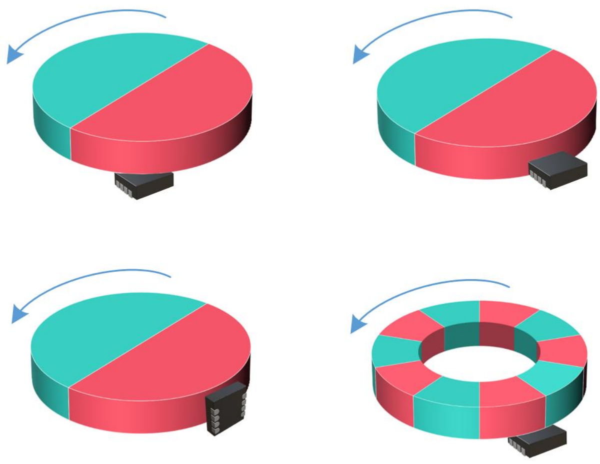
1 Features

- Integrated 3D (XY, XZ, YZ plane) Hall angle sensor with highly matched Hall elements
- Integrated multi-level low power consumption , high-precision zero-drift op amp, and high-precision 16Bits ADC
- Integrated CORDIC algorithm module, 16bits absolute angular position output
- Support absolute position detection, angular output range up to 360 degrees
- Magnetic Flux Density working range, XY plane ±65mT, XZ/YZ plane±40mT Note 1
- Support standard I2C communication interface
- Support system interrupt wake-up function
- Working Voltage 2.8V ~ 5.5V
- IO supply voltage as low as 1.8V
- Working Temperature -40℃ ~+85℃

2 Typical Application

- Electronic watch knob



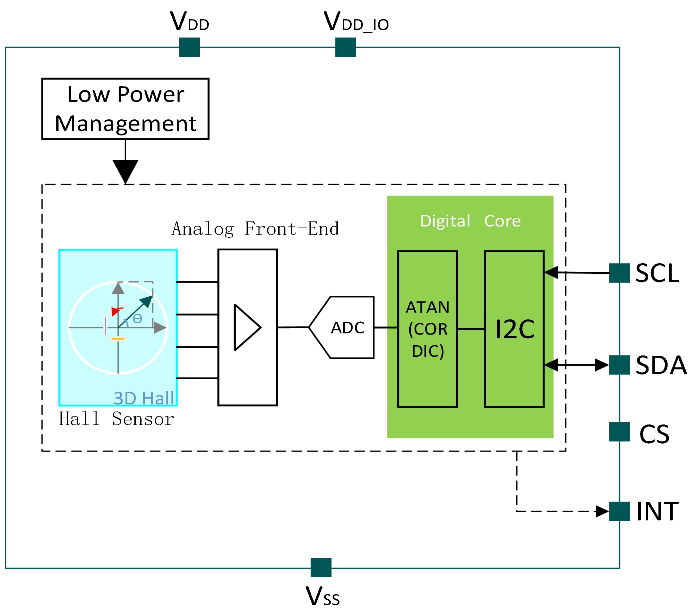
3 Overview

KTH5762 is a 3D (XY, XZ, YZ plane) Hall angle sensor with a highly matched Hall element, integrating low power consumption, low noise, high precision zero-drift op amp, high performance, low impedance MUX, using a high-precision 16-bit ADC, converting and outputting 16Bit absolute angle data. The chip provides an I2C communication interface.

KTH5762 supports a variety of working modes such as Duty Cycle Mode and Single Conversion Mode.

KTH5762 integrates a high-efficiency, low-power CORDIC algorithm module that supports the angle output of the plane and supports angle threshold detection. It has the characteristics of high integration and flexible application, and is widely used in various application scenarios.

4 Functional Diagram



Device Information

Model	Package	Package Size (Nominal)
KTH5762	DFN2*2.5-8L	2.00mm * 2.50mm

Note 1: It is recommended that the magnetic flux density of this plane is greater than 10mT.

Catalog

5 Pin Definition

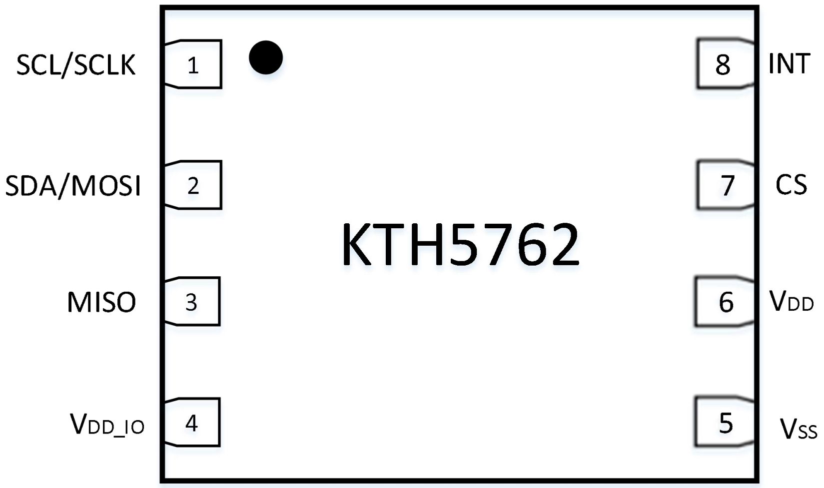


Figure 5-1 DFN2x2.5-8L Top view

Table 5-1 Pin Definition

Pin No.	Name	Description	Type
1	SCL/SCLK	I2C Clock Signal	Input
2	SDA/MOSI	I2C Data,Master Output Slave Input	Input/Output
3	MISO	SPI Data, Master Input Slave Output	Output
4	VDD_IO	IO Power Supply	Power Supply
5	VSS	Ground	Ground
6	VDD	Power Supply	Power Supply
7	CS	Chip Selection Enable Signal	Input
8	INT	Interrupt Signal After the host sends a Duty Cycle Mode command to the chip, when the XY plane angle value detected by the chip is greater than the value set in the corresponding register, the INT pin will be set to 1, and it will remain at 1 until the chip sends a read command to read back the measurement data. After the chip reads back, if the angle value detected by the current chip is still greater than the angle value set in the register, the INT pin will continue to be set to 1.	Output

6 Specifications

Note:The following parameters are measured at room temperature 25° C.

6.1 Absolute Parameters

Parameter	Description	Min.	Max.	Unit
V_{DD_MAX}	Maximum Supply Voltage	-0.3	6	V
$V_{DD\_IO\_MAX}$	Maximum Digital IO Supply Voltage	-0.3	6	V
$T_{STORAGE}$	Storage Temperature	-50	150	℃
V_{ESD}	ESD（HBM）		±5K	V

6.2 Recommend Operating Conditions

Parameter	Description	Min.	Typ.	Max.	Unit
V_{DD}	Supply Voltage	2.8	3.3	5.5	V
V_{DD_IO}	Digital IO Supply Voltage	1.8		V_{DD}	V
V_{IH}	Input High Level Voltage	0.75			V_{DD_IO}
V_{IL}	Input Low Level Voltage			0.25	V_{DD_IO}
$T_{OPERATION}$	Operating Temperature	-40	25	85	℃

6.3 Electrical Characteristics

Parameter	Description	Condition	Min.	Typ.	Max.	Unit
V_{DD}	Supply Voltage		2.8	3.3	5.5	V
V_{DD_IO}	Digital IO Supply Voltage		1.8		V_{DD}	V
$I_{DD,CONVXY}$	Conversion Current X-axis or Y-axis	VDD=3.3V		4.89		mA
$I_{DD,CONVZ}$	Conversion Current Z-axis			3.87		mA
$I_{DD,CONVT}$	Conversion Current Temperature			2.58		mA
$I_{DD, STBY}$	Duty Cycle Mode Standby Current			2.4		μA
$I_{DD,IDLE}$	Idle State Current			1.4		μA

6.4 Magnetic Properties

Parameter	Description	Condition	Min.	Typ.	Max.	Unit
Mxy	Magnetic Flux Density Linear Range		-65		65	mT
Mxz/ Myz	Magnetic Flux Density Linear Range		-40		40	mT
$N_{RMSAngle}$	Angle Output Noise	@B=20mT magnOsr=0 digCtrl=0		0. 98		Degree
$N_{RMSAngle}$	Angle Output Noise	@B=20mT magnOsr=1 digCtrl=0		0. 28		Degree
$N_{RMSAngle}$	Angle Output Noise	@B=20mT magnOsr=3 digCtrl=0		0. 128		Degree
$N_{RMSAngle}$	Angle Output Noise	@B=20mT magnOsr=3 digCtrl=3		0. 065		Degree

6.5 Timing Parameter

Parameter	Description	Min.	Typ.	Max.	Unit
T_{start}	Start Up Time		4		ms
T_{CONVM}	Single Axis Magnetic Filed Conversion Time (Programmable)	165		33349	μ s
		$69+32*2^{magnOsr}*（2+2^{digCtrl}）$			μ s
T_{CONVT}	Temperature Conversion Time (Programmable)	165		837	μ s
		$69+96*2^{tempOsr}$			μ s
T_{CONV_END}	Time from the end of the measurement to the turn off of simulation enablement		108		μ s
T_{active}	Time from IDLE to ACTIVE		220		μ s
T_{meas}	When measTime=0, the time to complete a measurement when the chip is in measurement mode	$m*T_{CONVM} + T_{CONVT} + T_{CONV\_END}$			μ s
T_{single}	Time from Single Convertion Mode to finish one single measurement	$T_{active} + m*T_{CONVM} + T_{CONVT} + T_{CONV\_END}$			μ s

Note：

- The default in the table above is m=2

7 Measurement Mode Description

KTH5762 supports a variety of working modes, it can be used in Duty Cycle Mode and Single Conversion Mode .

Table 7-1 Measurement Mode Introduction

Measurement Function	Function Introduction
Duty Cycle Mode	The chip periodically measures the selected XYZ channel, and when the XY plane angle measured by the chip exceeds the absolute threshold set in the register, the INT pin will be set to 1
Single Conversion Mode	The chip takes a single measurement of the BA channel
Idle Mode	Exit the Duty Cycle Mode and enter the idle state
Note: B is the plane magnetic flux density, and A is the absolute rotation angle	

7.1 Duty Cycle Mode

After the host sends a Duty Cycle Mode command to the chip, the chip is in a low-power measurement mode and measures the selected XYZ channel at a certain frequency until the host sends an Idle Mode command to the chip.

When the angle value detected by the chip is greater than the value set in the corresponding register, the INT pin is set to 1. And until the chip sends a read command to read back the measurement data, it remains at 1. After the chip reads back, if the angle value detected by the current chip is still greater than the angle value set in the register, the INT pin will continue to be set to 1. This function is only available for XY plane angle measurements. After the host reads back the measurement data through the Data Read Frame at one time, the INT pin is pulled low and otherwise remains high. The INT pin of the chip will not be actively pulled down, that is, the angle value measured by the chip at a certain time exceeds the angle value set in the register, after the INT pin is pulled up, if the angle value measured by the chip decreases at the next moment, it is lower than the set angle value, but the host does not read back the measurement data, and the INT pin will not actively pull down. After the chip reads back the data, if the angle value detected by the current chip is still greater than the angle value set in the register, the INT pin will continue to be set to 1.

7.2 Single Conversion Mode

After the host sends a command to the chip for a Single Conversion Mode, the chip will take a measurement of the measurement item (BA) and automatically return to the idle state.

7.3 Idle Mode

After the host sends an Idle Mode command to the chip, the chip enters the idle state. When the chip is in Duty Cycle Mode, the chip cannot perform operations other than the reading back frame of the measurement data, such as read and write registers.

If you need to perform other operations on the chip, you need to send an Idle Mode command to make the chip enter the idle state. However, after sending the Idle Mode command, if there is a measurement operation currently in progress, the chip will not immediately enter the Idle Mode, and it needs to wait for the current measurement to be completed before entering the idle state from the current Duty Cycle Mode. If other operations are required, wait for a measurement time delay before proceeding.

Note: Idle state refers to the chip not being in any measurement mode. Standby state refers to the chip is in a measurement intermittent state.

8 Operating Status Description

Bit	7	6	5	4	3	2	1	0
Status	RESERVED	Cycle	Single	Failing	RESERVED		softRst	DRDY

Except for resetting the chip, sending other commands to the chip will return the chip operating status description.

- Cycle

When the bit is set to 1, it indicates that the chip is currently in Duty Cycle Mode. When the host sends this mode command to the chip, the bit is set to 1 in the returned status, or when the chip is in this mode and the Data Read Frame is used to read back the measurement data at once, this bit is also set to 1.

- Single

When this bit is 1, it indicates that it is currently in Single Conversion Mode. When the host sends a Single Conversion Mode command to the chip, the corresponding bit in the status returned by the command is set to 1. After completing a single measurement, the chip returns to an idle state. If other commands are sent later, the corresponding bit in the returned status will be 0.

- Failing

When the current command sent is invalid, Failing=1. When in any measurement state, send other measurement commands again, Failing bit will be set to 1, for example, when sending a single measurement command while in Duty Cycle Mode, the Failing bit will be set to 1. At the same time, if reading and writing registers is performed in Duty Cycle Mode, the Failing bit will also be set to 1, indicating a command error.

- softRst

After the host sends a Reset command to the IC, the IC does not immediately return status. Therefore, it is necessary to determine whether the reset is successful based on the status returned for the first time when any command is received after the chip is reset. After the chip is successfully reset, the bit will be set to 1, and after returning the status once, this bit is cleared to 0. That is, when the chip receives any command for the second time after resetting, this bit of the status is 0.

- DRDY

When the host sends the Duty Cycle Mode to the chip, the corresponding magnetic field change detected by the chip exceeds the set threshold, this bit will be set to 1. After completing a data read, this bit is cleared to 0. When the host sends a Single Conversion Mode to the chip, the bit is set to 1 after completing the measurement and cleared to 0 after completing a data read.

9 I2C Communication

KTH5762 supports I2C communication mode.

9.1 I2C Communication Timing

Note: The following parameters are all measurement results at room temperature of 25 ℃ and VDD=3.3V.

Parameter	Symbol	Standard Mode		Quick Mode		Unit
		Min.	Max.	Min.	Max.	
SCL Clock Frequency	f (SCL)		100		400	kHz
SCL Clock Low Time	tw (SCLL)	4.7		1.3		μs
SCL Clock High Time	tw (SCLH)	4		0.6		μs
SDA Setup Time	tsu (SDA)	250		100		ns
SDA Data Hold Time	th (SDA)		3.45		0.9	μs
SDA and SCL Rise Time	tr (SDA) tr (SCL)		1000		300	ns
SDA and SCL Fall Time	tf (SDA) tf (SCL)		300		300	ns
START Condition Hold Time	th (ST)	4		0.6		μs
REPEATED START Condition Setup Time	tsu (SR)	4.7		0.6		μs
STOP Condition Setup Time	tsu (SP)	4		0.6		μs
Bus Free Time Between STOP and START Condition	tw(SP:ST)	4.7		1.3		μs

Table 9- 1 I2C Communication Parameters

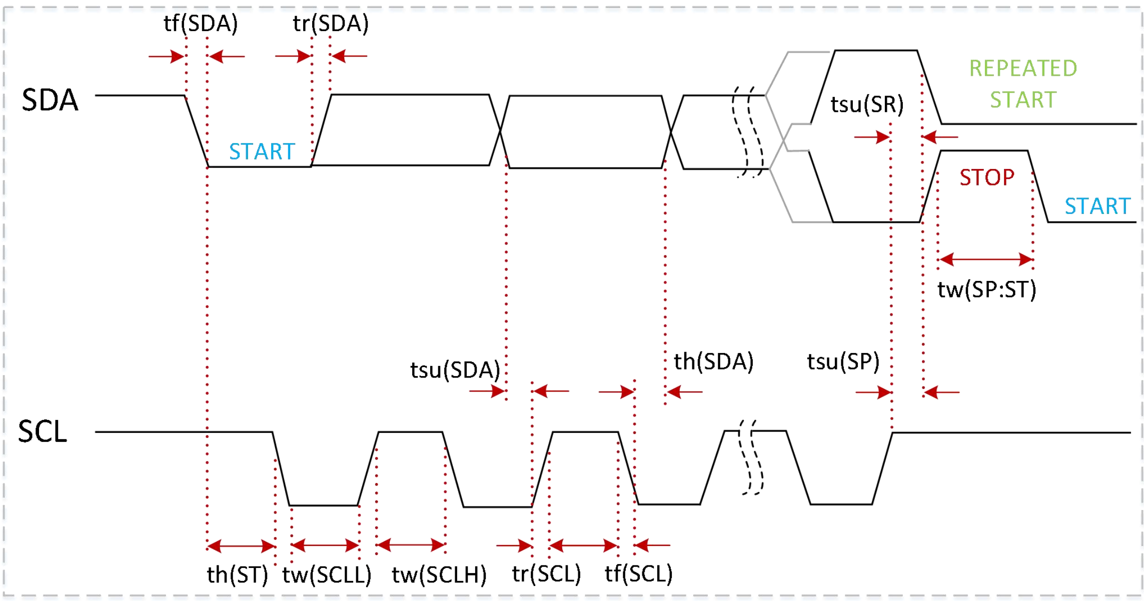


Figure 9- 1 I2C Timing Diagram

9.2 Communication Commands

KTH5762 supports the commands shown in the following table:

Table 9- 2 Command Table

Command Name	Byte1	Byte2	Byte3	Byte4	Note
Start Duty Cycle Mode	0010 #	N/A	N/A	N/A	#： XY Plane：0110 XZ Plane：1010 YZ Plane：1100
Start Single Conversion Mode	0011 #	N/A	N/A	N/A	
Idle Mode	1000 0000	N/A	N/A	N/A	
Reset	1111 0000	N/A	N/A	N/A	
Measurement Data Readback	0100 0110	N/A	N/A	N/A	
Read Register	0101 0000	Address[7:0] << 2	N/A	N/A	
Write Register	0110 0000	Data[15:8]	Data[7:0]	Address[7:0] << 2	

The I2C device address of KTH5762 is 7'b 1111000.

This is a list of the communication diagrams of each command, which is represented by the legend shown in the figure below:

S	IIC Start
RS	IIC Restart
P	IIC Stop
A	Slave Ack
Nack	Master Nack
A	Master Ack

Figure 9- 2 I2C Communication Diagram

10 Mode Settings

After the chip is powered on, internal initialization is performed, communication is not allowed within 4ms after the power supply is stable, and communication measurement is allowed when the chip enters the idle state after the initialization is completed.

KTH5762 supports a variety of working modes, see Chapter 7 for details of measurement modes description. This product can be used in Duty Cycle Mode and Single Conversion Mode.

10.1 Duty Cycle Mode

S	IIC Address[W]		A	Command	A	RS	IIC Address[R]		A	Status	NACK	P
S	111 1000	0(W)	A	0010 #	A	RS	111 1000	1(R)	A	0100 XXXX	NACK	P

Figure 10- 1 Duty Cycle Mode I2C Communication Diagram

#：XY Plane：0110　XZ Plane：1010　YZ Plane：1100

10.2 Single Conversion Mode

S	IIC Address[W]		A	Command	A	RS	IIC Address[R]		A	Status	NACK	P
S	111 1000	0(W)	A	0011 #	A	RS	111 1000	1(R)	A	0010 XXXX	NACK	P

Figure 10- 2 Single Conversion Mode I2C Communication Diagram

#：XY Plane：0110　XZ Plane：1010　YZ Plane：1100

10.3 Idle Mode

S	IIC Address[W]		A	Command	A	RS	IIC Address[R]		A	Status	NACK	P
S	111 1000	0(W)	A	1000 0000	A	RS	111 1000	1(R)	A	0000 XXXX	NACK	P

Figure 10- 3 Idle Mode I2C Communication Diagram

11 Reset

The Reset command is used to reset the chip, after sending the command, the internal register configuration of the chip is reset to the reset state, if the chip is in Duty Cycle Mode, before resetting the chip, you need to send the Idle Mode command to make the chip return to the idle state.

Reset I2C Communication Diagram is shown in the following figure:

S	IIC Address[W]		A	Command	A	P
S	111 1000	0(W)	A	1111 0000	A	P

Figure 10- 3 Reset I2C Communication Diagram

12 Data Read Frame

After the chip has completed a measurement, the Data Read Frame can also be used to read back the chip operating status and all measurement data at once.

The host sends a one-time data readback command to the chip, which can read back the AB data.

Returns a 16-bit angle value, and the angle corresponding to each LSB is $\frac{360^{\circ}}{2^{16}}$, that is, the angle of the magnetic field in the selected plane= $A[15:0]*\frac{360^{\circ}}{2^{16}}$.

Since the magnetic field value is calculated by the CORDIC algorithm, the corresponding value of the actual magnetic flux density should be: $\frac{B[15:0]*0.60725}{Sensitivity}$ ， in practical application, the B value can be used to estimate the magnitude of the magnetic field under the current plane, and Sensitivity values vary in different planes, so please consult technical support for details.

When the chip measures the data, the data is returned in the order of Status, A , B, and the following is the readback frame of the readback data.

S	IIC Address[W]		A	Command	A	RS	IIC Address[R]		A	Status	
S	111 1000	0(W)	A	0100 0110	A	RS	111 1000	1(R)	A	XXX0 XXXX	……

	A	Data A[15:8]	A	Data A[7:0]	A	Data B[15:8]	A	Data B[7:0]	Nack	P
……	A	0xXX	A	0xXX	A	0xXX	A	0xXX	Nack	P

Figure 12- 1 Data Readback I2C Communication Diagram

12.1 Read and Write Registers

When running read and write registers, the register address should be shifted two places to the left, as shown in the figure below.

S	IIC Address[W]		A	Command	A	Register << 2	A	RS	IIC Address[R]		A	Status	
S	111 1000	0(W)	A	0101 0000	A	XXXX XXXX	A	RS	111 1000	1(R)	A	0000 XXXX	……

	A	Data [15:8]	A	Data [7:0]	Nack	P
……	A	0xXX	A	0xXX	Nack	P

Figure 12- 2 Read Register I2C Communication Diagram

S	IIC Address[W]		A	Command	A	Data [15:8]	A	Data [7:0]	A	Register << 2	A	…
S	111 1000	0(W)	A	0110 0000	A	0xXX	A	0xXX	A	XXXX XXXX	A	…

..	RS	IIC Address[R]		A	Status	Nack	P
..	RS	111 1000	1(R)	A	0000 XXXX	Nack	P

Figure 12- 3 Write Register I2C Timing Diagram

13 Register Map Descrption

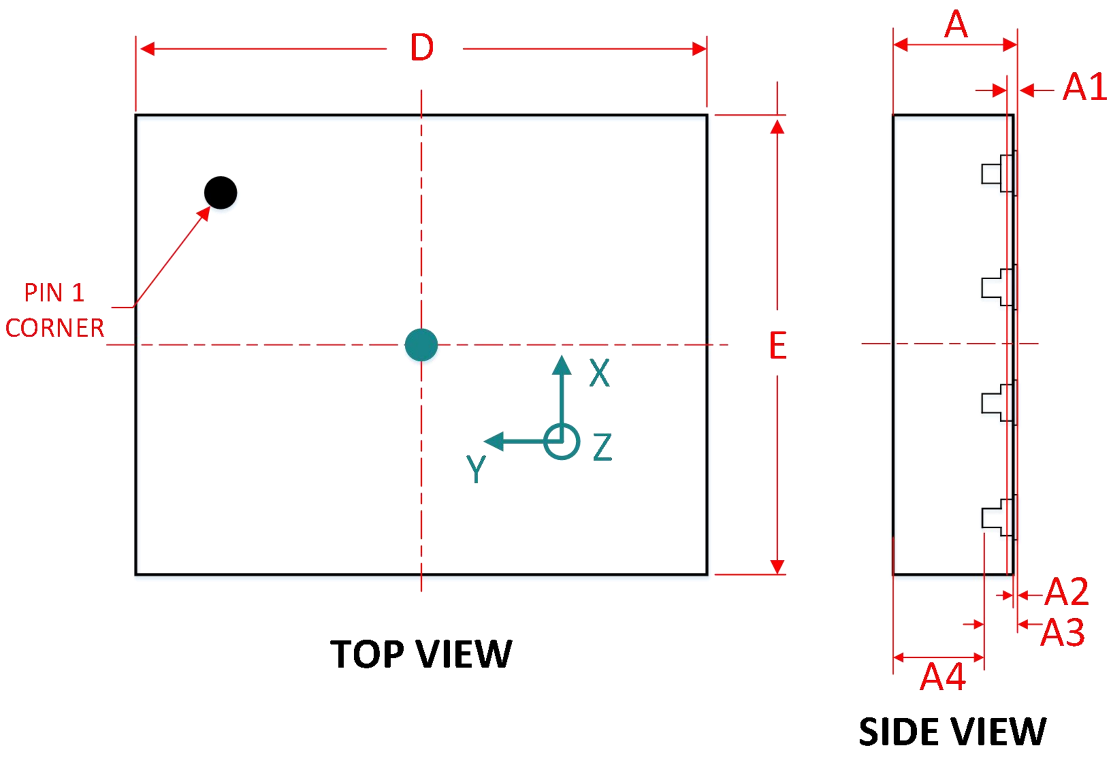
Address	Default	Bit	Name	R/W	Description
0x06	0x00	7	RESERVED	R	This address register is a status register, please refer to Chapter 8 for operating status description.
		6	Cycle	R	
		5	Single	R	
		4	Failing	R	
		3 : 2	RESERVED	R	
		1	softRst	R	
		0	DRDY	R	
0x19	0x00	15 : 0	wxyTh	RW	When the XY plane angle detected by the chip is greater than the configured value in wxyTh, the INT pin is pulled up, and the calculation method for writing the angle in wxyTh is consistent with the calculation method for reading the chip angle output.
0x1B	0x00	15:14	gainSel	RW	In cases where the magnetic field amplitude of the two axes is different due to assembly tolerances or off-axis applications, the selected magnetic field amplitude can be corrected by this register: When gainSel = 0, no amplitude correction is performed When gainSel = 1, amplitude correction is made on the X-axis When gainSel = 2, amplitude correction is made on the Y-axis When gainSel = 3, amplitude correction is made on the Z-axis According to the corresponding application scenario, select the axis that needs to be calibrated by amplitude, and after the gainSel is configured, the algorithm for calculating the current plane angle inside the chip will adjust the magnetic field value detected by the selected axis based on the set value of the gainValue, thereby achieving the goal of equal amplitude of the two axis magnetic fields used for angle calculation.
		13:0	gainValue	RW	gainValue corrects the amplitude of the selected axis in the gainSel. gainValue = k*8192 k is the amplitude ratio of the two axes currently used to calculate the plane angle. • If it is necessary to obtain the angle of the YZ plane, there may be differences in the sensitivity of the YZ axis measurement, assembly tolerances, and other factors that result in different magnetic field amplitudes between YZ

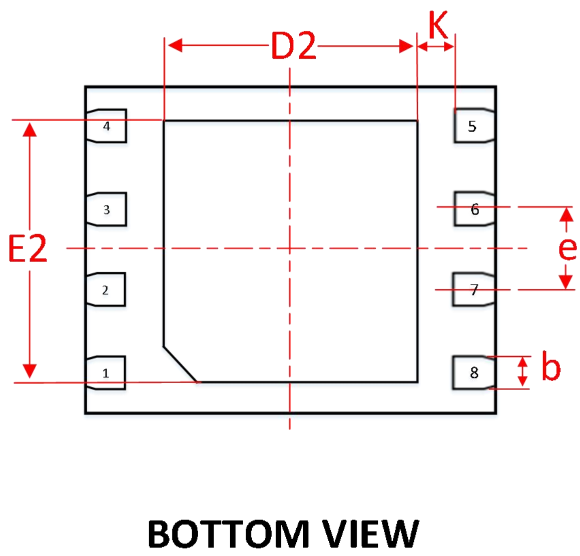
<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>axes; If you want to adjust the amplitude of the Z-axis so that the YZ amplitude is consistent when the knob is rotated for one turn, GainSel is set to 3
Then k = $\left|\frac{(|By\max|+|By\min|)/2}{(|Bz\max|+|Bz\min|)/2}\right|$
gainValue = $\left|\frac{(|By\max|+|By\min|)/2}{(|Bz\max|+|Bz\min|)/2}\right|*8192$
•If you want to correct the amplitude of the Y axis so that the YZ amplitude is the same when the knob is rotated for one turn, gainSel is set to 2
Then k= $\left|\frac{(|Bz\max|+|Bz\min|)/2}{(|By\max|+|By\min|)/2}\right|$
gainValue = $\left|\frac{(|Bz\max|+|Bz\min|)/2}{(|By\max|+|By\min|)/2}\right|*8192$
Note: The k<1 configuration is recommended

GainSel selects the axis where data needs to be modified, K is the multiple , and the gainValue is k*8192</td></tr>
<tr><td rowspan="3">0x1C</td><td rowspan="3">0x1470</td><td>15 : 14</td><td>AplaneSel</td><td>RW</td><td>Angular output plane selection
<table><tr><th>AplaneSel</th><th>Function</th></tr><tr><td>0</td><td>The chip outputs the angle value of the magnetic field in the XY plane</td></tr><tr><td>1</td><td>The chip outputs the angle value of the magnetic field in the YZ plane</td></tr><tr><td>2</td><td>The chip outputs the angle value of the magnetic field in the XZ plane</td></tr><tr><td>3</td><td>The chip outputs the angle value of the magnetic field in the XY plane</td></tr></table></td></tr>
<tr><td>13 : 11</td><td>RESERVED</td><td>R</td><td>Reserved bits</td></tr>
<tr><td>10 : 9</td><td>magnOsr</td><td>RW</td><td>The ADC oversampling rate measured by the magnetic field corresponds to two bits, from low to high, representing 32, 64, 128, and 256 sampling points at one time, respectively.
<table><tr><td>magnOsr</td><td>0x03</td><td>0x02</td><td>0x01</td><td>0x00</td></tr></table></td></tr>
</table>

<table>
<tr><td rowspan="3"></td><td rowspan="3"></td><td></td><td></td><td></td><td><table><tr><td>The number of sampling points</td><td>256</td><td>128</td><td>64</td><td>32</td></tr></table>The total number of points taken by the ADC =32x 2 magnOsr x (2^digCtrl + 2)， The time to complete an angle measurement= (The number of points taken from the ADC + 69) * 2μs</td></tr>
<tr><td>8 : 3</td><td>RESERVED</td><td>R</td><td>Reserved bits</td></tr>
<tr><td>2 : 0</td><td>digCtrl</td><td>RW</td><td>Digital filtering control parameters.</td></tr>
<tr><td rowspan="3">0x1D</td><td rowspan="3">0x00</td><td>15 : 10</td><td>RESERVED</td><td>R</td><td>Reserved bits</td></tr>
<tr><td>9 : 6</td><td>measSel</td><td>RW</td><td>Measure the select signal. When the host sends three measurement mode commands to the chip without any gating, the corresponding BA bit can be selected by measSel.<table><tr><td>measSel</td><td>0xC</td><td>0xA</td><td>0x6</td></tr><tr><td>Selected Plane</td><td>YZ Plane</td><td>XZ Plane</td><td>XY Plane</td></tr></table></td></tr>
<tr><td>5 : 0</td><td>maesTime</td><td>RW</td><td>In Duty Cycle Mode, the intermittent wait time between measurements (standby time) is controlled. The number of delays is controlled by the value set in measTime, and one lsb corresponds to a waiting delay of 20ms. Delay as many times as the decimal value in measTime is set.
For example, if measTime = 0x05, the waiting time between two measurements of the chip is 5 times of 20ms delay, 5*20ms=100ms.</td></tr>
<tr><td rowspan="2">0x1E</td><td rowspan="2">0x80</td><td>15</td><td>RESERVED</td><td>R</td><td>Reserved bits</td></tr>
<tr><td>14 : 0</td><td>Zero[14:0]</td><td>RW</td><td>Set the first 15 bits of the zero value for angle output.
Take the opposite value that needs to be set to zero and add 1,and write the first 15 bits to the zero register.
For example, if angle 0x01AA needs to be set to zero, then the value of zero is 0x7F2B.</td></tr>
</table>

14 DFN2x2.5-8L Package Dimensions



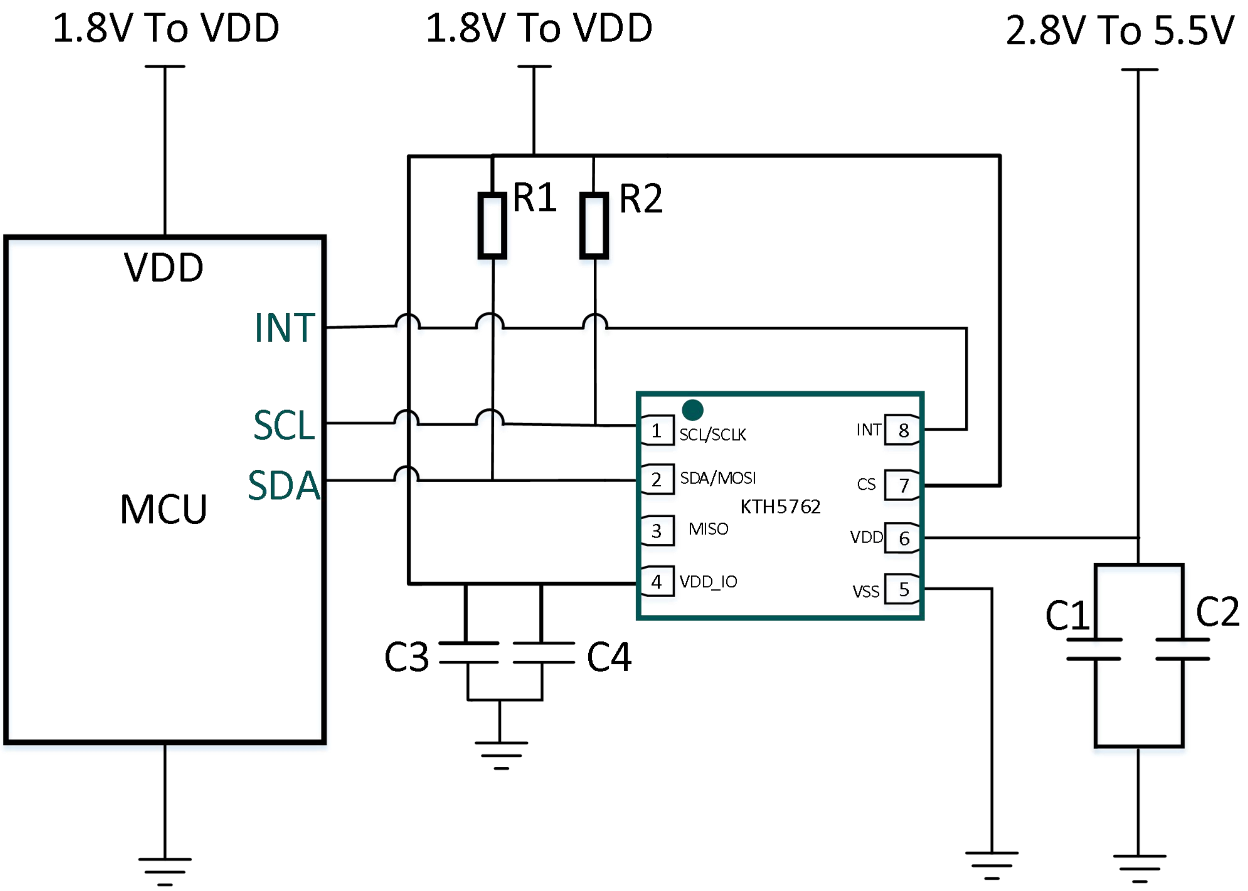


SYMBOL	MILLIMETER		
	MIN	NOM	MAX
D		2.5BSC	
E		2BSC	
A	0.50	0.55	0.60
A1		0.05	
A2	0	0.02	0.05
A3		0.152REF	
A4	-	0.4	-
D2	1.46	1.56	1.66
E2	1.5	1.6	1.7
K		0.22REF	
e		0.5BSC	
b	0.15	0.2	0.25

15 Reference Circuit

Note: When PCB layout, capacitors should be placed as close as possible to the chip.

R1 = R2 = 4.7k ohm
C1=C3=0.1µF
C2=C4=10 µF
I2C Address: 1111000R/W

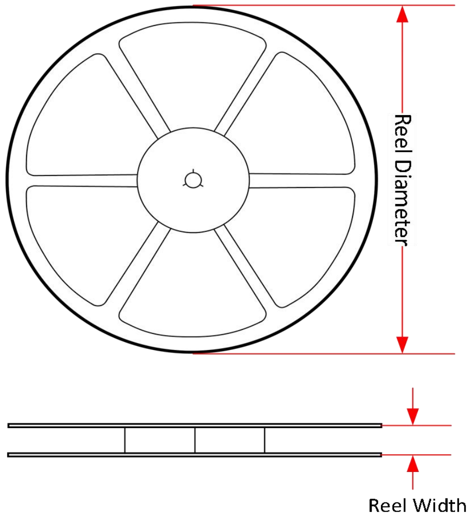


16 Order Information

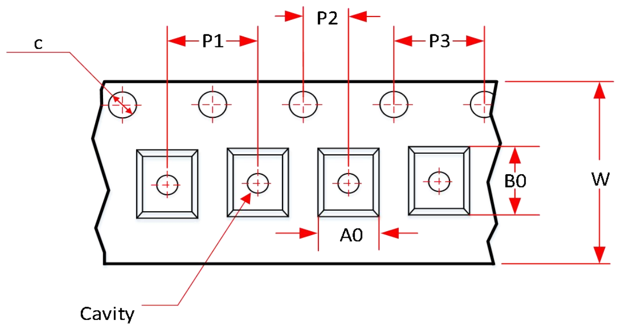
Part Number	Package	Temperature	Application	Number of Pins
KTH5762AQ3DNE	DFN2x2.5-8L	-40℃ ～+85℃	Consumer Grade	8

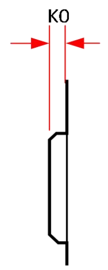
17 Tape and Reel Information

Reel Dimensions



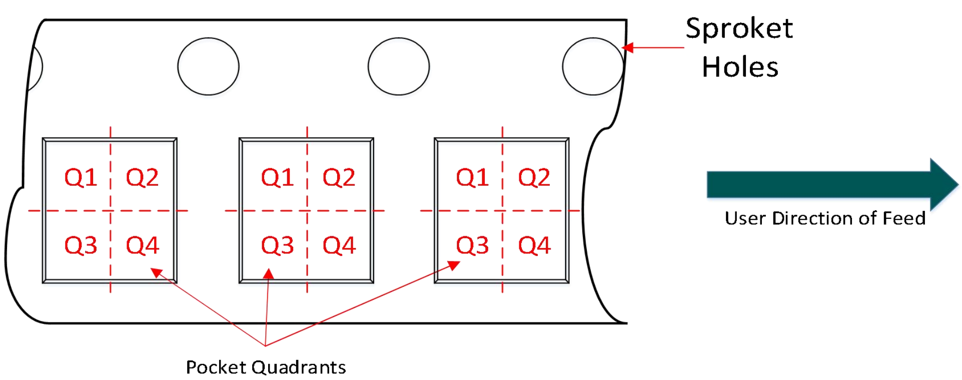
Tape Dimensions





A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

Quadrant Distribution of Product Pins



Package Type	Pins	SPQ	Reel Diameter	Reel Inside Width	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	P2 (mm)	P3 (mm)	C Diameter (mm)	W (mm)	Pin1 Direction
DFN2*2.5-8L	8	4000	180	9.5	2.25	2.75	0.7	4.00	2.00	4.00	1.5	8.00	Q2