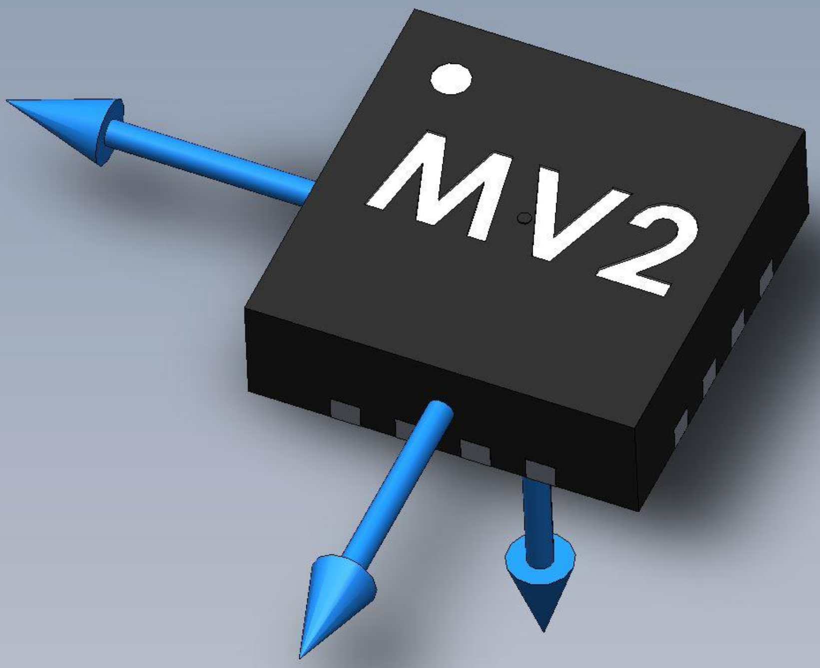
METROlab
Magnetic precision has a name



MagVector™ MV2
3-Axis Magnetic Sensor

Datasheet

Version 1.1

(Revision 1.0)

February 2016

REVISION HISTORY

v. 0.1	December 2013	- Unpublished -
v. 0.2	January 2014	- Unpublished - Specific notes to MagVector MV2 release 1 added Thermometer data in table 4 Options renamed (BSM, DRP) Various corrections
v. 0.3	January 2015	- Unpublished - Range extension option
v. 1.0 r. 1.0	December 2015	First release
v. 1.1 r. 1.0	February 2016	Update and complete general specifications Add a section on mounting precautions Correct minimum ADC resolution: 14 bits, not 13 Miscellaneous corrections

MagVector™ MV2 3-axis magnetic sensor
1-Overview

1-1 FEATURES

Measures total field: 3-axis

Selectable measurement ranges:
from 100 mT to 30 T

Low noise: 300 nT/√Hz

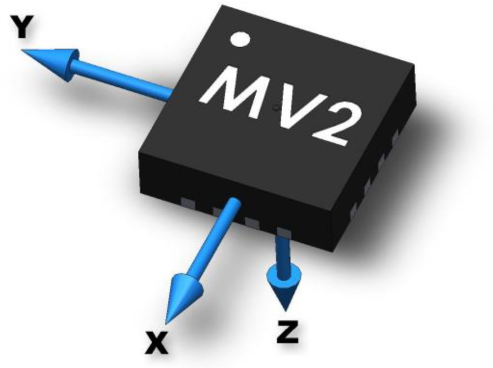
Supply voltage: 3.3 V or 5 V

Analog and digital interfaces

Selectable measurement rate: up to 3 kHz

Selectable resolution: 14 to 16 bits

Non-magnetic package



1-2 SAMPLE APPLICATIONS

High performance embedded applications

Custom multi-probe field mappers

Magnetic flux leakage measurement

1-3 GENERAL DESCRIPTION

The MagVector™ MV2, designed and manufactured by MPS Tech Switzerland (formerly Sensima Technology) in Gland, Switzerland, is a robust 3-axis magnetic Hall effect sensor. It features an analog as well as digital interface, selectable by the user. The analog mode delivers voltages proportional to the magnetic field, and the measurement range is configurable via simple wiring. In the digital mode, the MagVector MV2 communicates through a Serial Peripheral Interface (SPI) for configuration and data delivery. The non-magnetic QFN package is compatible with MRI environments.

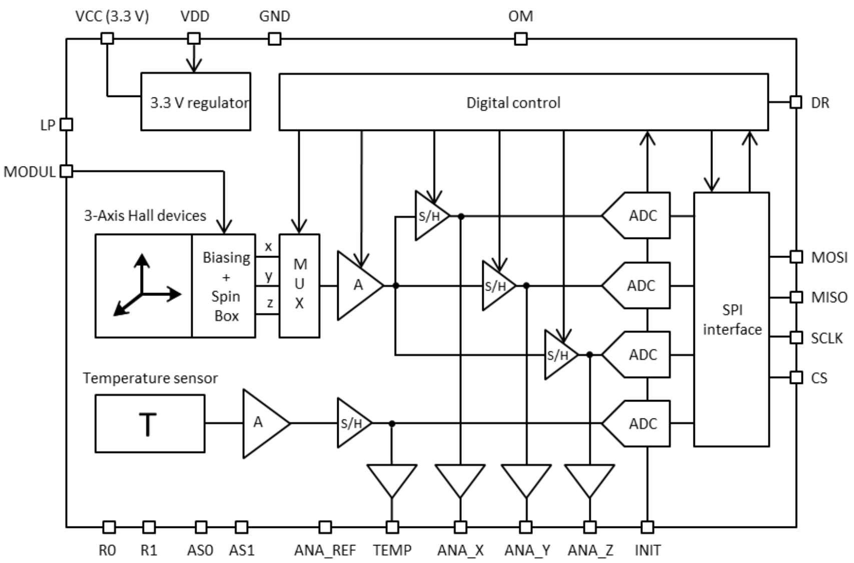


Figure 1. Block diagram

MagVector™ MV2 3-axis magnetic sensor
2-Document contents

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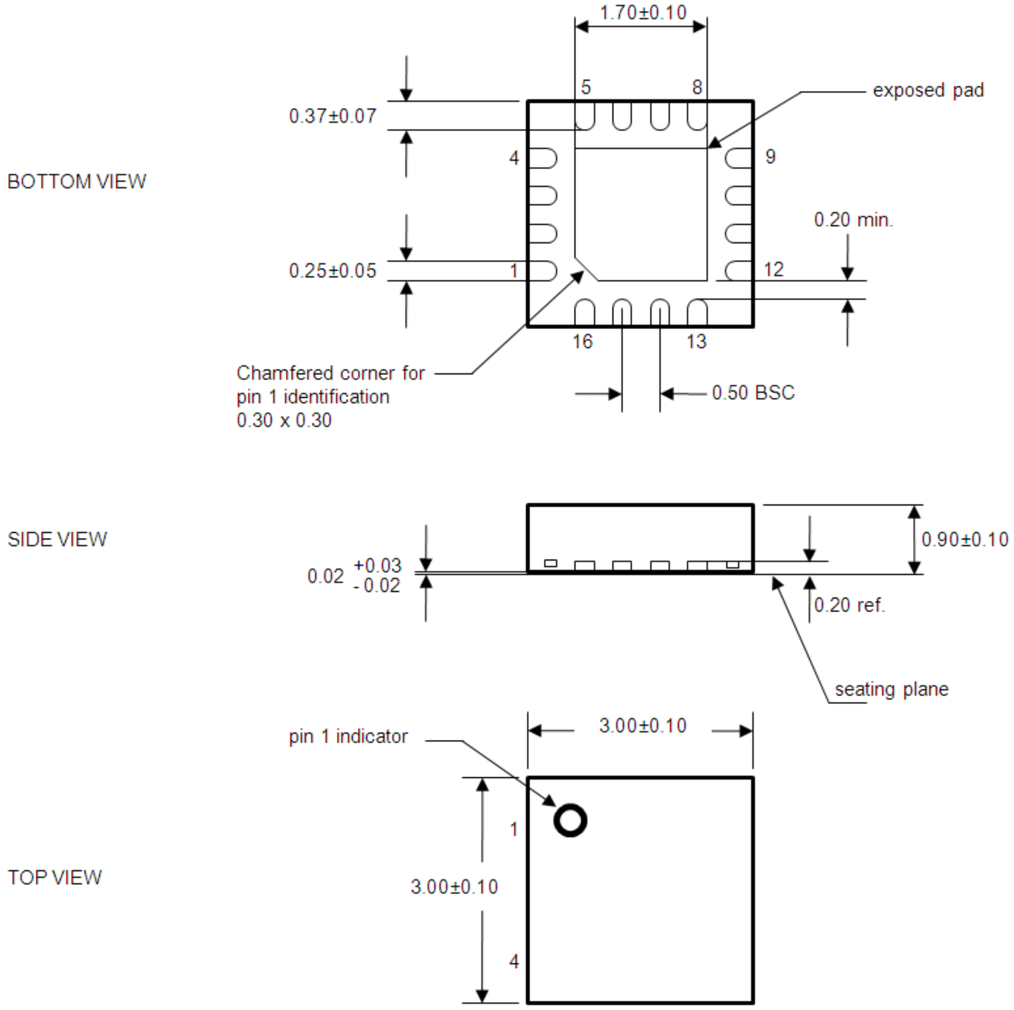
2-2 LIST OF FIGURES

2-3 LIST OF TABLES

MagVector™ MV2 3-axis magnetic sensor
3-General

3-1 PACKAGE DIMENSIONS AND MARKING

Package: 16L QFN 3x3x0.9mm, 0.50mm pitch with exposed pad of 1.70x1.70mm



NOTES:

All dimensions are in mm.

Package dimensions do not include mold flash, protrusions, burrs or metal smearing.

Co-planarity applies to the exposed terminals. Maximum co-planarity shall be 0.08.

Compliant with JEDEC-220.

Marking: 3 lines, e.g. “03/MV2/5AC”. The first line is the version number, the second is the product identifier, and the third is an internal identification code.

3-2 MOUNTING PRECAUTIONS

When mounting the MV2 on the printed circuit board (PCB), it is important to avoid stress. Stress induces piezoelectric voltages that interfere with the measurement of the Hall voltages; in particular, they vary with temperature and can cause offset drifts with very long time constants.

Specific recommendations include:

- PCBs made of FR-4 are recommended over, for example, ceramic PCBs, since the coefficient of thermal expansion of the substrate better matches that of the package.
- After soldering, the package should not be mechanically constrained in any way.

3-3 ABSOLUTE MAXIMUM RATINGS

Table 1. Absolute maximum ratings

Parameters	Min	Max	Unit
DC voltage at VCC	-0.5	7	V
DC voltage at VDD	-0.5	4	V
Input current on any pin (1)	-100	100	mA
Electrostatic discharge (2)		±2	kV
Package thermal resistance:			
– Junction to ambient (Theta JA)	50		°C/W
– Junction to case (Theta JC)	12		°C/W
Storage temperature	-40	150	°C

Notes:

These values denote absolute maximum ratings. These ratings are stress ratings only. Functional operation of the device at these conditions is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

(1) Norm: JEDEC78

(2) Norm: MIL 883 E method 3015

3-4 OPERATING CONDITIONS

Table 2. Operating conditions

Parameter	Symbol	Min	Typ	Max	Unit
DC supply voltage	VCC	4.5	5	5.5	V
DC supply voltage	VDD	3.28	3.3	3.32	V
DC supply current	I_{sup}	17	18.5	20	mA
Digital input signals:					
– “Low” input voltage	V_{il}			30% of VCC	V
– “High” input voltage	V_{ih}	70% of VCC			V
– Input current	I_i	±30		±100	µA
Digital output signals:					
– “Low” output voltage (1)	V_{ol}			0.4	V
– “High” output voltage (2)	V_{oh}	4			V
Operating temperature	T_{op}	-40		+125	°C

Notes:

The maximum drive capability of the analog outputs is 100 kΩ / 500 pF.

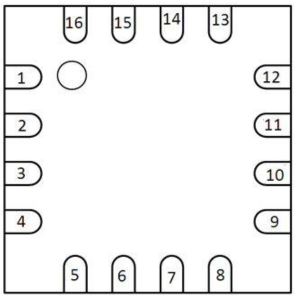
The digital output level matches the supply used: 5 V when supplied with 5 V and 3.3 V when supplied with 3.3 V.

(1) Measurement conditions: VCC = 5 V; I_o = +1 mA.

(2) Measurement conditions: VCC = 5 V; I_o = -1 mA.

3-5 PINOUT

Top view:



The functions of the pins differ according to the mode of operation, analog or digital – see Table 3 and Table 4. Unused pins can be left unconnected; the internal pull-down resistor is ~100 kΩ.

Table 3. Pinout – analog mode operation

Pin	Name	Type	Direction	Description	Pad input option
1	RA0	Digital	In	Field range 0	Pull-down
2	RA1	Digital	In	Field range 1	Pull-down
3	MA0	Digital	In	Meas. Axis 0	Pull-down
4	MA1	Digital	In	Meas. Axis 1	Pull-down
5	Z	Analog	Out	Z-axis output	
6	TEMP	Analog	Out	Temperature output	
7	REF	Analog	Out	Volt. reference (VCC/2)	
8	VDD	Supply	Power	Internal core supply voltage (3.3 V)	
9	D-A	Digital	In	Digital - Analog mode	1
10	LP	Digital	In	Low power mode	Pull-down
11	INV	Digital	In	Output inversion	Pull-down
12	EMR	Digital	In	Extended Measurement Range	Pull-down
13	GND	Supply	Power	Ground	
14	VCC	Supply	Power	Main supply voltage (5 V)	
15	Y	Analog	Out	Y-axis output	
16	X	Analog	Out	X-axis output	

Table 4. Pinout – digital mode operation

Pin	Name	Type	Direction	Description	Pad input option
1	MISO	Digital	Out	Serial MISO	Pull-down
2	SCLK	Digital	In	Serial CLK	Pull-down
3	CS	Digital	In	Serial CS	Pull-down
4	MOSI	Digital	In	Serial MOSI	Pull-down
8	VDD	Supply	Power	Internal core supply voltage (3.3 V)	
9	D-A	Digital	In	Digital - Analog mode	0 or floating
10	INIT	Digital	In	ADC initialization	Pull-down
12	DR	Digital	Out	Data ready	Pull-down
13	GND	Supply	Power	Ground	
14	VCC	Supply	Power	Main supply voltage (5 V)	

Unused pins may be left unconnected.

3-6 POWER SUPPLY

The MagVector MV2 is designed to be supplied with 5 V. An on-chip voltage regulator reduces and stabilizes the 5 V down to 3.3 V, which is the chip core supply voltage. However, it is also possible to supply the chip with 3.3 V. In that case, since there is no regulation, the supply needs to be stable within 0.5 % to reach the specified resolution.

The digital output level matches the supply used: 5 V when supplied with 5 V and 3.3 V when supplied with 3.3 V.

When using a 5 V supply, the internal core supply voltage can be monitored on the VDD pad.

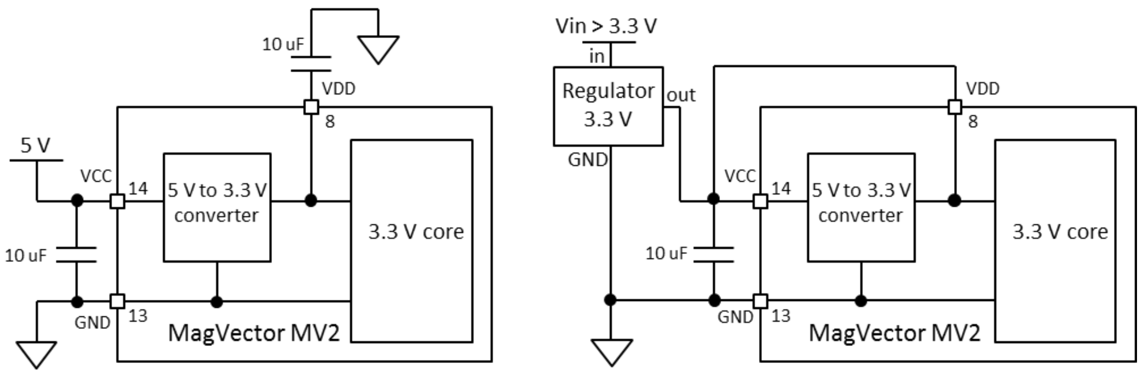


Figure 2. Connections for 5 V supply (left) and 3.3 V supply (right)

Notes:

In the 3.3 V configuration, VCC must be shorted to VDD.

The 10 µF capacitor values are approximate recommendations. In the 3.3 V configuration, the choice of the value of the decoupling capacitor depends on the specifications of the external voltage regulator. It is recommended to place a 100 nF decoupling capacitor in parallel to each 10 µF capacitors.

3-7 OPERATING MODES

The MagVector MV2 can be operated in two modes: digital or analog, depending on the logic level of the D-A input pin. If the D-A pin is tied to LOGIC 0 or left floating, the MagVector MV2 is operating in digital mode (default). In order to switch the operating mode of the MagVector MV2 from digital to analog, the D-A pin has to be tied to LOGIC 1 (VCC).

Table 5. Operating modes

D-A	Mode	See:
0	DIGITAL	Page 13, Section 5-Digital Mode Operation
1	ANALOG	Page 8, Section 4-Analog Mode Operation

3-8 SENSING DEVICE

The three components of the magnetic field are detected by three orthogonal Hall devices: the component B_z normal to the die plane is detected by a conventional "horizontal" Hall sensor, whereas the two in-plane components B_x and B_y are detected by "vertical" Hall sensors (see Figure 3).

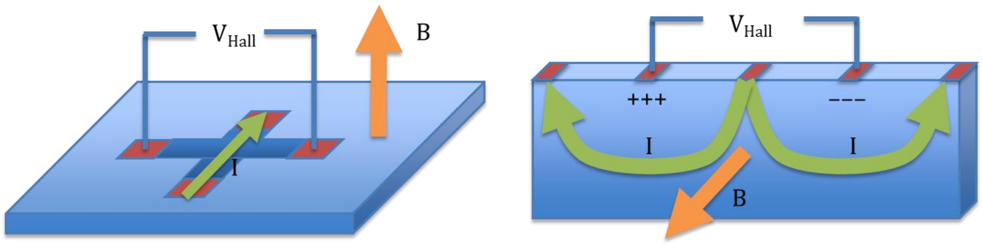


Figure 3. Conceptual diagrams of horizontal (left) and vertical (right) Hall sensors

The directions of the axes *(B_x, B_y, B_z)*, relative to the QFN package, are shown in the diagram in Section 1-Overview. The axes are oriented as indicated by the arrows in digital mode, in the opposite direction in analog mode (see Section 3-7).

The input and output leads of the Hall devices are sequentially permuted. This "spinning current" technique has several significant benefits: it minimizes the offset and, more importantly, the offset drift; it minimizes the Planar Hall Effect; and it minimizes 1/f noise.

The sensing volume has the shape of a thin square slab, 200x200 µm in the die plane and about 5 µm high. The Hall sensors are distributed such that the measured Hall voltage of all three axes closely approximates the flux density averaged throughout the slab. The sensing volume is located, with a precision of 50 µm, in the center of the QFN package, both horizontally and vertically.

3-9 SIGNAL CONDITIONING

By default, the 3 measurement signals are sequentially multiplexed, amplified and de-multiplexed (see Figure 4 for analog mode and Figure 6 for Digital Mode). This means that a single amplifier is used for all 3 axes. By controlling the gain, the user sets the magnetic field range. A separate, fixed-gain amplifier amplifies the temperature sensor output.

By default, the following ranges can be selected: 100 mT, 300 mT, 1 T and 3 T. The amplifier saturates when the magnetic field strength exceeds the range value by approximately 20%; for instance, if the range is 100 mT, the output saturates at around 120 mT.

Additional option bits allow the range to be extended by 30% or by a factor 10x – see Section 12 for analog mode and Sections 5-21 and 5-22 for digital mode,

3-10 MEASUREMENT AXIS SELECTION

By default, the 3 magnetic axes are multiplexed continuously at a rate well above the output frequency.

It is possible to prevent the continuous multiplexing and amplify just the x-, y- or z-axis. Single-axis mode is useful when the user wants to optimize the signal-to-noise ratio of one particular axis.

This mode is also recommended when a large magnetic field is applied in a direction other than the one being measured. In such conditions, without enabling the single-axis mode, the amplifier may saturate when amplifying the large Hall voltage. Since the amplifier recovery time is relatively long, the saturation can affect the value read for other axes.

Note that in single-axis mode, only one of the 3 magnetic field channels provides meaningful values. For instance, if the selected measurement axis is only x, the channels y and z are disabled, and therefore provide non-usable outputs.

MagVector™ MV2 3-axis magnetic sensor
4-Analog Mode Operation

4-1 SPECIFICATIONS

Table 6. Performance specifications in analog mode

Performance specifications in analog mode, VDD = 5 V, T = 25°C						
Parameter		**Min**	**Typ**	**Max**	**Unit**	**Note**
Sensitivity	3 T range	0.42	0.50	0.58	V/T	
	1 T range	1.26	1.50	1.74		
	300 mT range	4.2	5.0	5.8		
	100 mT range	12.6	15.0	17.4		
Sensitivity drift	All ranges		±200	±400	ppm/°C	
Measurement bandwidth		50			kHz	
Repeatability				0.1	%	
Spectral noise density	X & Y axis		330		nT/√Hz	
	Z axis		225		nT/√Hz	
RMS noise	X & Y axis		8		µT	RMS (0 - 600 Hz)
	Z axis		5.5		µT	RMS (0 - 600 Hz)
Static offset			30	50	mV	With respect to VCC/2
Offset temperature drift				0.1	mV/°C	
Temperature output sensitivity			4.2		mV/°C	
Temperature output @ 27°C		1.25		1.35	V	

4-2 SIGNAL CONDITIONING – ANALOG MODE

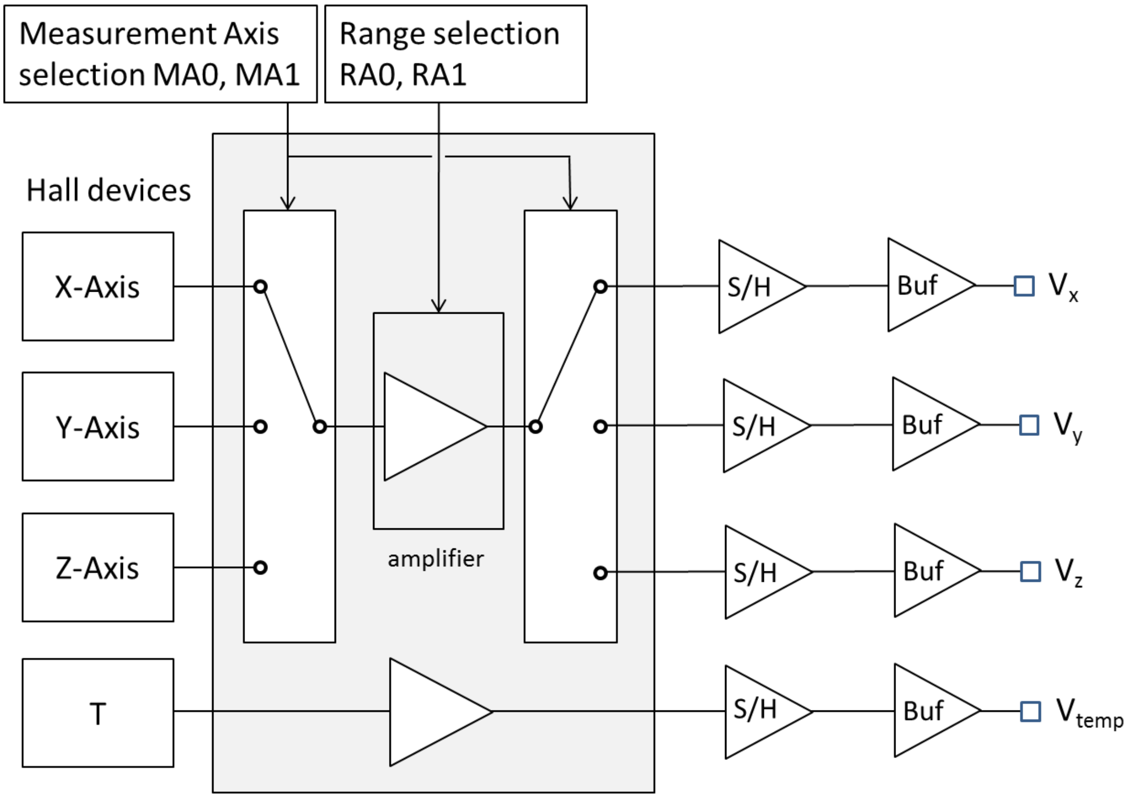


Figure 4. Block diagram of the signal conditioning – analog mode

4-3 OUTPUT STAGE

The analog voltages representing the magnetic field and the chip temperature are buffered through the output "Buf" stage. The maximum drive capability of the analog outputs is 100 kΩ / 500 pF.

The magnetic field outputs (Vx, Vy and Vz) are referenced to VCC/2, corresponding to zero magnetic field. This reference voltage is generated internally and available on the REF pin.

V_{temp} is referenced to GND.

4-4 APPLICATION CIRCUIT

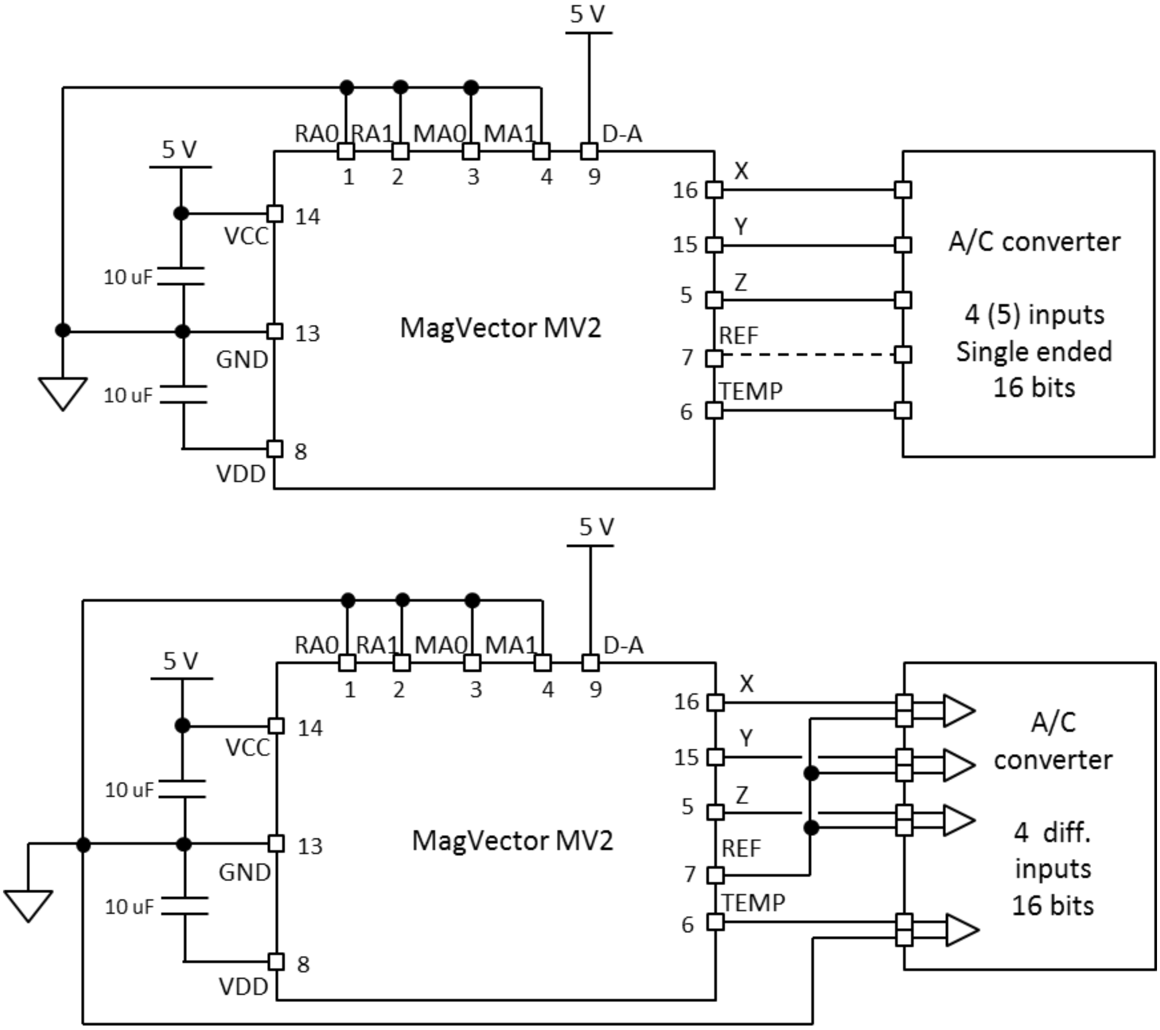


Figure 5. Circuits for sensor control and reading – analog mode

Note that all input pins are in pull-down configuration, i.e. if an input pin is not connected (left floating), it is considered as a LOGIC 0 setting.

4-5 OPTION SETTINGS IN ANALOG MODE

Note that the D-A pin has to be tied to LOGIC 1 (VCC). The following options can be selected in analog mode:

Table 7. Selectable options – analog mode

Pin	Name	Description	See
1	RA0	Range LSB	Page 11, Section 4-6
2	RA1	Range MSB	Page 11, Section 4-6
3	MA0	Measurement Axis LSB	Page 11, Section 4-7
4	MA1	Measurement Axis MSB	Page 11, Section 4-7
10	LP	Low Power	Page 11, Section 4-8
11	INV	Invert	Page 12, Section 4-9
12	EMR	Extended Measurement Range	Page 12, Section 4-10

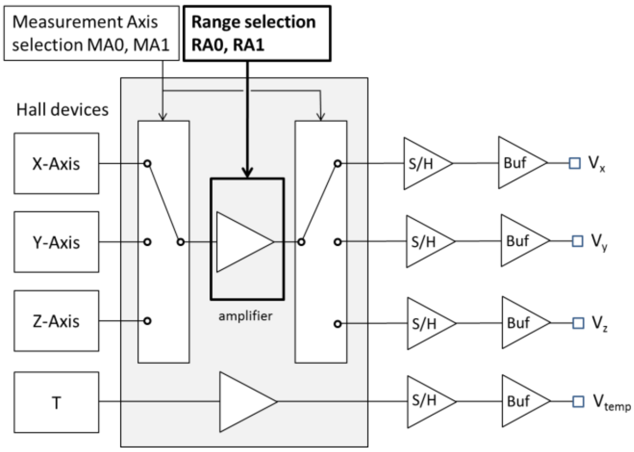
4-6 RA – RANGE

Pins: RA0 (1), RA1 (2)

The RA parameter sets the amplification gain. When the measured magnetic field is within the range (between - range to + range), the sensor output is proportional to the applied magnetic field amplitude.

Table 8. Range selection – analog mode

RA1	RA0	Magnetic field range
0	0	±100 mT
0	1	±300 mT
1	0	±1 T
1	1	±3 T



4-7 MA – MEASUREMENT AXIS

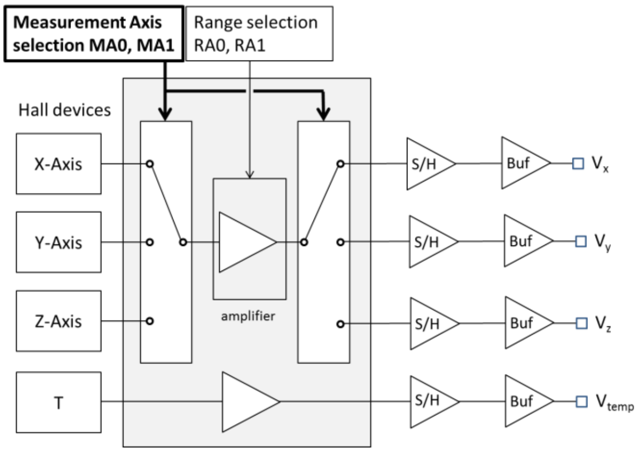
Pins: MA0 (3), MA1 (4)

The parameter MA determines which Hall device is amplified. Depending on the setting, all 3 axes are sequentially scanned and amplified, or the scanning is stopped and only one selected axis is amplified. See the table below.

The pins MA0 and MA1 are tied to GND (or left floating) or VCC to determine their logic state, LOGIC 0 or LOGIC 1, respectively.

Table 9. Measurement axis selection – analog mode

MA1	MA0	Measurement axis
0	0	3 axis
0	1	X axis
1	0	Y axis
1	1	Z axis



4-8 LP – LOW POWER

Pin: LP (10)

The MagVector MV2 can be switched to a low power mode by setting the LP pin to LOGIC 1. This mode reduces the current consumption by ~6 mA and the SNR by a factor of √2. Note that other parameters, such as temperature drift or offset, can also change.

4-9 INV – INVERT

Pin: INV (11)

When the INV pin is tied to LOGIC 1, the MagVector MV2 reverses the Hall bias currents, and therefore reverses the measured magnetic field voltages relative to the REF pin (VCC/2). Toggling this option can be used, for example, to emulate a low frequency modulator / demodulator.

4-10 EMR – EXTENDED MEASUREMENT RANGE

Pin: EMR (12)

When the EMR option is enabled by tying the EMR pin to LOGIC 1, the MagVector MV2 increases the selected range by 30%. The intended purpose of this option is to approximately compensate the reduced voltage swing of the output buffer when using a 3.3 V supply instead of 5 V.

MagVector™ MV2 3-axis magnetic sensor
5-Digital Mode Operation

5-1 SPECIFICATIONS

Table 10. Performance specifications in digital mode.

Performance specifications in digital mode, VDD = 5 V, T = 25°C						
Parameter		**Min**	**Typ**	**Max**	**Unit**	**Note**
Sensitivity[1]	3 T range	7.3	7.5	7.8	LSB/mT	
	1 T range	22	22.5	23		
	300 mT range	72	73.4	74		
	100 mT range	213	214	217		
Sensitivity drift	All ranges	-	±200	±400	ppm/°C	Can be compensated by programming
Measurement rate		0.375		3	kHz	Programmable
Number of bits delivered		14		16		Programmable
Spectral noise density	X & Y axis		330		nT/√Hz	
	Z axis		225		nT/√Hz	
RMS noise	X & Y axis		8		µT	RMS (0 - 600 Hz)
	Z axis		5.5		µT	RMS (0 - 600 Hz)
Static offset[1]			250	350	LSB	
Offset temperature drift			6		µT/°C	
Temperature output sensitivity[1]			46		LSB/°C	
Temperature output @ 27°C			23000		LSB	

[1] For 16-bit resolution. For lower resolution (15 or 14 bits), the values must be rescaled by a factor 2 or 4, respectively.

Table 11. Serial Peripheral Interface specification

Maximum clock frequency	10 MHz
Clock duty cycle	50%
SPI standard: - CPOL (Clock Polarity) - CPHA (Clock Phase)	Mode 0: 0: CLK idle state = Low 0: CLK readout edge = Rising
CS idle state	High
CS setup time	50 ns
CS hold time	50 ns
DORD (Data order)	0: MSB first
Data word size	16 bits
Minimum data word separation	100 ns
Data availability	DR or MISO – see Section 5-16

5-2 SIGNAL CONDITIONING – DIGITAL MODE

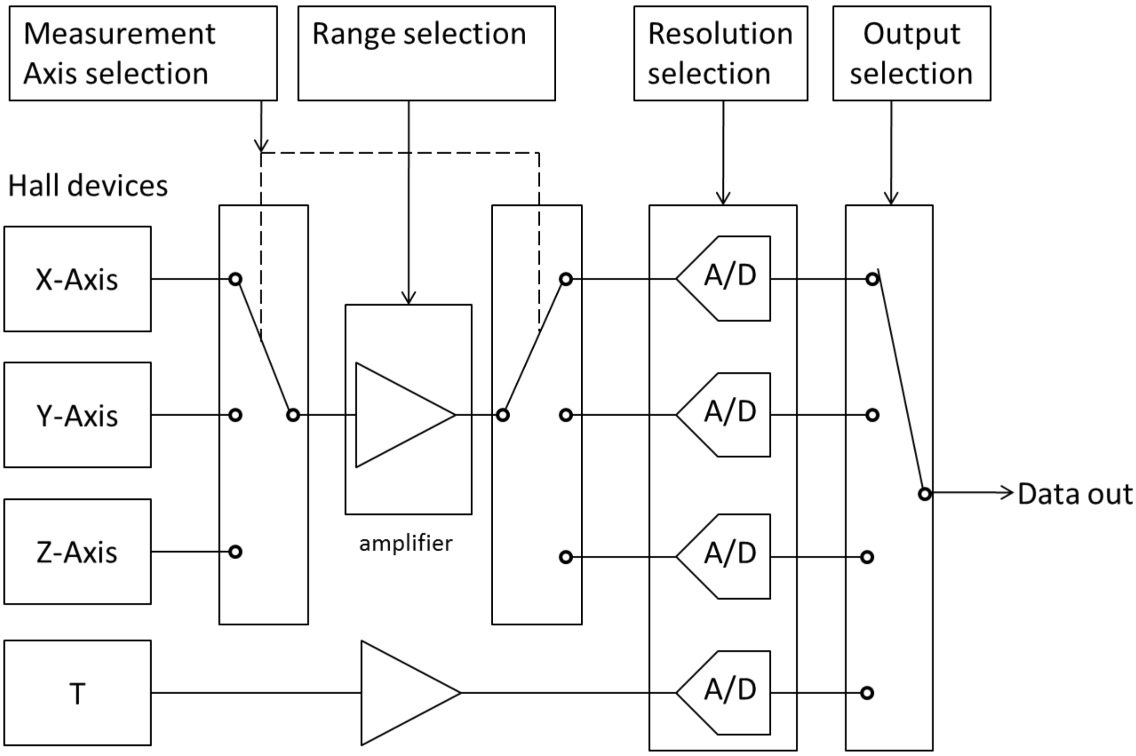


Figure 6. Block diagram of the signal conditioning – digital mode

5-3 A/D CONVERSION

The magnetic field signals out of the amplifier are de-multiplexed to the 3 A/D converters (see Figure 6).

Each A/D conversion requires several samples to generate one output. The A/D output rate can be adjusted by the user, from 0.375 to 3 kHz. The output rate determines the integration time and, as a consequence, the measurement resolution. This is why the parameter affecting the A/D rate is called “resolution” (RE). The tradeoff for the user is a low bandwidth, low noise output, or a high bandwidth, noisier output.

The number of bits delivered by the MagVector MV2 always exceeds the resolution. In other words, the least significant bit is always fluctuating. This allows the user to further average the signal. When the resolution parameter is changed, the number of bits delivered to the output automatically changes (it can go from 14 to 16 bits).

When selecting the RE parameter, the user affects all four A/D conversions equally.

The A/D conversion block can be controlled by a logic input on INIT pin. Enabling INIT (tied to LOGIC 1) will reset and halt the A/D conversion; disabling INIT (floating or tied to LOGIC 0) will reinitialize and start the A/D conversion block operating. This option can be helpful to control the precise A/D conversion time. In normal operation, it is recommended to leave the INIT pin not connected.

The end of the A/D conversion on the selected output channel is indicated by a Data Ready signal (see Section 5-5), which by default is routed to the DR pin. Optionally, this signal can be multiplexed with the MISO signal (see Section 5-16).

5-4 OUTPUT STAGE

The digital value out of each A/D is stored in the output stage. When the user requests a certain output (one of the 3 axes or the temperature), the output stage multiplexer picks the selected channel and the value is transferred to the SPI interface.

Note that in the single axis mode, of the 3 magnetic field channels, only one contains meaningful data. For instance, if the measurement axis selected is only x, the channels y and z are disabled, and therefore provide zero-field digital values.

5-5 APPLICATION CIRCUIT

The MagVector MV2 is logical slave, and therefore the controller must send a chip select (CS) and clock signal (CLK) in order to receive the data from the sensor (MISO). The data consists of the digital value of the selected output. Prior to receiving the data, the user must send a request containing some user settings. The request usually contains the output channel.

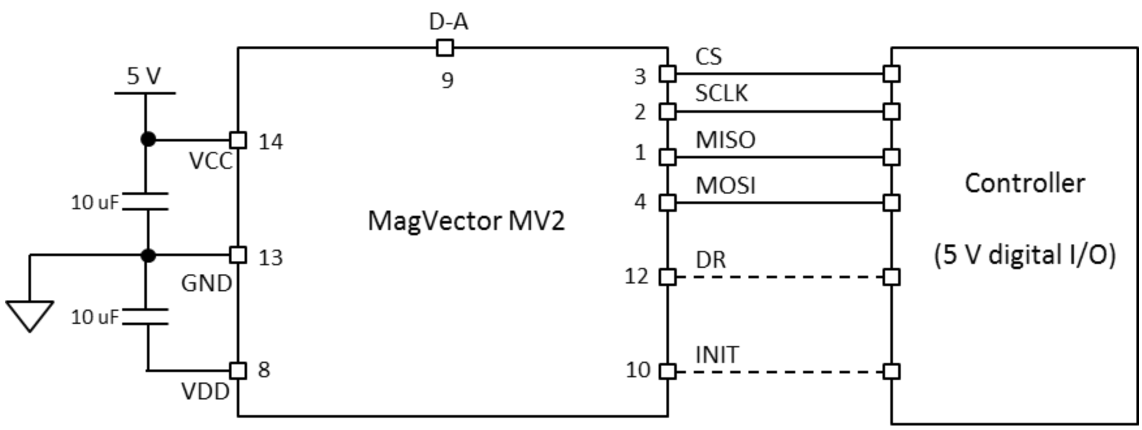


Figure 7. Circuit for sensor control and reading – digital mode

The Data Ready (DR) signal indicates that new data is ready (LOGIC 1); otherwise old data will be reread (LOGIC 0). DR passes from LOGIC 1 to LOGIC 0 as soon as the SPI transfer starts (CS goes from LOGIC 1 to LOGIC 0).

By selecting the appropriate option bit, the Data Ready signal can be multiplexed with MISO, instead of requiring a signal line of its own (see Section 5-16). The controller can also control the exact timing of the A/D conversion, using the INIT pin (see Section 5-3).

5-6 MULTIPLE DEVICES

It is possible to connect several MagVector MV2s on the same SPI bus. In this case, SCLK, MISO and MOSI are connected in parallel, while the CS signal is individual per chip. To avoid conflicting flows of data, only one data out (MISO pin) should be enabled at the time. For this reason the default value of the MISO pin is DISABLED and remains in a high impedance state (“tristate” logic) when the chip is in an idle state (CS high).

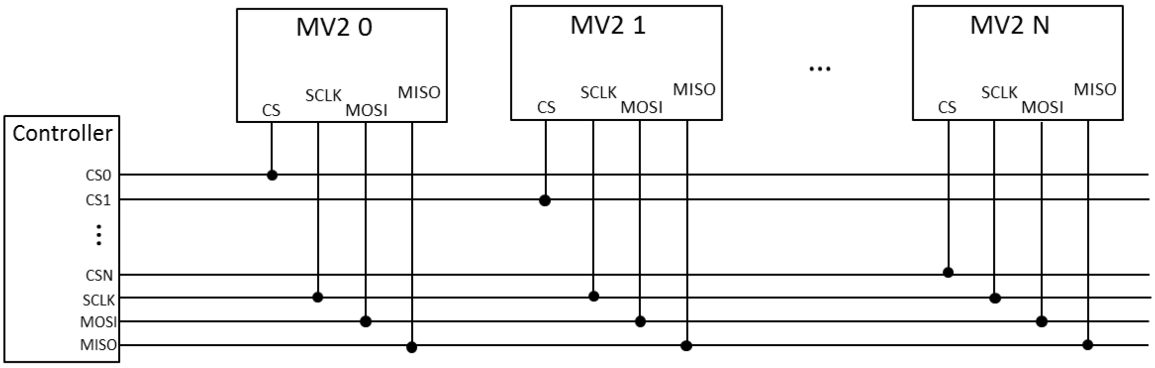


Figure 8. Parallel connection of MagVector MV2s

5-7 SERIAL COMMUNICATION

The MagVector MV2 is read and programmed by a master controller through a standard 4-wire Serial Peripheral Interface (SPI). See Table 11 for a summary of the SPI specification.

The sensor data are sent to the master via the MISO (Master In Slave Out) pin and the sensor can be programmed through MOSI (Master Out Slave In) pin. The MISO and MOSI words are 16 bits long. Within one single series of 16 clock counts, sent by the master, one MISO word and one MOSI word can be transmitted simultaneously. Two successive words must be separated by at least 100 ns.

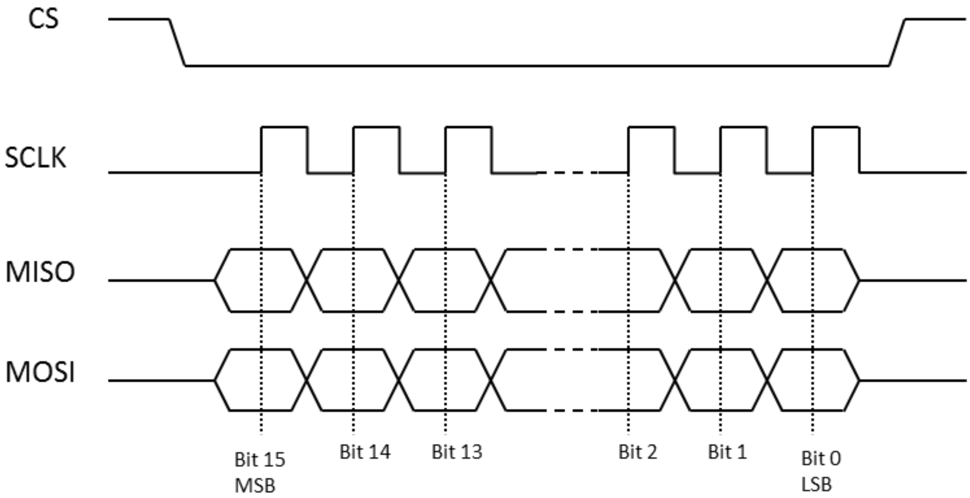


Figure 9. Timing diagram of one word

The availability of new data at the SPI port is indicated by DR signal. When a SPI communication cycle starts (falling edge of CS), the DR signal is cleared until new data is available in the SPI output buffer. The SPI output buffer refresh rate depends on the A/D output rate (see Section 5-3).

5-8 COMMUNICATION PROTOCOL

The sensor is configured by sending a 16-bit word through the MOSI pin (see Section 5-9). In particular, this includes the requested measurement axis. The configuration data are then stored in one of three volatile registers, and will remain until another data word is sent to the same register or until the chip is powered off.

The sensor returns the Hall measurement of the requested axis as a 16-bit unsigned integer value (see Section 5-10). As a data word is read from the MagVector MV2, the configuration data for the next data word to be read (indicating, for instance, another measurement axis) can be sent simultaneously, within the same series of 16 clock counts (see fig. 4).

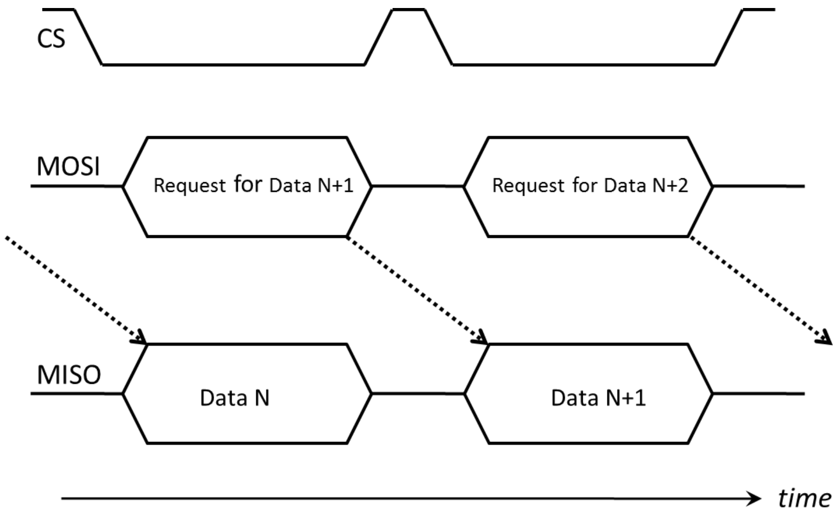


Figure 10. Sequence of data for communicating with the MagVector MV2

The user can read back the contents of the configuration registers at any time. By sending a request in the form of 8 bits (see Section 5-9), the MagVector MV2 returns the register value within the same transmission.

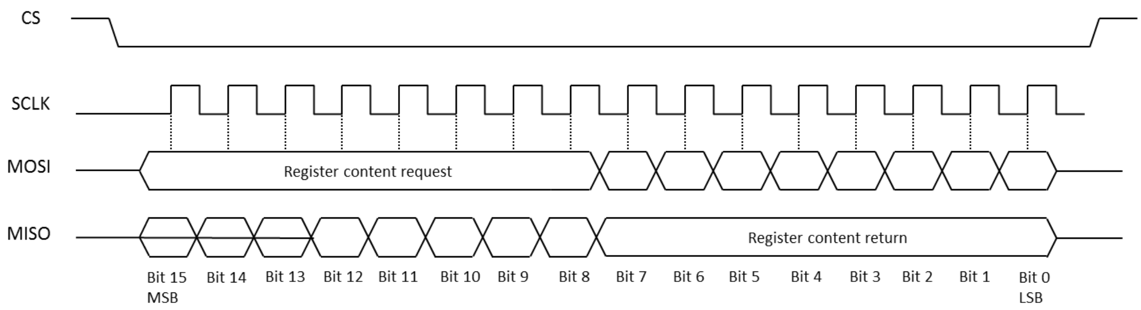


Figure 11. Timing diagram of the register read back

5-9 DATA FORMAT – DATA IN

To configure the device, a 16-bit word has to be sent. This word is composed of an 8-bit control address and an 8-bit value containing the user settings, as shown in Figure 12 and described in greater detail in Table 12.

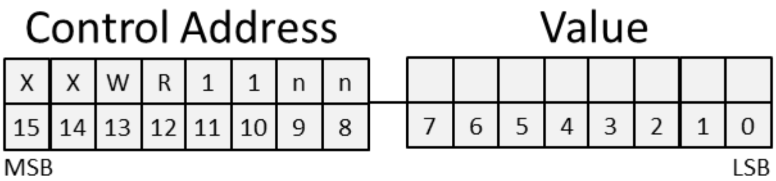


Figure 12. Format of Data In

Table 12. Format of Data In

Bit	**Description**
15 (MSB), 14	Don't Care
13	1 = Write: write the register
12	1 = Read: read back the register
11, 10	11
9, 8	Register number (see Section 5-11): 00: primary measurement specifications 01: other measurement options 10: temperature compensation and test
7 – 0 (LSB)	Register value to be programmed

Example: Configure the MagVector MV2 to read the Y-axis with a resolution of 15 bits, while the 3 measurement axes are scanned, with measurement range of 300 mT. The request to be sent is:

0	0	0	1	1	1	0	0	-	0	0	0	1	0	1	0	1

5-10 DATA FORMAT – DATA OUT

The magnetic field amplitude is transmitted in a word of 16 bits. The MSB is transmitted first.

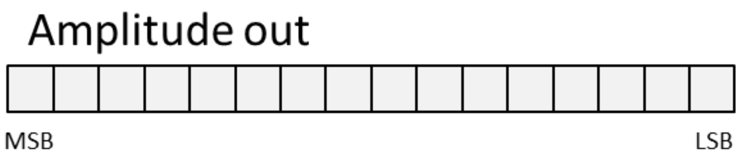


Figure 13. Format of Data Out

The digital output is an unsigned integer value, comprised between 0 and 2^N, where N is the selected resolution of the A/D converter (N=13, 14, 15 or 16; see Section 5-12).

At zero magnetic field, the output would ideally be half the maximum value, $2^N/2$ (see Figure 14 for the case N =16 and 100 mT field range). In reality, the value will correspond to the sensor offset. When the MagVector MV2 is exposed to a magnetic field, the output value is proportional to the field up to the field range (100 mT, 300 mT, 1 T or 3 T), with a proportionality constant being the sensitivity parameter in Table 10. The ADC saturates at a field about 20% larger than the range.

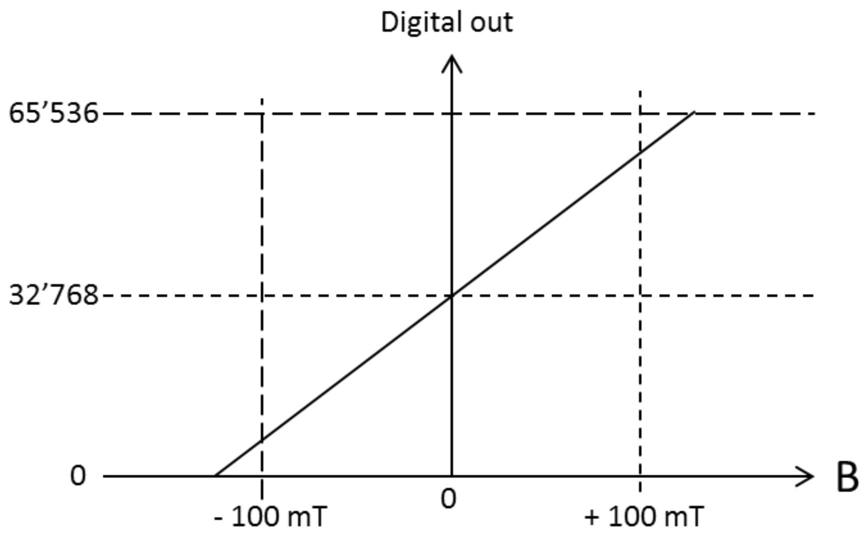


Figure 14. Output of one particular axis as a function of the field amplitude when the resolution is 16 bits, unsigned value representation.

5-11 REGISTERS

The following tables summarize the function of each bit in the three registers. Subsequent sections provide additional detail.

Table 13. Contents of Register 00

Register 00		Default value: all zeroes	
Bit	**Name**	**Description**	**See**
7 (MSB)	MA1	Measurement Axis MSB	Page 22, Section 5-15
6	MA0	Measurement Axis LSB	Page 22, Section 5-15
5	RE1	Resolution MSB	Page 21, Section 5-14
4	RE0	Resolution LSB	Page 21, Section 5-14
3	RA1	Range MSB	Page 21, Section 5-13
2	RA0	Range LSB	Page 21, Section 5-13
1	OS1	Output Selection MSB	Page 20, Section 5-12
0 (LSB)	OS0	Output Selection LSB	Page 20, Section 5-12

Table 14. Contents of Register 01

Register 01		Default value: all zeroes	
Bit	**Name**	**Description**	**See**
7 (MSB)	LMR	Large Measurement Range	Page 24, Section 5-22
6	SC	Spinning Current	Must be zero
5	EMR	Extended Measurement Range	Page 24, Section 5-21
4	HC	High Clock	Page 24, Section 5-20
3	INV	Invert	Page 24, Section 5-19
2	LP	Low Power	Page 23, Section 5-18
1	PO	Permanent Output	Page 23, Section 5-17
0 (LSB)	SP	Status Position	Page 23, Section 5-16

Table 15. Contents of Register 10

Register 10		Default values: DSB = TSC = 0, TC = 0001	
Bit	**Name**	**Description**	**See**
7 (MSB)	DSB	Disable Separated Bias	Must be zero
6	TC3	Temperature Compensation 3 (MSB)	Page 24, Section 5-23
5	TC2	Temperature Compensation 2	Page 24, Section 5-23
4	TC1	Temperature Compensation 1	Page 24, Section 5-23
3	TC0	Temperature Compensation 0 (LSB)	Page 24, Section 5-23
2	TSC	Test System Clock	Must be zero
1		Unused	
0 (LSB)		Unused	

5-12 OS – OUTPUT SELECTION

Register: 00

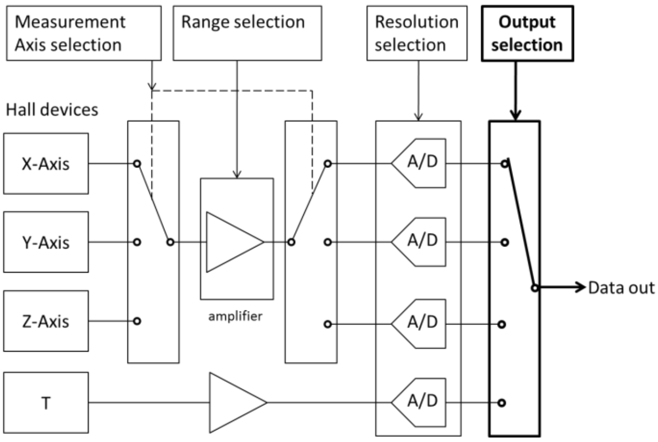
Bits: <Bit0> and <Bit1>

This option selects the channel (Bx, By, Bz or T) that will be delivered in the next SPI word out.

Note: when changing the range, or when changing the axis in single axis mode, the user should wait until the value is stable. The required delay corresponds to the ADC refresh rate: from 0.375 kHz to 3 kHz, depending on the resolution chosen.

Table 16. Output Selection

OS_1	OS_0	Data Out
0	0	Bx
0	1	By
1	0	Bz
1	1	T



5-13 RA – RANGE

Register: 00

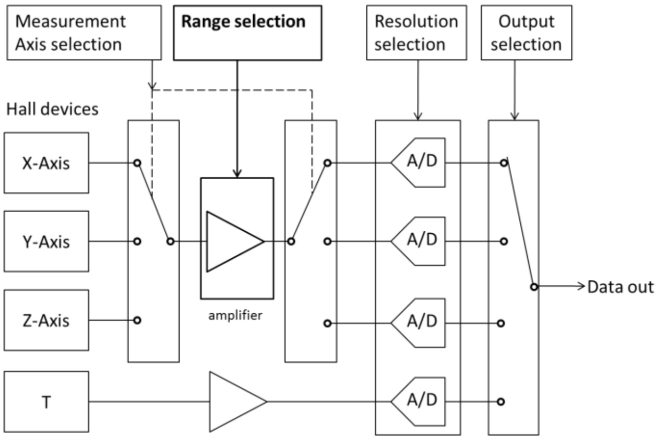
Bits: <Bit2> and <Bit3>

The RA parameter sets the amplification gain. When the measured magnetic field is within the range (between - range to + range), the sensor output is proportional to the applied magnetic field amplitude.

Note that the range also depends on the Extended Measurement Range (EMR – see Section 5-21) and Large Measurement Range (LMR – see Section 5-22) bits; the effective range is RA * (1 + 0.333 * EMR + 9 * LMR).

Table 17. RA – Range selection – digital mode

RA_1	RA_0	Magnetic field range
0	0	±100 mT
0	1	±300 mT
1	0	±1 T
1	1	±3 T



5-14 RE – RESOLUTION

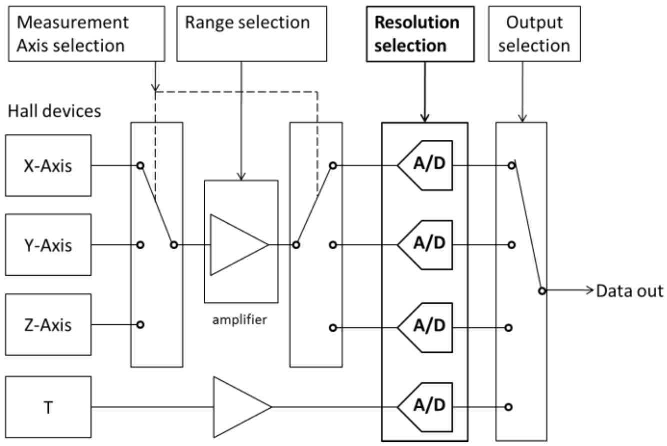
Register: 00

Bits: <Bit4> and <Bit5>

The resolution of the Analog-to-Digital (A/D) conversion is set by the parameter RE. This parameter affects the conversion time and the refresh rate at the output. Since a greater integration time reduces the noise, the parameter RE also changes the number of delivered bits.

Table 18. RE – Resolution Selection

RE_1	RE_0	Number of bits	Refresh rate (kHz)
0	0	14	3
0	1	15	1.5
1	0	16	0.75
1	1	16	0.375



When the number of bits delivered N is smaller than 16, then the last 16-N bits (LSB) are zeros. For instance, if the number of bits delivered is 14, the output format is as follows:

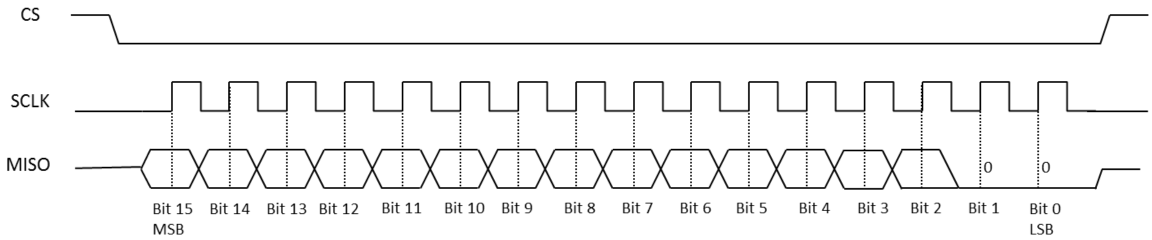


Figure 15. Timing of the data out when the resolution set to 14 bits.

5-15 MA – MEASUREMENT AXIS

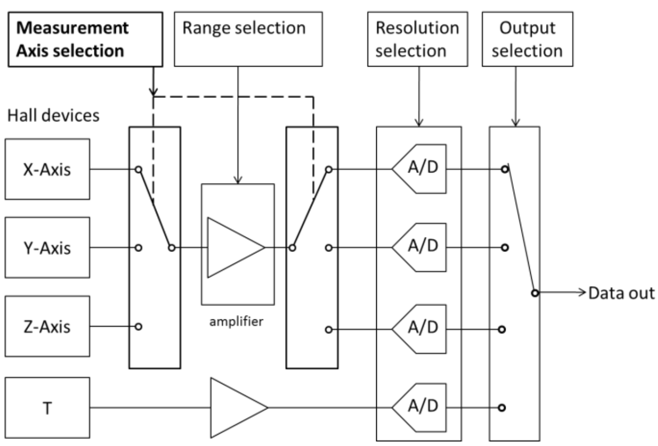
Register: 00

Bits: <Bit6> and <Bit7>

The parameter MA determines which Hall device is amplified. Depending on the setting, all 3 axes are sequentially scanned (at the rate specified by the RE parameter – see Section 5-14) and amplified, or the scanning is stopped and only one selected axis is amplified. See the table below.

Table 19. MA – Measurement axis selection – digital mode

MA_1	MA_0	Measurement axis
0	0	3 axes
0	1	X axis
1	0	Y axis
1	1	Z axis



5-16 SP – STATUS POSITION

Register: 01

Bits: <Bit0>

The availability of a new data to be read via SPI is indicated by the status signal Data Ready (see Section 5-5). By default, this signal is routed to the DR pin. To minimize the number of connections between the MagVector MV2 and a controller, the DR signal can be multiplexed with the MISO pin when SPI is idle (CS pin at LOGIC 1).

Note that the PO (Permanent Output MISO) option has to be enabled to use this option.

The hardware position of Data Ready signal is summarized below.

Table 20. Status Position bit

SP	CS	Pin 1	Pin 12
0	0	MISO	DR
0	1	MISO	DR
1	0	MISO	hiZ
1	1	DR	hiZ

5-17 PO – PERMANENT OUTPUT

Register: 01

Bits: <Bit1>

By default, the SPI output is disabled and the MISO pin is in a high impedance state (tri-stated) when the SPI is in idle state (CS pin is tied to LOGIC 1). This allows connecting several MagVector MV2s in parallel on the same SPI bus.

However, a MISO pin in high impedance state may generate a significant current consumption out of the master device. Therefore, if there is only a single MagVector MV2 on the SPI bus, it is recommended to permanently activate the MISO output. In this case, the MISO output remains at a well-defined logic level, even when SPI is idle (CS pin at LOGIC 1).

5-18 LP – LOW POWER

Register: 01

Bits: <Bit2>

The MagVector MV2 can be switched to a low power mode. This mode reduces the current consumption by ~6 mA and the SNR by a factor of $\sqrt{2}$. Note that other parameters, such as temperature drift or offset, can also change.

5-19 INV – INVERT

Register: 01

Bits: <Bit3>

When the INV option is enabled, the MagVector MV2 reverses the Hall bias currents, and therefore reverses the measured magnetic field outputs relative to $2^N/2$ (where N represents the ADC resolution). Toggling this option can be used, for example, to emulate a low frequency modulator / demodulator.

5-20 HC – HIGH CLOCK

Register: 01

Bits: <Bit4>

Enabling the HC option doubles the analog clock, which improves the SNR, typically by a factor of $\sqrt{2}$. However, in three-axis measurement mode (MA = 00), the MagVector MV2 may suffer from a slight cross-sensitivity between axes, and selecting this option will provide worse cross sensitivity.

5-21 EMR – EXTENDED MEASUREMENT RANGE

Register: 01

Bits: <Bit5>

Enabling the EMR option increases the selected range (RA – see Section 5-13) by 30%. In principle, this option is intended to be used in analog mode (see Section 4-10), to approximately compensate the reduced voltage swing of the output buffer when using a 3.3 V supply instead of 5 V.

5-22 LMR – LARGE MEASUREMENT RANGE

Register: 01

Bits: <Bit7>

Enabling the LMR option increases the selected range (RA – see Section 5-13) by 10x. This option is intended to extend the measurement range to 10 or 30 T, for very strong fields.

5-23 TC – TEMPERATURE COMPENSATION

Register: 10

Bits: <Bit3> through <Bit6>

Typically, the sensitivity of the Hall devices drifts with temperature (see Table 10). In order to compensate the temperature induced sensitivity drift, the Hall bias can be programmed to acquire a linear dependence with temperature. By default, TC=0001, which means that the gain is constant. The optimum value of TC needs to be found experimentally.