

FH3D02* DUAL 3D HALL SENSOR PRODUCT SHEET

* Equivalent to FH5401c

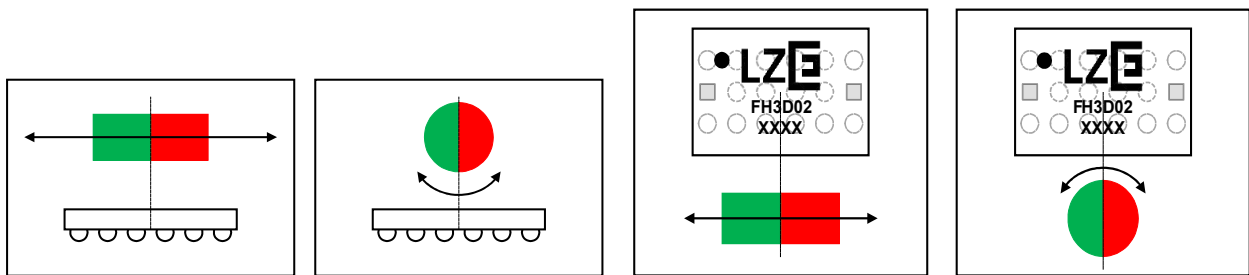
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1 FH3D02 Overview

1.1 General Description

The FH3D02 is a dual 3D magnetic field sensor using two 3D Hall sensors using the HallinOne® technology, which are also called “pixels”. The versatile magnetic field sensor is suited for measuring all magnetic field components in three dimensions. It can be used as a magnetic field probe or a position sensor for linear or rotary movement of permanent magnets. A variety of applications can be evaluated instantly with the standard programming. With specific programming even more applications can be addressed.



Example applications of the FH3D02

1.2 Features

- Integrated hall sensor for 3D magnetic vector measurement with high linearity
- Usage of HallinOne® technology
 - <https://www.iis.fraunhofer.de/hallinone>
- Two 3D sensors allow for differential measurements to suppress external magnetic fields
- Ready-to-use adjustment for X/Y applications
- Fully corrected offsets
- CORDIC for angle calculation of two magnetic field components
- Four different measurement modes for sequential measurements of different magnetic field components.
- Integrated temperature sensor
- Measurement rate up to 1 kHz
- PWM output of measurement values
- Internal EEPROM for calibration data and configuration
- Linearization of angle with interpolated look-up- table
- No ferromagnetic components used (no hysteresis, no saturation)
- Low noise, high resolution
- High magnetic and geometric precision
- External field independence following automotive standards
- SPI interface (up 16 Mhz)
- Prepared for self-test and self-monitoring
- Wide operating temperature range from -40°C to 105°C
- Small package and footprint

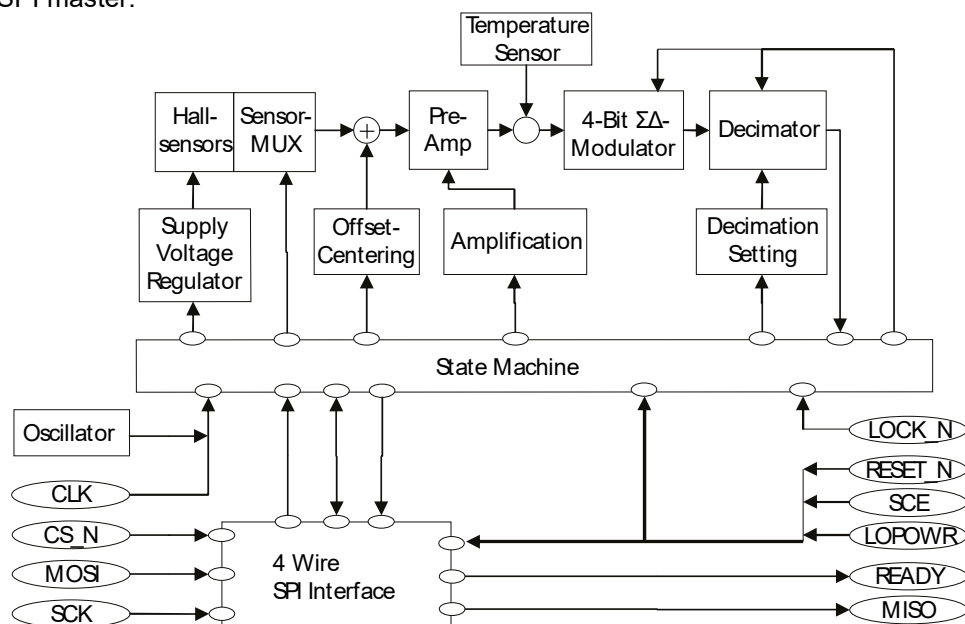
1.3 Applications

- 3D position and orientation determination (using multiple devices)
 - o <http://www.iis.fraunhofer.de/hallinmotion>
- Magnetic field measurement in lab equipment
 - o <http://www.iis.fraunhofer.de/hallinsight>
- Mechanical position sensing in consumer and industrial applications
- Rotary encoder (standalone, PWM output)
- Linear positioning measurement
- Contactless angle measurement
- Current sensing
- Quality control
- Fluid level measurement
- 3D speed sensing
- Utility meters
- Current sensing
- Control knobs and selector switches
- 3D proximity sensing
- 3D valve positioning

REMARK: FH3D02 Dual 3D Hall sensors are not qualified for automotive applications. If you would like to purchase qualified automotive devices, please contact LZE GmbH.

1.4 Functional Block Diagram

The sensor chip provides two 3D Hall pixels, which are supplied by a voltage regulator and are selected by the sensor MUX. The analogue signal computation channel consists of a programmable gain amplifier and offset centering, $\Sigma\Delta$ -modulator and a decimation register. The state machine controls voltage regulator, sensor MUX, decimation, offset centering and performs a 4-phase measurement cycle and temperature measurement. The decimation results are transmitted via a 4-wire SPI interface to a connected SPI master.



Functional block diagram of the integrated sensor periphery

2 Characteristics

2.1 Absolute Maximum Ratings

Stresses beyond those listed here may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated under "Operating Conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Parameter	Min	Max	Unit	Note
VDD		5	V	
Input pin voltage	-0.3	VDD+0.3	V	
Input current (latchup immunity)	-100	100	mA	Standard: JEDEC 78
Electrostatic discharge		±2	kV	Standard: MIL 883 E method 3015
Storage temperature	-55	125	°C	
Body temperature		260	°C	Norm: IPC/JEDEC J-Std-020
Humidity non-condensing	5	85	%	
Moisture Sensitive Level (MSL)		1		Unlimited floor time
EEPROM write cycles		40,000	cycles	Single write access to every EEPROM-address

Absolute maximum ratings

2.2 Operating Conditions

Parameter	Min	Max	Unit	Note
Supply Voltage (VDD)	3.0	3.6	V	3.3 typical
Ambient temperature	-40	105	°C	
I/O pin output current		8	mA	
I/O pin input level low		0.3*VDD		
I/O pin input level high	0.7*VDD			
I/O pin output level low		0.4	V	at 8 mA load current
I/O pin output level high	VDD-0.5		V	at 8 mA load current

Operating conditions

2.3 Magnetic Specifications

Parameter	Symbol	Min	Typ	Max	Unit	Note
Magnetic field range	B_{\max}	-70		70	mT	-40°C ... 105°C
		-100		100	mT	at 25°C
Magnetic sensitivity			250		LSB/mT	
Magnetic resolution			4		$\mu\text{T/LSB}$	
Magnetic offset	B_{ofs}	-0.25		0.25	mT	at 25°C
Magnetic offset drift		-0.25		0.25	mT	-40°C ... 105°C
Sensitivity error X, Y, Z	S_{err}	-20		20	%	at 25°C
Sensitivity drift X, Y, Z	S_{drift}	-5		5	%	-40°C ... 105°C
Sensitivity matching X/Y		-0.5		0.5	%	-40°C ... 105°C
Sensitivity matching X/Z		-15		15	%	at 25°C
Sensitivity matching drift X/Z, Y/Z		-10		10	%	-40°C ... 105°C
Cross-sensitivity X/Y	S_{crossXY}	-1		1	%	-40°C ... 105°C
Cross-sensitivity X/Z, Y/Z	S_{crossZ}	-10		10	%	-40°C ... 105°C

Magnetic specifications

2.4 Current Consumption

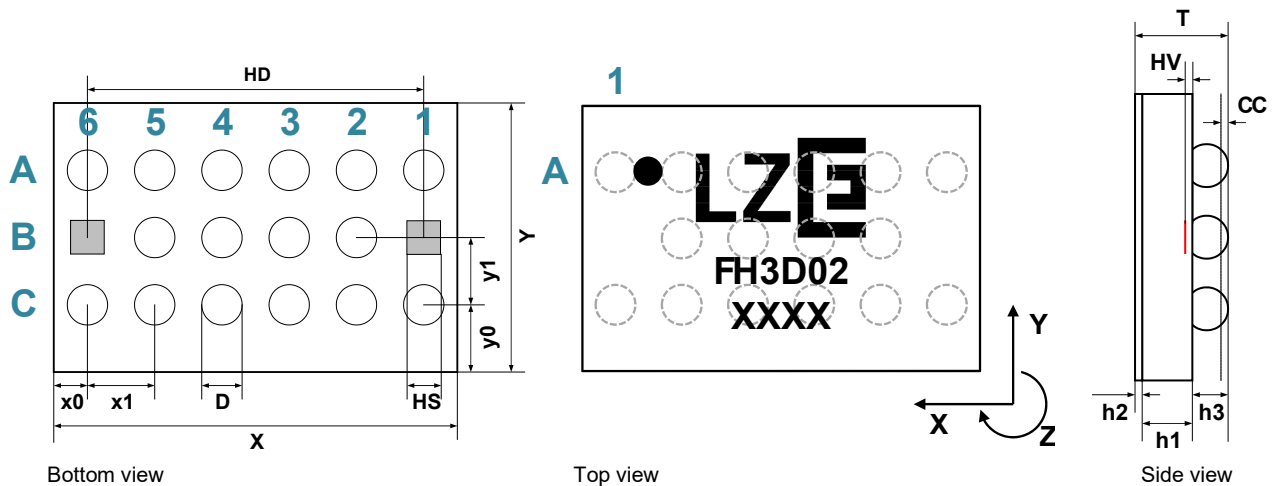
Parameter	Symbol	Min	Typ	Max	Unit	Note
IDD during measurements	IDD_{meas}		10	15.5	mA	
IDD during standby, awaiting a measurement start	IDD_{standby}		1	2.25	mA	
IDD during reset	IDD_{reset}		0.6		mA	
IDD in low power mode ⁽²⁾	IDD_{lowpower}			10	μA	Current consumption in various operation modes ⁽³⁾⁽⁴⁾

(1) Output currents on I/O pins are not included

(2) Values are DC mean currents. IDD_x can be temporarily higher.

3 Package and Circuit Connection

3.1 Footprint and Dimensions



Parameter	Symbol	Min	Typ	Max	Unit	Note
Hall Sensor Size	HS		250		μm	
Hall Sensor Distance	HD		2500		μm	
Chip length	X	3015	3035	3055	μm	
Chip width	Y	2015	2035	2055	μm	
Chip thickness	T	570	600	630	μm	
X-Distance chip border to bumps	x0		285		μm	
Bump pitch X-direction	x1		500		μm	
Y-Distance chip border to bumps	y0		535		μm	
Bump pitch Y-direction	y1		500		μm	
Wafer thickness	h1	325	335	355	μm	
Backside Laminate	h2		25		μm	
Bump height	h3		240		μm	
Solder Ball Coplanarity	CC		40		μm	
Hall Sensor vertical position	HV		30		μm	
Bump diameter	D	315	325	335	μm	

Package dimensions

3.2 Pins

Pin	Symbol	Type	Description
A1	MISO	DO_T	Master in / Slave out (SPI interface data output)
A2	CLK	DIO	Clock input / output. Must be connected to VSS if internal clock is used
A3 B3	VSS1	S	Ground (0V) Note: both VSS1 and VSS2 must be connected
A4	SCE	DI_ST	Test pin, must be connected to VSS in normal operation
A5	LOPOW R	DI_ST	Shutdown & Reset input. Connect to VSS in normal operation
A6	CS_N	DI_ST	Chip select (active low)
B2	MOSI	DI_ST	Master out / Slave in (SPI interface data input)
B4 C5	VSS2	S	Ground (0V) Note: both VSS1 and VSS2 must be connected
B5	SCK	DI_ST	SPI clock input
C1	READY	DO_T	Measurement ready signal
C2	RESET_ N	DI_PU	Reset input (active low)
C3	LOCK_N	DI_ST	Test pin, must be connected to VSS in normal operation
C4	VDD	S	Positive supply voltage (3.3 V)
C6	PWM	DO	Linearized angle output in PWM mode.

Pin/Bump list

DIO digital input & output
 DI_ST digital Schmitt-Trigger input
 DI_PU digital input with pull-up
 DO digital output
 DO_T digital output /tri-state
 S supply pin

Notes:

- Pins LOCK_N and SCE are test pins for factory testing. They must be connected to VSS in normal operation to prevent accidental enabling of a test mode.
- Output READY is set high when a measurement cycle is completed and the results in the output registers are valid. It is cleared by reading data from address 0122h.
- CLK allows to monitor the internal clock or to apply an external clock.
- Output MISO is only activated when CS_N is low. It is in high impedance state otherwise, this allows for parallel operation of multiple ICs.
- CS_N is active low and activates data transmission. If only a single device is used, CS_N may remain low for several commands, for example while reading the output registers.

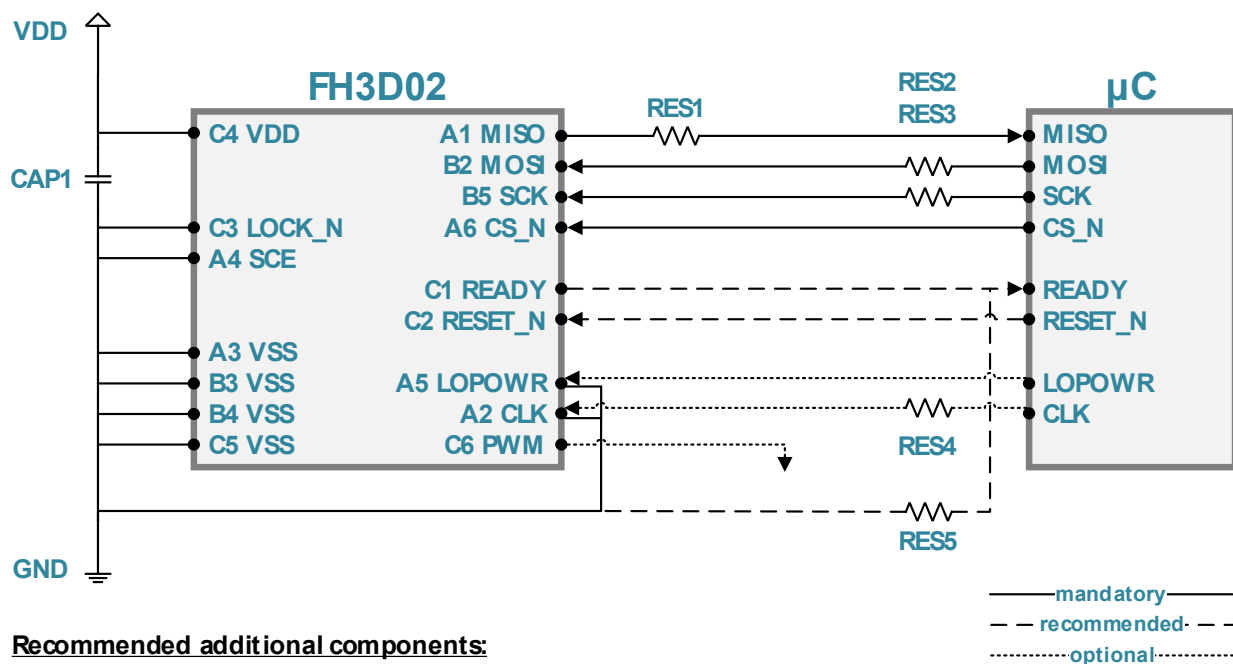
3.3 Electrical Connection

The sensor chip must be connected to a supply of 3.3V via its VDD and VSS pins. All unused pins should be connected to VSS to guarantee proper function. A decoupling capacitor between VDD and VSS close to the sensor chip is strongly recommended as well as the usage of non-magnetic components nearby to prevent magnetic interference.

For communication of a single sensor with a microcontroller, all four SPI signals CS_N, SCK, MOSI and MISO have to be connected. Fast digital signals (like clock and data signals) should be terminated with series resistors near the transmitting device to prevent disturbing signal reflections.

It is recommended to use the two additional signals READY and RESET_N to recognize finished measurements and execute a proper reset cycle of the sensor chip. If multiple sensors are connected to the same lines, a pull-down resistor for the READY signal should be used.

For optional usage of low power mode or an external clock generated by the controller, LOPOWER and CLK have to be wired properly, whereas the CLK signal also should be terminated with a series resistor at the μC . If PMW output is used, the corresponding signal has to be wired to the receiver.



Recommended additional components:

CAP1: Non-magnetic capacitor near pins (100 μF)

RES1: Non-magnetic series resistor matching line impedance at sensor (50 Ω - 100 Ω)

RES2 – RES4: Series resistor matching line impedance at μC (50 Ω - 100 Ω)

RES5: Pull-down resistor when using multiple sensors on same SPI bus (12k Ω)

Please note:

It is strongly recommended to use a PCB with wide bandwidth, low impedance supply layers and impedance controlled digital signal lines with matching series resistors to the hardware setup.

A stable supply and clean signals are mandatory for low sensor noise and faultless communication at high SPI frequency.

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