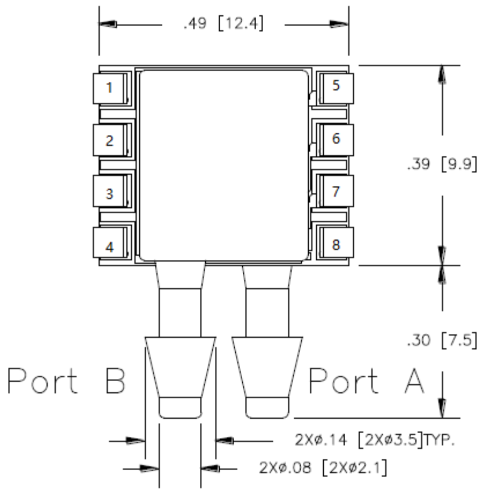
Excitation .... 3.3±0.3Vdc
Supply current(@3.3Vdc typical) 2mA
Excitation .... 5±0.25Vdc
Supply current(@5Vdc typical) 3mA
Warm up .... <7ms
ESD susceptibility 4KV

Environmental

Operation temperature .... –40 to 125°C
Compensated temperature .... 0 to 60°C
Solder temperature(SIP/DIP).. 5s Max. at 250℃
Reflow peak temperature (SMT).. 15s Max. at 250℃
Thermal hysteresis .... ±0.5% FS
Gravity(1g) sensitivity .... ±0.15% FSO
Pressure cycles .... 10 million FS cycles
Overload(1mbar).. >100 * FS
Overload(5mbar).. >40 * FS
Overload(10/25mbar).. >20 * FS
Overload(15/50/75mbar).. >10 * FS
Burst pressure.. >3 * Overload
Vibration .... <20 g@10~2000Hz
Shock .... <100 g, 11ms pulse
Media .... Ceramic,Silicon,Glass,Silicone epoxy compatible
Cover .... Polyamide
Substrate .... Ceramic
Sealing .... Silicone epoxy
Pressure port .... 1/8” barbed ports(for 3/32” ID tubing)
Electrical connection.. DIP,SIP or SMT

Schematic & Dimension:

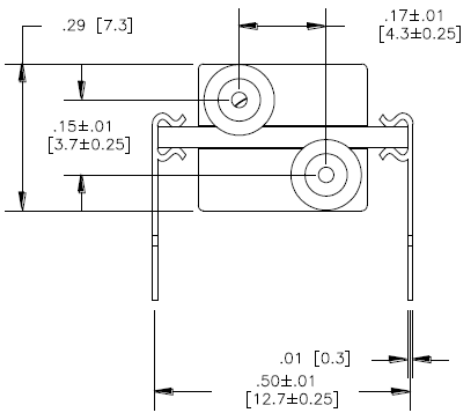


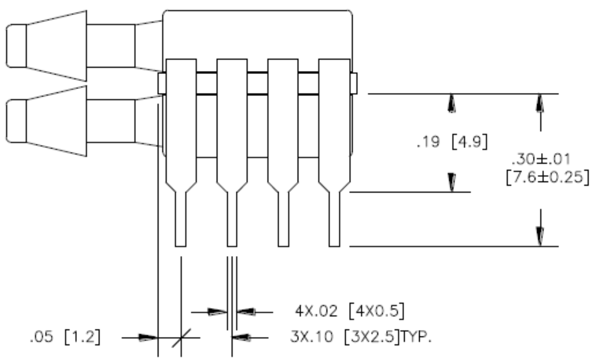


Ordering Information

P2101R-10MG-SD-SA-5

- Range in mbar: 5/10/15/25/50/75 for Gauge; 1/5/10/15/25/50/75 for Differential
- Reference type: G= Gauge pressure; D= Differential
- Port type: T= Top port; S= Sider port
- Solder type: D= DIP; S= SIP; M= SMT
- Interface: I= I²C; S= SPI
- Output option: A= 10~90%; B= 5~95%
- Excitation type: 3.3= 3.3Vdc; 5= 5Vdc





I^{2}C AND SPI INTERFACE SPECIFICATIONS

1. Operation Modes

Figure 1.2 illustrates the sensor power-up sequence and subsequent operation depending on the selected interface communication mode (I^{2}C or SPI) as determined by interface-related first activities after power-up or reset. If the first command after power-up is a valid I^{2}C command, the interface will function as an I^{2}C interface until the next power-on reset (POR). If there is no valid I^{2}C command, but an active signal at the SS pin is detected as the first valid activity, then the interface will respond as an SPI slave. With either interface, after the voltage regulators are switched on, the sensor's low-voltage section (LV) is active while the related interface configuration information is read from memory. Then the LV section is switched off, the sensor goes into Sleep Mode, and the interface is ready to receive commands. The interface is always powered by V_{DD}, so it is referred to as the high voltage section (HV).See Table 1.1 for definitions of the commands.

1.1 SPI/I^{2}C Commands

The SPI/I^{2}C commands supported by the sensor are listed in Table 1.1. Note: Every return starts with a status byte followed by the data word. Note: Any ADC measurement and SSC calculation output is formatted as a 24-bit data word, regardless of the effective ADC resolution used.

1.2. Common Functionality and General Status Byte

Commands are handled by the command interpreter in the LV section. Commands that need additional data are not treated differently than other commands because the HV interface is able to buffer the command and all the data that belongs to the command and the command interpreter is activated as soon as a command byte is received.

Every response starts with a status byte followed by the data word. The data word depends on the previous command. It is possible to read the same data more than once if the read request is repeated (I^{2}C) or a NOP command is sent (SPI). If the next command is not a read request (I^{2}C) or a NOP (SPI), it invalidates any previous data.

The P21XXR series sensor supports the parallel setup of two amplifier-ADC-configurations using *SM_config1* (default) and *SM_config2*. Switching between the two setups can be done with the commands B0HEX and B1HEX. Note that the respective activation command must always be sent prior to the measurement request.

The status byte contains the following bits in the sequence shown in Table 1.2.1 and 1.2.2:

Table 1.2.1 General Status Byte

Bit	7	6	5	4	3	2	1	0
Meaning	0	Powered?	Busy?	Mode		Memory error?	Config Setup	ALU Saturation?

Table 1.2.2 Mode Status

Status[4:3]	Mode
00	Normal Mode (sleep and cyclic operations)
01	Command Mode
10	reserved
11	reserved

2. I^{2}C Interface Specification

The I^{2}C interface is a simple 8-bit protocol using a serial data line (SDA) and a serial clock line (SCL) where each device connected to the bus is software addressable by a unique address. For detailed specifications of the I^{2}C protocol, see *The I^{2}C Bus Specification, Version 2.1, January 2000*.

2.1 I^{2}C Selection

I^{2}C Mode will be selected if the very first interface activity after sensor power-up is an I^{2}C command. In I^{2}C Mode, each command is started as shown in Figure 2.1.3. Only the number of bytes that are needed for the command must be sent. After the execution of a command (busy = 0), the expected data can be read as illustrated in Figure 2.1.2 or if no data are returned by the command, the next command can be sent. The status can be read at any time as illustrated in Figure 2.1.1.

Figure 2.1.1 I²C Read Status

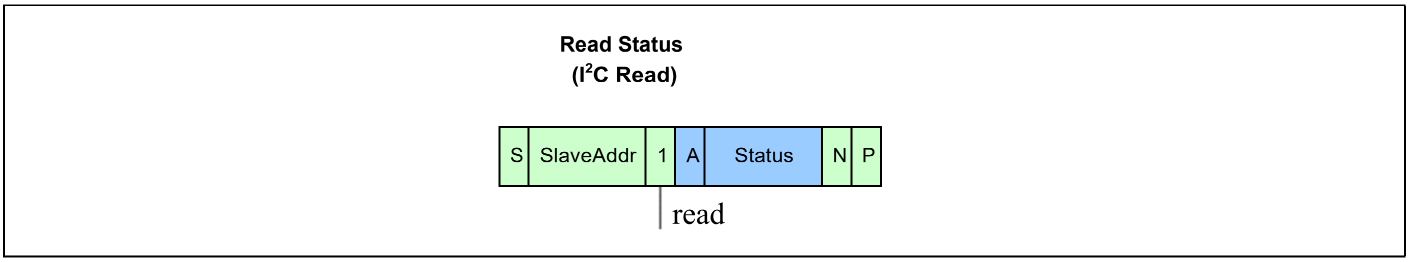
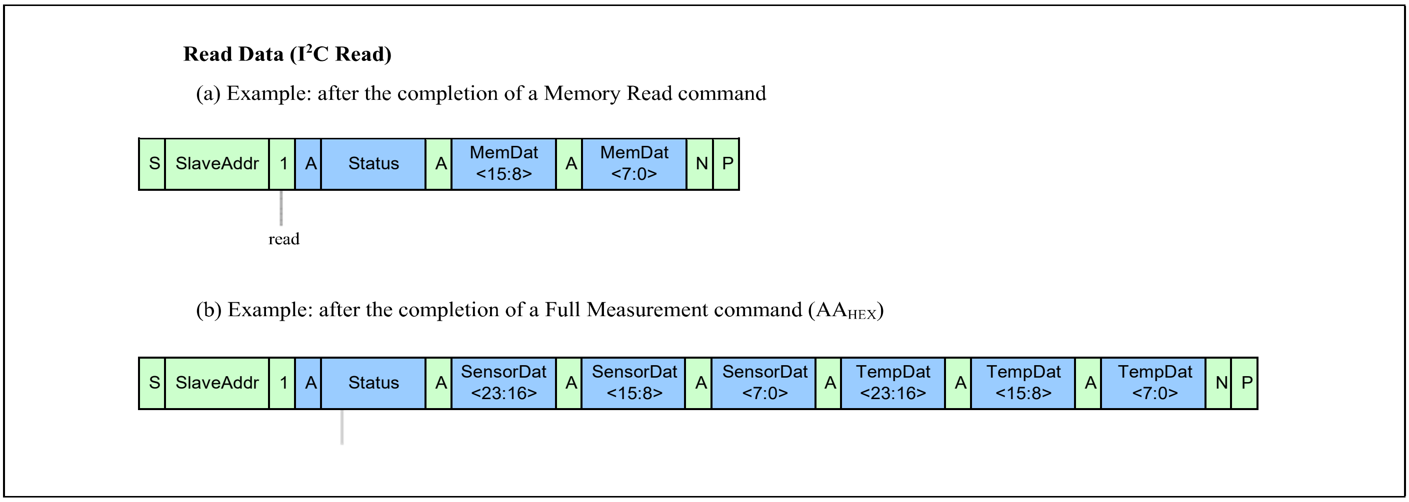


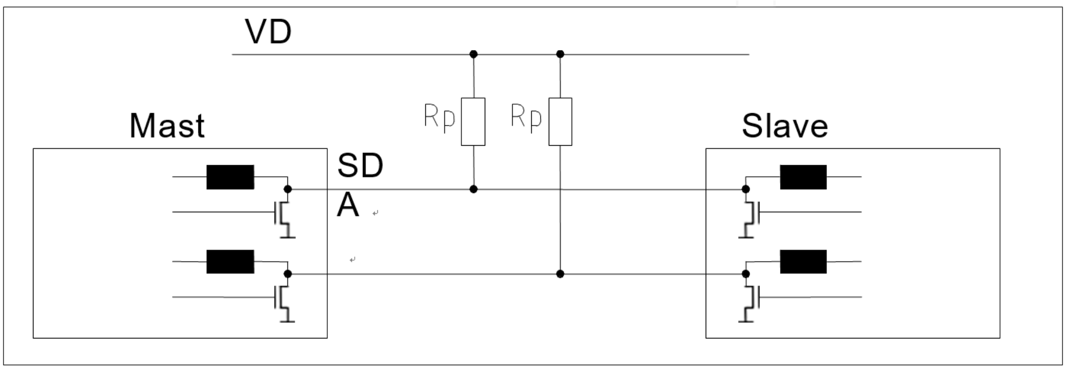
Figure 2.1.2 I²C Read Data



2.2 Interface Connection-External

Bi-directional bus lines are implemented by the devices (master and slave) using open-drain output stages and a pull-up resistor connected to the positive supply voltage. The recommended pull-up resistor value depends on the system setup (capacitance of the circuit or cable and bus clock frequency). In most cases, 4.7kΩ is a reasonable choice. The capacitive loads on SDA and SCL line have to be the same. It is important to avoid asymmetric capacitive loads.

I²C Transmission Start Condition



Both bus lines, SDA and SCL, are bi-directional
and therefore require an external pull-up resistor.

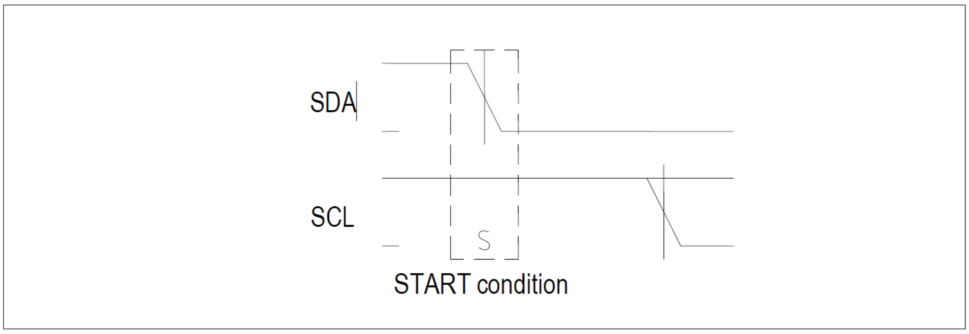
2.3 I²C Address

The I²C address consists of a 7-digit binary value. The factory setting for the I²C slave address is 0x28, 0x36 or 0x46 depending on the interface type selected from the ordering information. The address is always followed by a write bit (0) or read bit (1).The default hexadecimal I²C header for read access to the sensor is therefore 0x51, 0x6D, 0x8D respectively, based on the ordering information.

2.4 Transfer Sequences

Transmission START Condition (S): The START condition is a unique situation on the bus created by the master, indicating to the slaves the beginning of a transmission sequence (the bus is considered busy after a START).

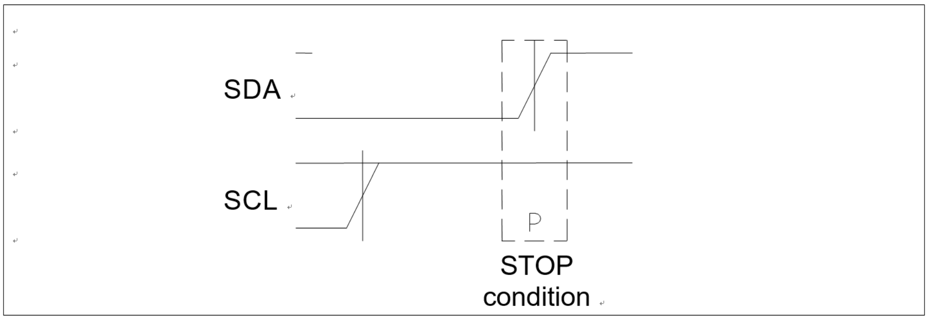
I²C Transmission Start Condition



A HIGH to LOW transition on the SDA line while SCL is HIGH

Transmission STOP Condition (P): The STOP condition is a unique situation on the bus created by the master, indicating to the slaves the end of a transmission sequence (the bus is considered free after a STOP).

I²C Transmission Stop Condition

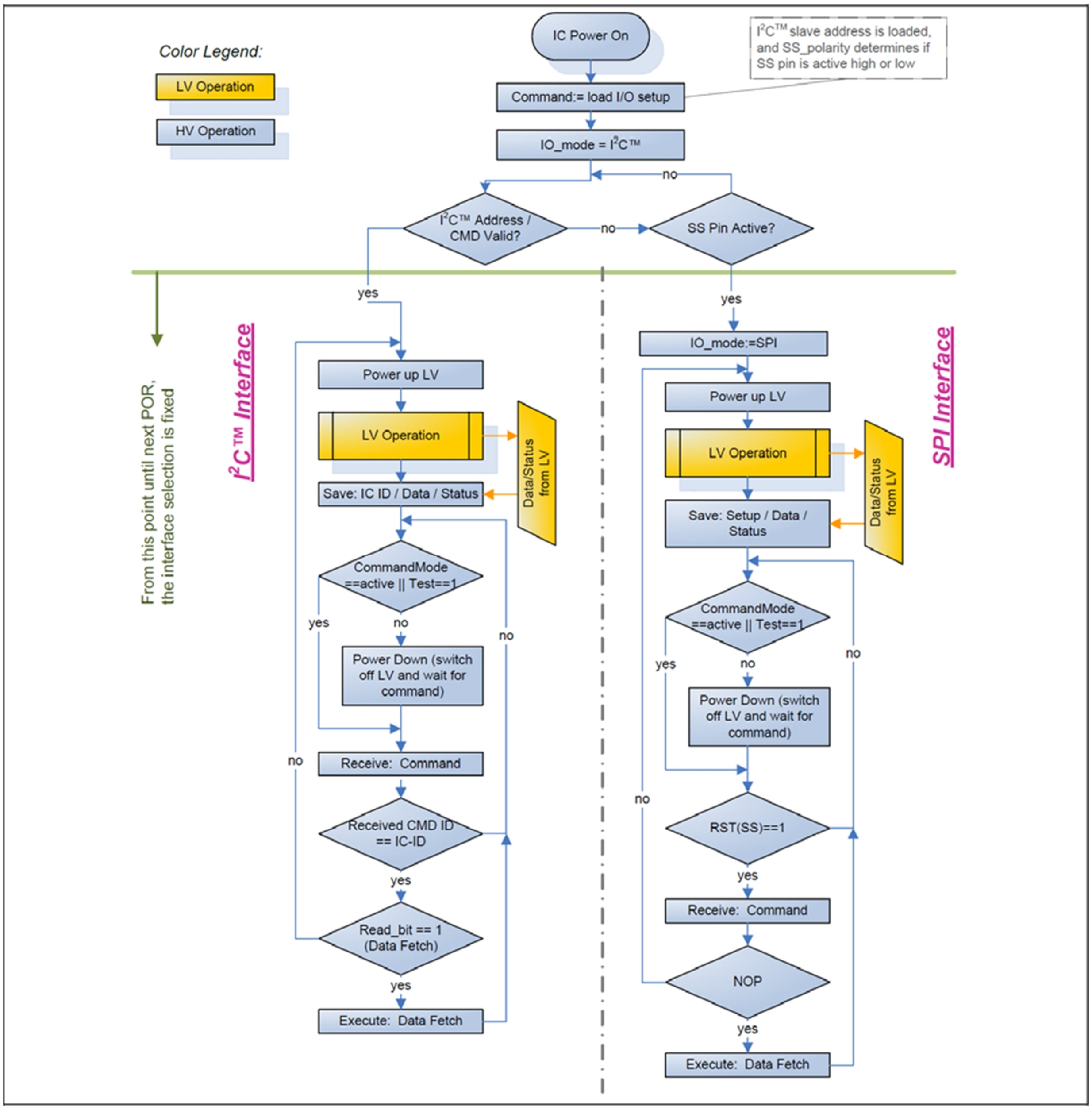


A LOW to HIGH transition on the SDA line while SCL is HIGH

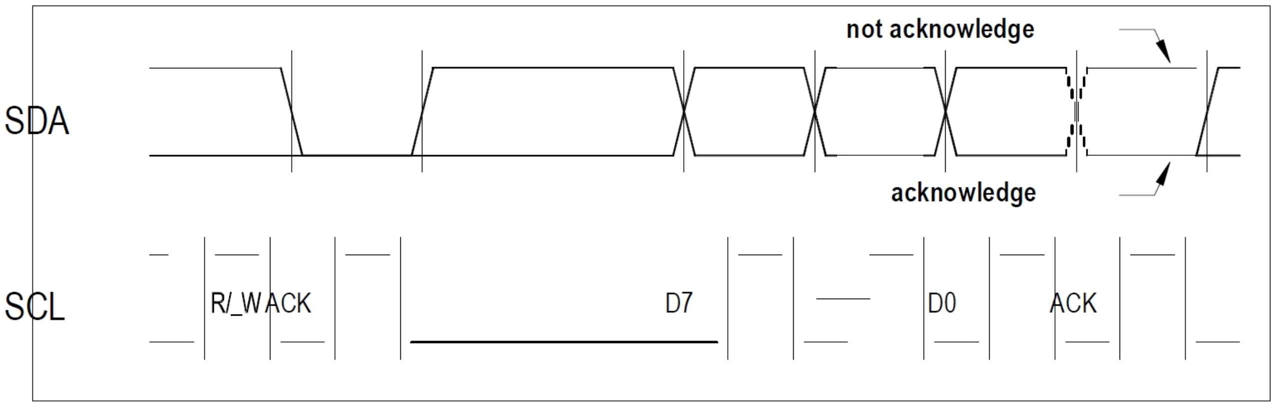
Acknowledge (ACK) / Not Acknowledge (NACK): Each byte (8 bits) transmitted over the I²C bus is followed by an acknowledge condition from the receiver. This means that after the master pulls SCL low to complete the transmission of the 8th bit, SDA will be pulled low by the receiver during the 9th bit time. If after transmission of the 8th bit the receiver does not pull the SDA line low, this is considered to be a NACK condition.

If an ACK is missing during a slave to master transmission, the slave aborts the transmission and goes into idle mode.

Figure 1.2 Operational Flow Chart: Power Up



I²C Acknowledge / Not acknowledge



Each byte is followed by an acknowledge or a not acknowledge, generated by the receiver

2.5 Data Transfer Format

Data is transferred in byte packets in the I²C protocol, which means in 8-bit frames. Each byte is followed by an acknowledge bit. Data is transferred with the most significant bit (MSB) first.

A data transfer sequence is initiated by the master generating the Start condition (S) and sending a header byte. The I²C header consists of the 7-bit I²C device address and the data direction bit (R/_W).

The value of the R/_W bit in the header determines the data direction for the rest of the data transfer sequence. If R/_W = 0 (W RITE), the direction remains master-to-slave, while if R/_W = 1 (READ), the direction changes to slave-to-master after the header byte.

2.6 Command Set and Data Transfer Sequences

The I²C master command starts with the 7-bit slave address with the 8th bit = 1 (READ). The sensor acts as the slave and sends an acknowledge (ACK) indicating success. The sensor has six I²C read commands:

AA,AB,AC,AD,AE,AF. Table below 1.6.1 shows the the measurement details of the six I²C read commands. Figure 1.6.2 indicate the I²C read status. Figure 1.6.3 indicate the data read sequence. Figure 1.6.4 indicate the I²C command request format.

Available measurement procedures are
AZSM: auto-zero (external) sensor measurement
SM: (external) sensor measurement
AZTM: auto-zero temperature measurement
TM: temperature measurement

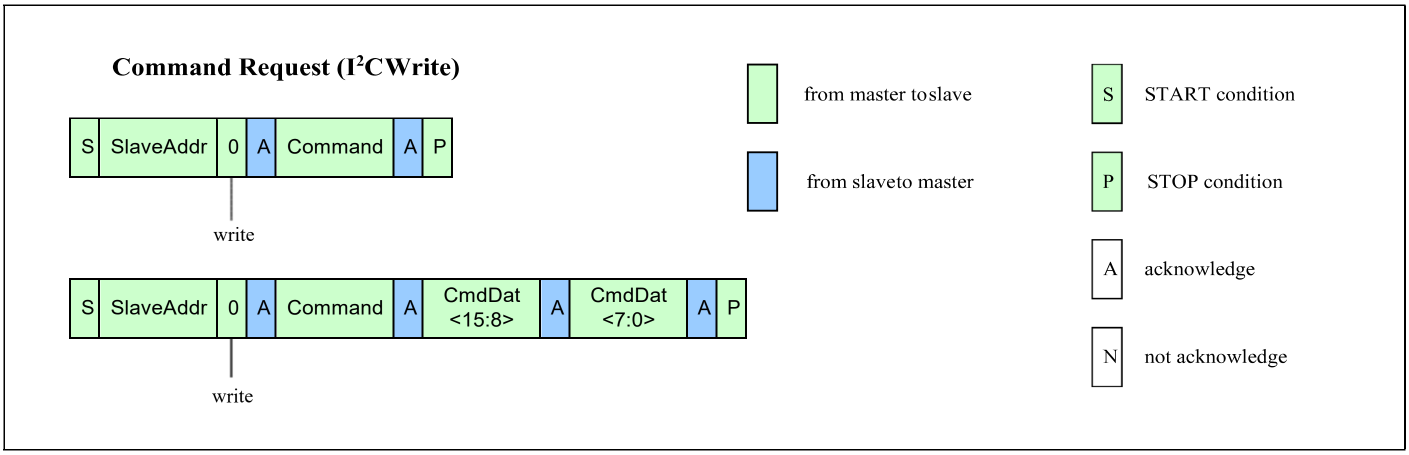
Table 1.1 – I²C Measurement Command

Command (Byte)	Return	Description	Normal Mode	Command Mode
AA_{HEX}	24-bit formatted fully corrected sensor measurement data + 24-bit corrected temperature data 1)	**Measure** Trigger full measurement cycle (AZSM, SM, AZTM, and TM, as described above) and calculation and storage of data in the output buffer using the configuration from MTP.	Yes	Yes
AB_{HEX}	24-bit formatted fully corrected sensor measurement data + 24-bit corrected temperature data 1)	**Measure Cyclic** This command triggers a continuous full measurement cycle (AZSM, SM, AZTM, and TM) and calculation and storage of data in the output buffer using the configuration from MTP followed by a pause determined by *CYC_period* (bits[14:12] in memory register 02_{HEX}).	Yes	Yes

Averaging data command				
AC_{HEX}	24-bit formatted fully corrected sensor measurement data + 24-bit corrected temperature data 1)	**Oversample-2 Measure** Mean value generation: 2 full measurements are conducted (as in command AA_{HEX}), the measurements' mean value is calculated, and data is stored in the output buffer using the configuration from MTP; no power down or pause between the 2 measurements.	Yes	Yes
AD_{HEX}	24-bit formatted fully corrected sensor measurement data + 24-bit corrected temperature data 1)	**Oversample-4 Measure** Mean value generation: 4 full measurements (as in command AA_{HEX}) are conducted, the measurements' mean value is calculated, and data is stored in the output buffer using the configuration from MTP; no power down or pause between the 4 measurements.	Yes	Yes
AE_{HEX}	24-bit formatted fully corrected sensor measurement data + 24-bit corrected temperature data 1)	**Oversample-8 Measure** Mean value generation: 8 full measurements (as in command AA_{HEX}) are conducted, the measurements' mean value is calculated, and data is stored in the output buffer using the configuration from MTP; no power down or pause between the 8 measurements.	Yes	Yes

AF_{HEX}	24-bit formatted fully corrected sensor meas-urement data + 24-bit corrected temperature data 1)	**Oversample-16 Measure** Mean value generation: 16 full measurements (as in command AA_{HEX}) are conducted, the measurements' mean value is calculated, and data is stored in the output buffer using the configuration from MTP; no power down or pause between the 16 measurements.	Yes	Yes

Figure 2.1.3 I²C Command Request



2.7 I²C Protocol Differences

There are three differences in the described above protocol compared with original I²C protocol:

- Sending a start-stop condition without any transitions on the SCL line (no clock pulses in between) creates a communication error for the next communication, even if the next start condition is correct and the clock pulse is applied. An additional start condition must be sent, which results in restoration of proper communication.
- The restart condition – a falling SDA edge during data transmission when the SCL clock line is still high – creates the same situation. The next communication fails, and an additional start condition must be sent for correct communication.
- A falling SDA edge is not allowed between the start condition and the first rising SCL edge. If using an I²C address with the first bit 0, SDA must be held down from the start condition through the first bit.
- All mandatory I²C-bus protocol features are implemented. Optional protocol features such as clock stretching, 10-bit slave address, etc., are not supported by the sensor's interface.

3 SPI Interface Specification

The SPI Mode is available if the first interface activity after the sensor power-up is an active signal at the SS pin.

ication. The polarity and phase of the SPI clock are programmable via CPHA, which selects which edge of SCLK latches data, and CPOL, which indicates whether SCLK is high or low when it is idle. The polarity of the SS signal and pin are programmable via the SS_polarity setting. The different combinations of polarity and phase are illustrated in the figures below.

In SPI mode, each command except NOP is started as shown in Figure 3.3. After the execution of a command (busy = 0), the expected data can be read as illustrated in Figure 3.5 or if no data are returned by the command, the next command can be sent. The status can be read at any time with the NOP command (see Figure 3.4).

Figure 3.1 SPI Configuration CPHA=0

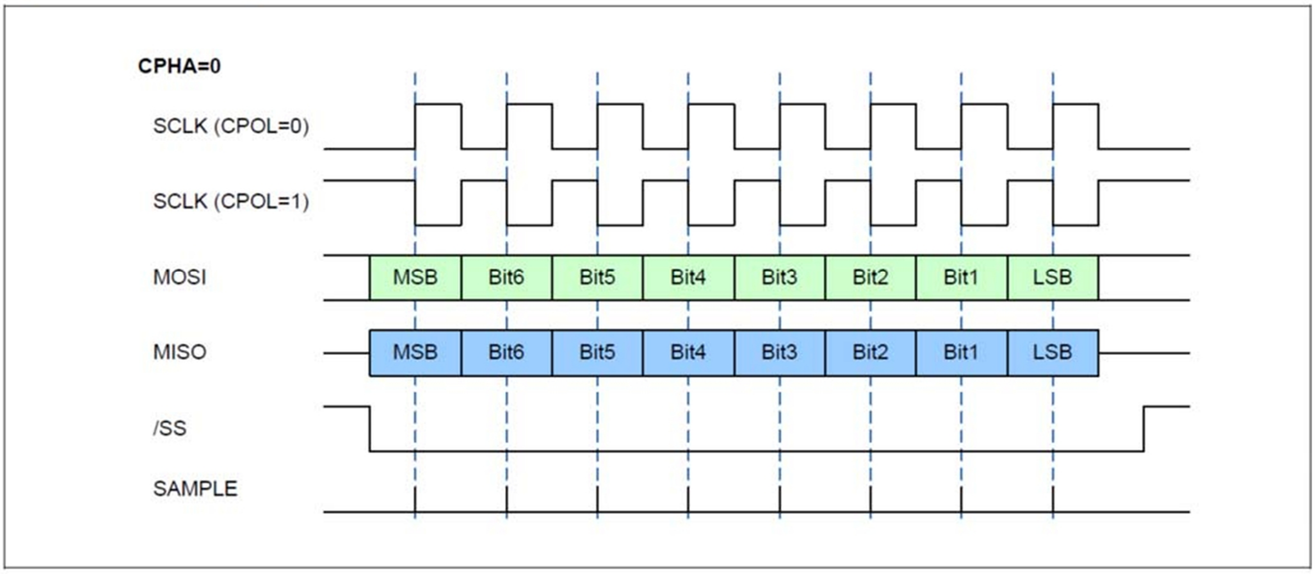


Figure 3.2 SPI Configuration CPHA=1

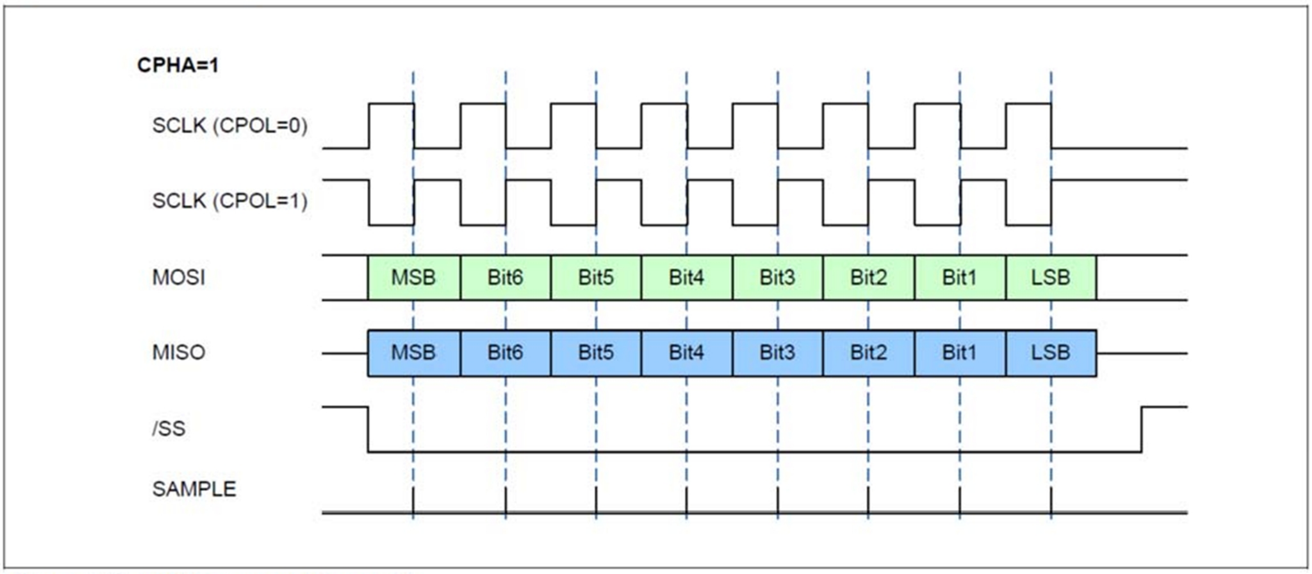


Figure 3.3 SPI Command Request

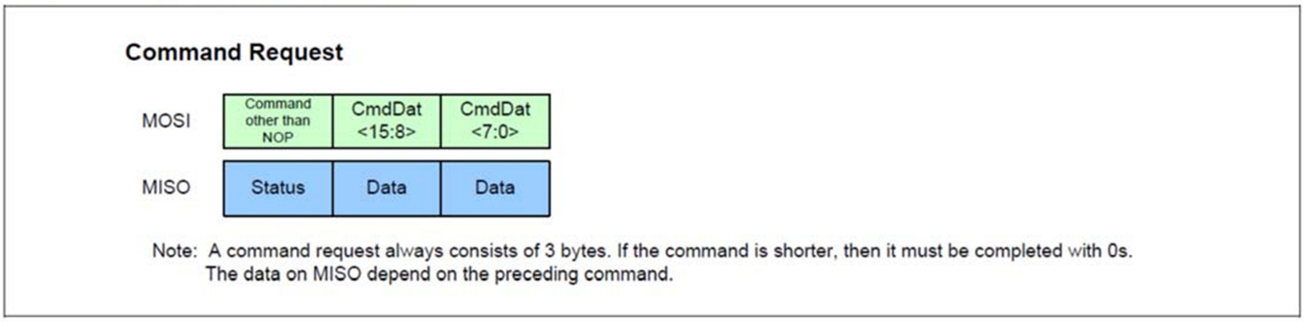


Figure 3.4 SPI Read Status

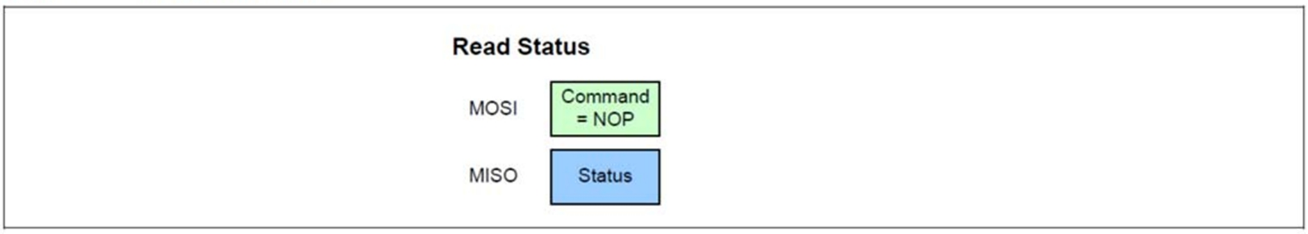
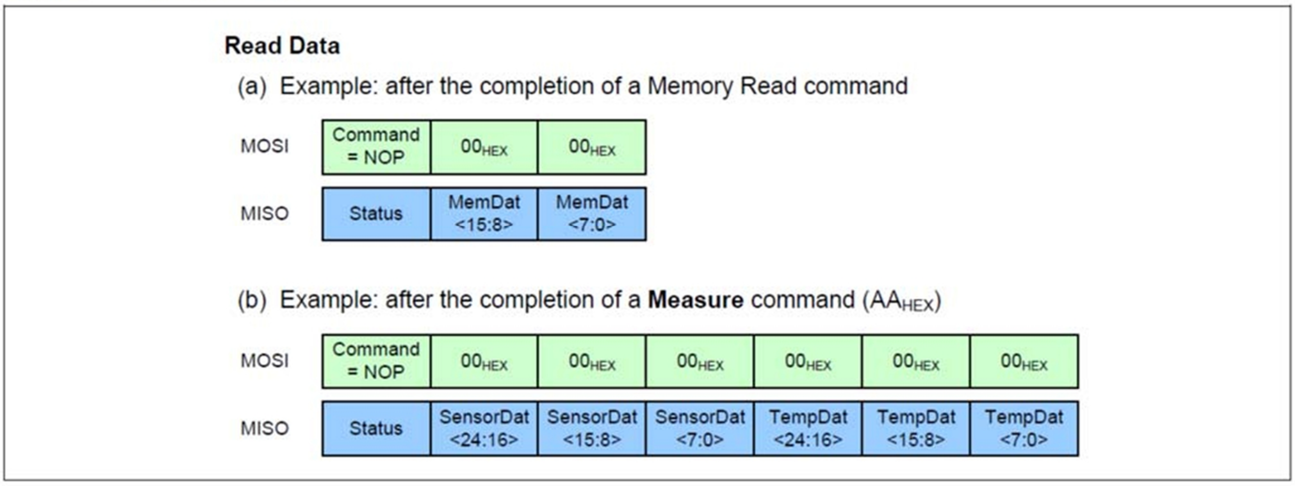


Figure 3.5 SPI Read Data



4.TIMING PARAMETERS

I^2C INTERFACE PARAMETERS

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
SCLK CLOCK FREQUENCY	f_{SCL}	100		400	KHz
START CONDITION HOLD TIME RELATIVE TO SCL EDGE	t_{HDSTA}	0.1			uS
MINIMUM SCL CLOCK LOW WIDTH [1]	t_{LOW}	0.6			uS
MINIMUM SCL CLOCK HIGH WIDTH [1]	t_{HIGH}	0.6			uS
START CONDITION SETUP TIME RELATIVE TO SCL EDGE	t_{SUSTA}	0.1			uS
DATA HOLD TIME ON SDA RELATIVE TO SCL EDGE	t_{HDDAT}	0			uS
DATA SETUP TIME ON SDA RELATIVE TO SCL EDGE	t_{SUDAT}	0.1			uS
STOP CONDITION SETUP TIME ON SCL	t_{SUSTO}	0.1			uS
BUS FREE TIME BETWEEN STOP AND START CONDITION	t_{BUS}	2			

[1] COMBINED LOW AND HIGH WIDTHS MUST EQUAL OR EXCEED MINIMUM SCL PERIOD.

SPI INTERFACE PARAMETERS

PARAMETERS	SYMBOL	MIN	TYP	MAX	UNITS
SCLK CLOCK FREQUENCY	f_{SCL}	50		800	KHz
SS DROP TO FIRST CLOCK EDGE	t_{HDSS}	2.5			uS
MINIMUM SCL CLOCK LOW WIDTH [1]	t_{LOW}	0.6			uS
MINIMUM SCL CLOCK HIGH WIDTH [1]	t_{HIGH}	0.6			uS
CLOCK EDGE TO DATA TRANSITION	t_{CLKD}	0		0.1	uS
RISE OF SS RELATIVE TO LAST CLOCK EDGE	t_{SUSS}	0.1			uS
BUS FREE TIME BETWEEN RISE AND FALL OF SS	t_{BUS}	2			uS

[1] COMBINED LOW AND HIGH WIDTHS MUST EQUAL OR EXCEED MINIMUM SCLK PERIOD.