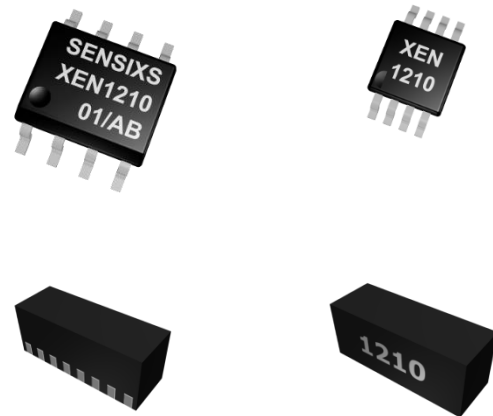


# XEN1210

## Magnetic Sensor

### Features

- Single axis magnetic measurement
- One chip solution
- 15nT resolution
- Unmatched low offset (Sub- $\mu$ T) and gain precision
- Wide magnetic field range ( $\pm$ 63mT)
- No magnetic hysteresis
- Measurement rate up to 5kSPS
- Low voltage operation (2.5V to 3.3V)
- Single supply
- Serial SPI communication
- $-40^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  Temperature Range
- Surface mount package (1.4x1.6x4mm)
- Package 3D solderable
- Available in tape and reel



### General Description

XEN1210 is a magnetic field sensor based on the Hall effect. It uses Sensixs's Q-Hall technology, which with a resolution of 15nT and a magnetic field range of 63mT combines the best of Hall and AMR technology in one.

In position and speed applications where conventional Hall and AMR technology suffer from a large natural offset (drift), its unmatched low offset and offset stability simplifies the design. In contrast to AMR compass sensors no set/reset sequence is required.

The XEN1210 can be used for a wide range of magnetic sensing applications.

A maximum read-out frequency of 5kSPS can be obtained.

The control is fully digital and readout and programming is performed via the SPI bus.

For battery applications, power can be saved by taking single shot measurements. In power-off mode the current draw is limited to below 100nA.

Except for SOIC8 and MSOP8, the XEN1210 is available in SFN8 packages, which can be freely oriented on a PCB in 3 dimensions. By combining a number of XEN1210 sensors in (different) orientations rotary or linear position sensor systems can be designed.

### Applications

- Compass Sensors
- Linear Magnetic Field Sensor
- Linear Position and Speed Measurement
- Rotary Position and Speed Measurement
- Current Sensing

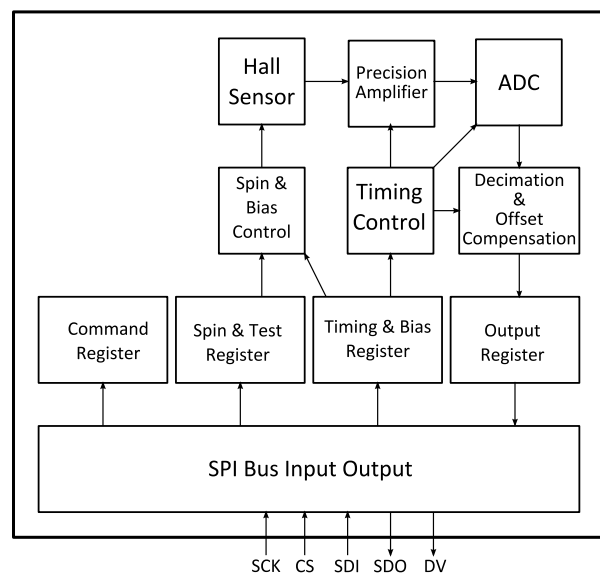


Figure 1: Functional block diagram.

# XEN1210

## Magnetic Sensor

### Specifications

Table 1: Specifications for the XEN1210.

Specification	Conditions	Min	Typ.	Max	Unit
<i>Power supply</i>					
VDD		2.5	3.3	3.6	V
IDD	Sleep mode		50		nA
	Idle mode		10		μA
	Power-up mode (Always On)		4.7		mA
<i>Magnetic Specifications</i>					
Field Range <sup>1</sup>			±63		mT
Gain mismatch			0.5		%
Gain TC			400		ppm/K
Gain TC mismatch <sup>2</sup>			25		ppm/K
Offset	Without calibration		1.5		μT
Offset TC			15		nT/K
Resolution (24 bits <sup>3</sup> )			7.5		nT/LSB
Noise <sup>4</sup>			55		nT/√Hz
Hysteresis				10	nT
Maximum exposed field	No effect				
<i>Compass Application</i>					
Heading Noise <sup>5</sup>	Horizontal Field=17μT, full power		0.125		°/√Hz
<i>System speed</i>					
CLK <sup>6</sup>		0.8	1	2.5 <sup>7</sup>	MHz
Sample speed	5Mhz CLK			5	kHz
Turn on time	5kHz programmed measurement time, device needs no additional turn on time.	200			μs
<i>SPI Bus</i>					
SPI Speed			400		kHz
<i>Temperature</i>					
Temperature Range		-40		+125	°C

**Magnetic Flux Density:** 100 micro Tesla (μT) = 1 gauss (G) = 10e (in air)  
**Magnetic Field:** 1 oersted (Oe) = 79.58 amperes/meter (A/m)  
 100 000 gamma = 1 Oe = 79.58 A/m

<sup>1</sup> At 75% Hall Biasing.

<sup>2</sup> Single batch data.

<sup>3</sup> The LSB is used for encoding the data valid flag, therefore the maximum obtainable resolution is 15nT, this is however well below the practical noise floor, so if the data valid flag is not used, no bitwise masking is required.

<sup>4</sup> Measured with 100% Hall biasing, best temperature performance is with 75% Hall biasing but leads to 25% more noise.

<sup>5</sup> Refer to our compass application notes.

<sup>6</sup> XEN1210 needs a stable clock frequency.

<sup>7</sup> Higher clocks are possible but the noise performance of the XEN1210 will deteriorate with higher clocks.

# XEN1210

## Magnetic Sensor

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### Introduction

The XEN1210 is a CMOS linear magnetic field sensor with a very low offset. It uses Sensix's patented high performance spinning-current Hall-plate technology, a precision amplifier and a sigma delta AD converter, and offers full digital control and communication through a SPI serial bus. The device does not need calibration and in contrast to low-offset AMR sensors does not use a set/reset method. It has no hysteresis and is indestructible by high magnetic fields. It does not need any external components and is truly a one-chip solution.

Speed and internal measurement time can be changed at will. The clock frequency in combination with the setting in the speed register determine the measurement time of the device from 0.2ms to 66ms. The device can be read out using the data valid signal as an interrupt for the Host CPU or at any desired readout speed. A data-valid flag is present in the data itself.

Hall bias settings can be programmed to exchange power consumption and performance.

The device addresses a large magnetic range without the need of gain settings. A 24-bit digital output is provided.

There is no power-up reset so the device has to be initially programmed by the host CPU each time the supply is switched on. The device can be put in sleep mode, idle mode, in continuous measurement mode or in single shot mode. The main use of these modes is the preservation of power.

The device is available in MSOP8 and SFN8 packages, which can be freely oriented on a PCB in 3 dimensions. By combining a number of XEN1210 sensors in different orientations, rotary or linear position sensor systems can be designed.<sup>8</sup>

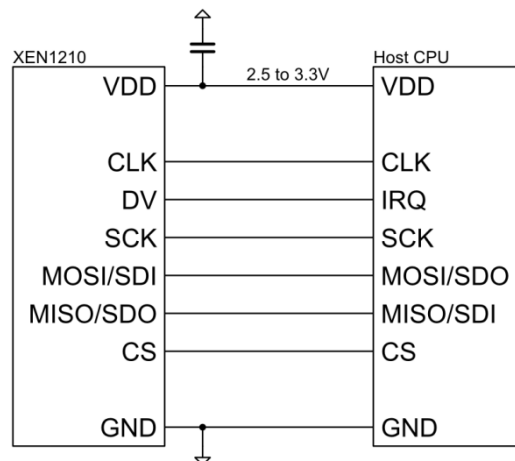


Figure 2: Typical connection scheme of two XEN1210 to a Host CPU. A 100nF decoupling capacitor can be used when the supplies are not clean.

<sup>8</sup> Please refer to our compass and position application nodes for practical examples.

# XEN1210

## Magnetic Sensor

### Digital Communication - SPI interface

Communication with the XEN1210 occurs via the serial SPI interface. The SPI interface is externally controlled by four signals : chip select (CS), serial clock (SCK), serial data in (MOSI/SDI), and serial data out (MISO/SDO). SPI mode is 1, which means that SCK has a zero base value (CPOL=0) and data is read on SCK's falling edge, while data is changed on the rising edge (CPHA=1). Typically the speed of SCK is 100kHz. Read-out speeds up to 1MHz are allowed as long as the  $T_{buf}$  is satisfied.  $T_{buf}$  is typically two times the CLK period.

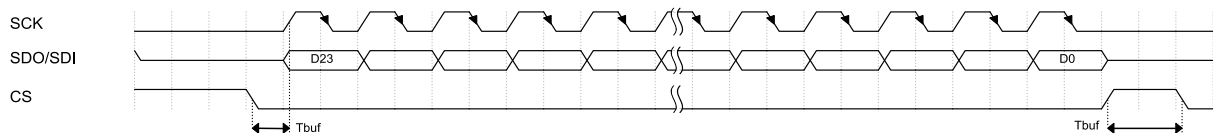


Figure 3: Timing of the SPI bus interface with chip select, clock, and data signals.

The SPI interface has one serial shift register and two buffers: a receive-buffer in which the data is loaded from the shift register at the end of CS, and a transmit-buffer from which the data is loaded into the shift register at the beginning of CS. Writing the SPI register will shift in serial data from SDI and shift out serial data from SDO pin. Reading and writing is therefore always performed simultaneously.

Transmission always goes in a multiple of 3 bytes with the MSB (bit D23) send first. The SPI interface is still operational when the device is in power-off mode.

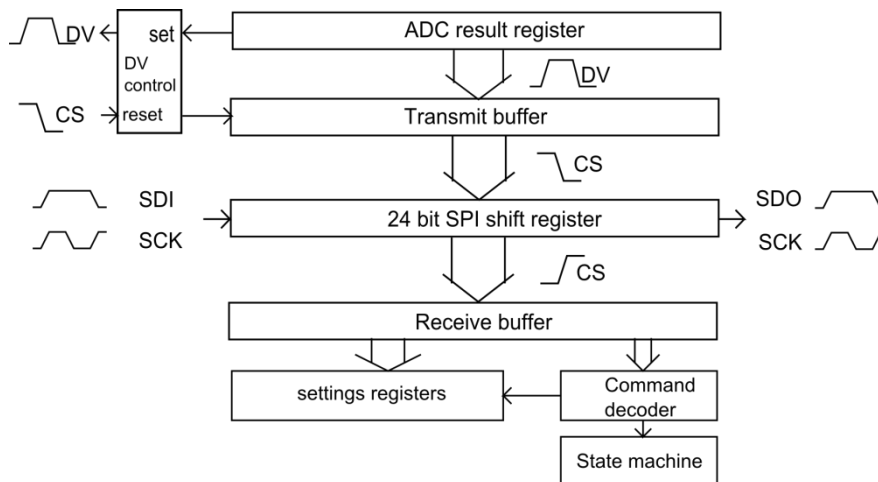


Figure 4: Functional block diagram SPI register.

### Data Output Format

The XEN1210 provides a 3-byte result in two's complement code. Table 2 shows the digital encoding of the magnetic reading. Data is double buffered and can be read out any time. When new data becomes available through the internal ADC, the XEN1210 pulls up the data valid pin for one clock period and refreshes the 3 byte transmit buffer. The LSB (bit D0) of the buffer is also used as a data valid flag.

When the transmit buffer is loaded into the SPI register at the start of a SPI transmission, the data valid flag is reset to 0. When new ADC data is loaded into the transmit buffer, the DV flag is set to 1. This helps to see if the last read data is new or if it has been read before. If data is not read before a new sample of the ADC is available it is lost. Since the system noise is usually higher than the LSB, it is not strictly necessary to bit-wise mask the data-valid flag, when calculating the magnetic field strength.

# XEN1210

## Magnetic Sensor

Table 2: Decoding the two's complement code and data-valid flag.

LSB's	HEX code	Field strength	Remarks
+ 2 <sup>23</sup> -1	0x7FFFFFFF	+63 mT	
+ 255	0x0000FF	+1.9 μT	
+3	0x000011	+21.5nT	Data valid
+2	0x000010	+15nT	Data non valid.
+1	0x000001	+7.5nT	Data valid
0	0x000000	0	Data non valid.
-1	0xFFFFF	-7.5nT	Data valid
-255	0xFFFF01	-1.9 μT	
- 2 <sup>23</sup>	0x800000	-63 mT	

### Data Read Out

When the XEN1210 is read out, care has to be taken that the SDI pin is high. The SDO pin of the host CPU connected to this SDI should be high or high impedance. In the latter case the internal pull-up of the XEN1210 SDI pin ensures a high state. This is necessary to avoid that the device's operation is changed by unintentionally programming it.

### Commands

The XEN1210 can be controlled and the settings programmed by sending commands over the SPI bus. Commands are coded in a 3-byte format. The first byte (D23-D16) is the program byte, which defines the desired action. The two remaining bytes (D15-D8 and D7-D0) are the setting bytes, which control the speed and biasing of the device.

### Operation Commands

The XEN1210 can be controlled with 4 operation commands: power-on, power-off, system-reset, and single-shot. With these commands only the program byte is used and the setting bytes are ignored. The primary purpose of the modes is system synchronization and power management.

Table 3: Operation commands used with the XEN1210.

Operation Command	Program Byte
System-Reset	0x10
Power-On	0x20
Power-Off	0x40
Single-Shot	0x60

### Reset

The reset command is used during power-on to reset the state machine of the XEN1210 to its initial state, devices can be synchronized as a group or individual.

### Power-off

The power-off command switches off the power to all circuits except for the SPI interface. Communication and programming is still possible during power-off. Power consumption in this mode is several micro-amps.

For full system power saving mode CLK has to be pulled low as well. This also stops the SPI communication. Power consumption during power-off will be less than 100nA.

# XEN1210

## Magnetic Sensor

### Power-on

The power-on command applies power to all circuits. When sending power-on, the system also resets with a system reset command. In this mode measurements are taken continuously and can be read from the SPI bus.

### Single-shot

The single-shot command calls the power-on command, performs a single measurement, and calls the power-off command. It is very important NOT to send a new single-shot command before the previous command sequence has finished. This is indicated by the data-valid pulse on the DV pin. If the single-shot command is send before the previous command sequence has finished then the XEN1210 is reset, so the previous single shot sequence will not finish and no new data is provided. The time needed for a single-shot sequence depends on the timing settings of the XEN1210. The single-shot command only works when the device is powered off. In this mode, power can be saved by using the device only when data is required.

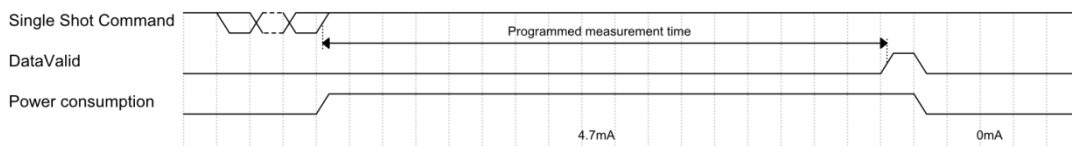


Figure 5: The measurement time after a single shot command depends on the timing settings. Only during measurement power is consumed.

### Settings Commands

There are 2 setting commands: one for the timing and bias register, and one for the test register. The setting commands will refresh the setting registers of the device.

Table 4: Setting commands used with the XEN1210.

Settings Command	Program Byte	Setting Bytes
Timing and biasing	0x01	See Table 5.
Test	0x02	See Table 7.

### Timing settings

The timing settings control the speed of measurement. There are 7 settings, with each step doubling the number of clock cycles used in the internal ADC. The total conversion time is still dependent on the frequency of CLK. In Table 5, two situations have been calculated: one at 1MHz clock speed, and one at 5MHz clock speed. At 5MHz the noise performance is slightly deteriorated. The bias settings for the Hall plate are on 75%. The noise and timing data are for continuous mode only.

Table 5: Read out frequency and measurement time for the speed settings and 1MHz or 5MHz clock.

Timing Settings	Clock Cycles	1MHz			5MHz		
		Time [ms]	Max SPS [Hz]	Noise ( $\sigma$ ) [ $\mu$ T]	Time [ms]	Max SPS [Hz]	Noise ( $\sigma$ ) [ $\mu$ T]
0x1113	1024	1.0	976.6	2.3	0.20	4882.8	5.8
0x2113	2048	2.1	488.3	1.6	0.41	2441.4	4.1
0x3113	4096	4.1	244.1	1.2	0.82	1220.7	2.9
0x4113	8192	8.2	122.1	0.81	1.64	610.4	2.1
0x5113	16384	16.4	61.0	0.57	3.28	305.2	1.4
0x6113	32768	32.8	30.5	0.41	6.55	152.6	1
0x7113	65536	65.5	15.3	0.29	13.1	76.3	0.7

# XEN1210

## Magnetic Sensor

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### Single shot timing settings

At single shot mode part of the time is reserved for the start-up and stabilizing of the system. The codes are factory programmed into a safe start up. This will however consume some power and demand some measurement delay time. Please contact Sensixs Design for other start up codes.

Table 6 Start up code to use at single shot measurements.

Timing Settings Command	Timing Settings
Safe start up	0x--13
Half safe	-
No start up	-

### Hall bias settings.

In Table 7 the recommended settings for the Hall biasing are shown. The biasing can be increased and decreased with 25% to 100% or to 50%. Please contact Sensixs Design if you want to optimally use these code. The settings control the Hall current and the scale of the magnetic reading will scale with the chosen biasing compared to the factory setting of 75%. As a result the maximum range and the magnetic noise will scale down with a higher bias setting. 100% biasing is only recommended for a temperature range below 60 degrees Celcius.

Table 7 Bias setting commands.

Bias Settings Command	Biasing Settings
100% Hall Biasing	0x--33
75% Hall Biasing (preferred)	0x--13
50% Hall Biasing	0x--23

### Test settings

The test factor contains a number of factory set values and needs to be programmed on 0x3A00

### Combined Commands

Operation commands and setting commands can be combined, by adding the command codes. This is most useful for the single shot command, where a sample time can be programmed for each individual single shot.

Table 8: Combined commands.

Command	Program Byte	Setting Bytes
Single-Shot and Timing	0x61	0x1113

## Typical initialization and operation

### Power supply on initialization

The XEN1210 does not reset when power is applied, and the device has to be fully programmed before use. Good programming practice is to first send a power-off command and then program both timing and test registers with the desired settings.

# XEN1210

## Magnetic Sensor

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Table 9: Device initialization sequence.

Command	Program Byte	Setting Bytes
Power-Off	0x40	0x0000
Timing	0x01	0x1113
Test	0x02	0x3A00

### Full Power Mode

A full-power operation can be entered by sending the power-on command. Directly after sending the power-on command, all devices that are connected to the bus are synchronized and will start measuring continuously at the programmed speed.

The XEN1210 data can now be read by either using the DV pin as an interrupt, or by just clocking out the SPI data. Duplicate data can be filtered by looking at the data valid flag in the LSB of the data word.

Table 10: Device put into continuous measurement mode.

Command	Program Byte	Setting Bytes
Power-On	0x20	0x0000

### Reprogramming during operation

Because settings are implemented immediately, reprogramming during operation should be combined with a system synchronization command. This will prevent a change of settings while a measurement takes place, which can lead to incorrect magnetic readings. Synchronization and reprogramming can be combined in a single command.

Table 11: Reprogramming the device during measurement.

Command	Program Byte	Setting Bytes
Power-On and Timing	0x21	0x1113
System-Reset and Timing	0x11	0x1113

### Single-Shot Mode

A single-shot operation with a measurement time of 1ms (with 1MHz clock) is shown in Table 12. The command powers on the device for 1 measurement and powers off immediately after. The device then keeps the data in memory until read by the host CPU.

Table 12: Taking a single shot with a sample time of 1ms.

Command	Program Byte	Setting Bytes
Single-Shot and Timing	0x61	0x1113



# XEN1210 Magnetic Sensor

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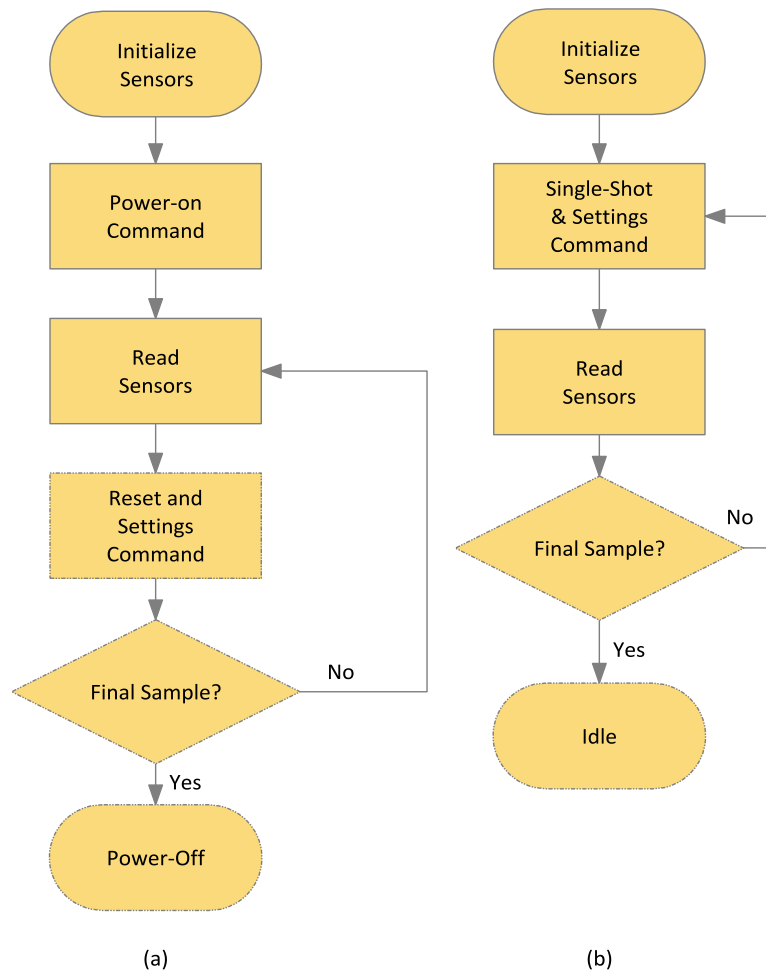


Figure 6: Flow diagram for continuous operation (a) or single shot operation (b).

# XEN1210

## Magnetic Sensor

### Connection schemes

By using multiple XEN1210, in similar or different orientations, many magnetic measurement problems can be solved. The devices can be electrically connected in two ways:

#### Parallel

The devices can be used with SDI and SDO fully parallel and separate CS pins. They are selected individually.

#### Daisy chain

Several devices can be daisy chained by connecting SDO to the next SDI. As such, they function as one long shift register, so commands and data are sent and received in multiples of 3 bytes. Commands and data of the individual devices in the chain have to be positioned in the correct order.

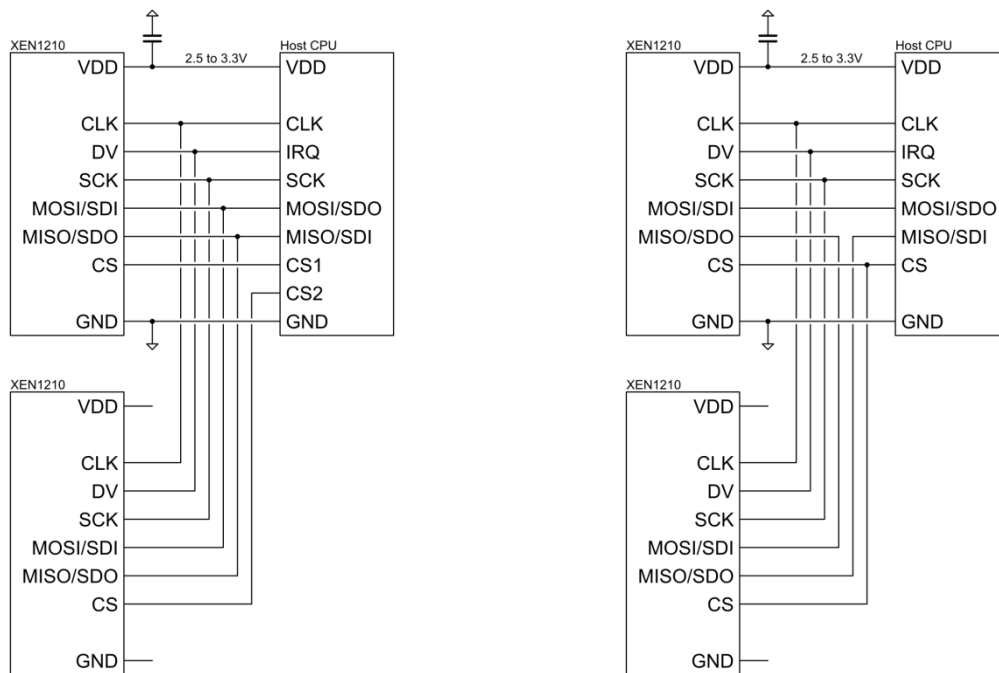


Figure 7: Devices connected in parallel mode use a separate chip select signal (left), and devices connected in daisy chain mode use a single chip select signal and loop the SDI-SDO shift registers (right).

# XEN1210

## Magnetic Sensor

### Lead Pin Configuration

The XEN1210 is delivered in SOIC8 and MSOP8 and a custom made package in called SFN8, which can be used to measure the XY axis of the magnetic field.

### Vertical package SFN8

The vertical package is a special SMD mountable package, which is an adapted version of the QFN technology. Eight leads on one side are used for interconnection. The package dimensions are 4mm\*1.6mm\*1.4 mm. In comparison with standard QFN technology, the thickness of the package is increased to 1.4mm. This allows stable positioning of the package on its side.

In this vertical position, soldering is performed with the solder to the side of the package instead of underneath. The package can be oriented in any direction on the PCB and is intended to measure the x-y axis for a 2 or 3D magnetic field sensor.<sup>9</sup> The magnetic sensitivity and position of the Hall-plate are shown in Figure 8. The pin numbering and their functional description can be found in Table 13.

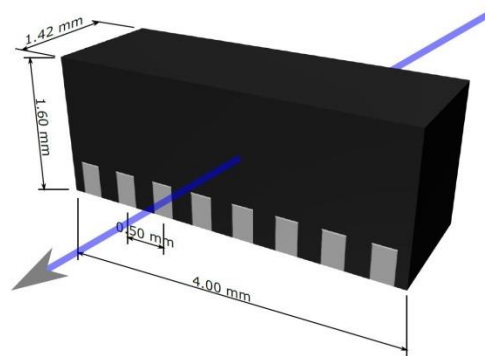


Figure 8: Footprint and magnetic sensitivity position.

Table 13: XEN-1210 SFN8 pin configuration

Pin	Name	Type	Functionality
1	CLK	Dig. In	CLOCK is the main clock and determines the speed of the module. Typical clock frequency is 1-5MHz.
2	CS	Dig. In	Chip Select selects the device when this input is low. A high level deselects the device and forces SDO into tri-state mode.
3	SCK	Dig. In	Serial shift Clock determines the speed of the SDI/SDO shift register.
4	SDI/MOSI	Dig. In	Serial Data Input pin. Data shifted in is committed on the falling edge of SCK.
5	SDO/MISO	Tri-state Out	Serial Data Output pin. Data is shifted out on the positive edge of SCK.
6	DV	Dig. Out	The Data Valid pin is pulled down for one clock period when the internal shift register is refreshed with new data. It can be used as an interrupt signal for the host CPU. DV pins cannot be shared.
7	GND	Power	Analog and Digital Ground
8	VDD	Power	Analog and Digital Power Supply (2.5V - 3.3V)

<sup>9</sup> Further instructions for placement and soldering can be found in our technical notes. Pre-soldered 3D units with LCC-20 footprint are also available.

# XEN1210

## Magnetic Sensor

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### XEN1210-SOIC8

The device is sensitive to magnetic fields applied perpendicular to the top of the package.

Table 14: XEN-1210-SOIC8 pinning

Pin	Name	Type	Functionality
1	CS	Dig. In	Chip Select selects the device when this input is low. A high level deselects the device and forces SDO into tri-state mode.
2	SCK	Dig. In	Serial shift Clock determines the speed of the SDI/SDO shift register.
3	SDO/MISO	Tri-state Out	Serial Data Output pin. Data is shifted out on the positive edge of SCK.
4	GND	Power	Analog and Digital Ground
5	VDD	Power	Analog and Digital Power Supply (2.5V - 3.3V)
6	DV	Dig. Out	The Data Valid pin is pulled down when the internal shift register is refreshed with new data. It can be used as an interrupt signal for the $\mu$ P.
7	SDI/MOSI	Dig. In	Serial Data Input pin. Data shifted in is committed on the falling edge of SCK
8	CLK	Dig. In	CLock is the main clock frequency and determines the speed of the module. Typical clock frequency is 1-5MHz.

### XEN1210-MSOP8

The device is sensitive to magnetic fields applied perpendicular to the top of the package.

Table 15: XEN-1210-SOIC8 pinning

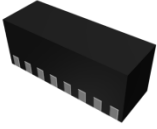
Pin	Name	Type	Functionality
1	CS	Dig. In	Chip Select selects the device when this input is low. A high level deselects the device and forces SDO into tri-state mode.
2	SCK	Dig. In	Serial shift Clock determines the speed of the SDI/SDO shift register.
3	SDO/MISO	Tri-state Out	Serial Data Output pin. Data is shifted out on the positive edge of SCK.
4	GND	Power	Analog and Digital Ground
5	VDD	Power	Analog and Digital Power Supply (2.5V - 3.3V)
6	DV	Dig. Out	The Data Valid pin is pulled down when the internal shift register is refreshed with new data. It can be used as an interrupt signal for the $\mu$ P.
7	SDI/MOSI	Dig. In	Serial Data Input pin. Data shifted in is committed on the falling edge of SCK
8	CLK	Dig. In	CLock is the main clock frequency and determines the speed of the module. Typical clock frequency is 1-5MHz.

# XEN1210

## Magnetic Sensor

### Reels XEN1210 SFN8

Table 16: Reel information

Parameter	Dimension Reel vertical mounting
	
Ao	tdb
Bo	tdb
Ko	tdb
Po	tdb
P1	tdb
P2	tdb
Do	tdb
D1	tdb
E1	tdb
F	tdb
W	tdb

### Ordering information

Table 17: Ordering number.

Ordering number	Product
XEN1210-SFN8	Single sensor XY direction
XEN1210-MSOP8	Single sensor MSOP8
XEN1210-SOIC8	Single Sensor SOIC8

# XEN1210

## Magnetic Sensor

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### General Information

#### Product Status

The XEN1210 is in production in SFN8, SOIC8 and MSOP. The SFN8 is delivered in reel, with a vertical position of the package. The SOIC8 and MSOP8 are delivered in tubes.

ASIC dies, other chip packages, are available on request. The magnetic technology used in the XEN1210 is also available as IP. At higher volumes, application specific products are offered.

Customers are encouraged to check for further product developments. Please contact Sensixs Design b.v. for further details.

#### Right to make changes

Sensixs Design reserves the right to make changes to improve reliability, function or design of the devices. Sensixs Design assumes no responsibility or liability for the use of this product.

#### Application Information

Applications that are described herein are for illustrative purposes only. Sensixs Design makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

#### Life critical applications

These products are not qualified for use in life support applications, aeronautical applications or devices or systems where malfunction of these products can reasonably be expected to result in personal injury

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