CONNTEK

KTH5701

Low Power, High Precision
3D Hall Sensor
EVB KIT
Users' Manual

Technical Support
sales.global@conntek.com.cn

2024- 8- 22

Disclaimer

The information in this document is provided by Quanzhou KTsense Microelectronics Co., Ltd. (泉州昆泰芯微电子科技有限公司) (hereafter referred to as "KTsense Micro") on an "as is" basis for informational purposes only. KTsense Micro does not guarantee the accuracy of the information contained herein or the outcomes of its implementation. KTsense Micro assumes no liability for any errors or inaccuracies that may be present in this document. Users assume full responsibility for the application of the practices outlined in this document.

KTsense Micro owns the registered trademark CONNTEK, under which the CONNTEK brand sensors are marketed.

This document comes without any warranties, express or implied, including but not limited to warranties of merchantability, satisfactory quality, non-infringement, and fitness for a particular purpose. KTsense Micro, along with its employees, agents, and affiliates, is not liable for any losses arising from the use or reliance on this document.

This document is subject to change without prior notice and should not be construed as a commitment by KTsense Micro. Users should ensure they have the latest version of the relevant information before placing orders or integrating the product into their systems.

Users must evaluate the suitability of the product described in this document for their specific applications, including the required level of reliability and fitness for purpose.

This document and the described product may be subject to export control regulations. Export may require prior authorization from the competent authorities. The product is not intended, authorized, or warranted for use in applications requiring extended temperature ranges or unusual environmental conditions. High reliability applications, such as medical life-support or aviation systems, are specifically excluded.

The product may not be used for the development, production, maintenance, or storage of:

1. Chemical, biological, or nuclear weapons, including missile systems for such weapons.
2. Civil firearms, including spare parts or ammunition.
3. Defense-related products or materials for military or law enforcement use.
4. Applications that could cause serious harm to persons or property and that can be used as a means of violence in armed conflicts or similar situations.

No licenses or rights to any intellectual property of KTsense Micro or third parties are granted.

If this document is marked as "confidential"or similar, or if the content is reasonably understood to be confidential, the recipient must not disclose any part of the document to third parties without the express written consent of KTsense Micro. The recipient must take all necessary measures to maintain the confidentiality of the document, using at least the same degree of care as they use to protect their own confidential information, but no less than a reasonable degree of care. The recipient may only disclose the document to employees on a need-to-know basis, provided they are bound by confidentiality terms similar to those in this disclaimer. The document may only be used for the purpose for which it was received and may not be used for commercial purposes or to the detriment of KTsense Micro or its customers. These confidentiality obligations will last indefinitely but in any case, for no less than 10 years from the receipt of the document.

This disclaimer is governed by the laws of China, and any disputes arising from it will be subject to the exclusive jurisdiction of the courts in Shenzhen, China.

The invalidity of any provision in this disclaimer does not affect the validity of the remaining provisions. Previous versions of this document are repealed.

Copyright

Contact Information

For the latest version of this document, go to our website at https://en.conntek.com.cn/.

For additional information, please contact our Direct Sales team and get help for your specific needs:

Region	Contact Information
Overseas	Email: sales.global@conntek.com.cn
China	Email: sales@conntek.com.cn

Table of Contents

1 Overview

This document introduces the KTH5701 high-precision 3D Hall sensor evaluation board kit. The evaluation board is designed to evaluate the performance of the KTH5701. Readers can quickly become familiar with the relevant features, application range, and the GUI operation methods associated with the KTH5701 based on the content of this document.

1.1 KTH5701 Brief Introduction

The KTH5701 is a high-precision 3D Hall sensor that integrates three independent Hall devices for the X, Y, and Z axes, as well as a temperature sensor for magnetic field temperature compensation. The signal chain uses a high-precision operational amplifier and a 16-bit ADC to digitize the measured analog quantities. External commands can select measurements of the magnetic fields in the X, Y, Z axes, and the temperature. By modifying specific registers, the magnetic field output can be switched to angle output in the XY, YZ, or XZ planes to accommodate angle measurement applications.

It is worth noting that regardless of whether the chip outputs magnetic fields or angles, the chip always measures the current X, Y, and Z three-axis magnetic fields. The chip integrates a CORDIC algorithm internally, which calculates the angle of a plane based on the configuration in the registers. For example, if the registers are configured to output the angle of the magnetic field in the XY plane, the angle is calculated using the X-axis and Y-axis magnetic field values measured by the chip through the CORDIC algorithm. The KTH5701 can output the angular data for any of the XY, YZ, or XZ planes depending on the register configuration. However, for ease of installation and use of the structural components, the on-axis knob in this kit is only suitable for the XY plane.

1.2 Evaluation Kit Contents

Figure 1: KTH5701 Evaluation Kit Package Appearance

The components of the evaluation kit are listed in Table 1. If any components are missing, please contact us promptly.

Part	Quantity
KTH5701EVB	1
Off-axis knob	1
On-axis knob	1
Linear displacement kit	1
Joystick kit	1
Screws	6
Hex screwdriver	1
MicroUSB cable	1

Table 1: KTH5701 Evaluation Kit Components

2 Evaluation Kit Description

The KTH5701 evaluation kit is designed to provide users with an easy-to-use platform to quickly get familiar with the KTH5701. The kit includes a visual user interface (GUI) that allows for reading and writing registers, obtaining, and storing current magnetic field measurement data. To better understand the configuration of the registers, the GUI not only provides simple read/write register functions but also includes specific parameter configurations, such as digital filter depth and chip measurement standby time control.

The kit also includes four 3D printed models to demonstrate some common application scenarios of the KTH5701. Corresponding usage instructions and parameter calculation formulas are provided in Section 5 of this document.

3 Quick Start Guide

3.1 Using the GUI

1. Install the GUI software in a directory with an English path to ensure proper operation.
2. Double-click the desktop icon to enter the GUI interface.
3. Click the main interface icon to enter the operation interface.
4. The main GUI interface will appear as shown below:

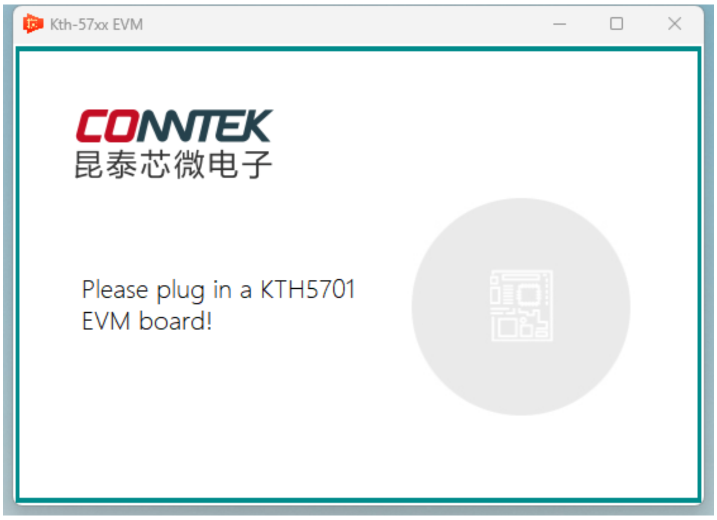


Figure 2: Main GUI interface while PCB is not connected

5. Connect the EVM board to your PC via USB. The GUI will automatically detect the connection and display the status as shown:

Figure 3: EVM Board Connection Status

6. If the connection is successful, click and enter the main GUI interface.

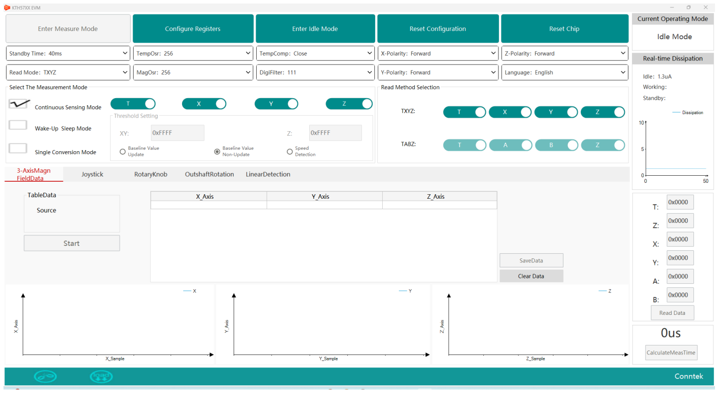


Figure 4: EVM GUI Main Interface

3.2 Steps to Obtain Three-Axis Magnetic Field Output (TXYZ)

The EVM kit is designed to quickly get users familiar with the KTH5701. The steps in the GUI represent the general procedure for enabling measurement mode and obtaining measurement data.

In the term TXYZ, T represents the current temperature, X indicates the magnetic field strength along the X-axis, Y corresponds to the magnetic field strength along the Y-axis, and Z denotes the magnetic field strength along the Z-axis. The sensitivity directions of each axis are shown in the figure below. The proportional relationship between the three-axis output data and the magnetic field strength, as well as the sensitivity of each axis, can be found in the KTH5701 datasheet.

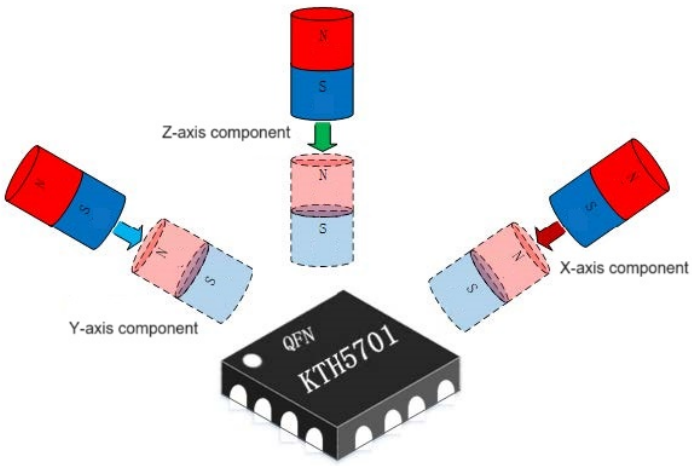
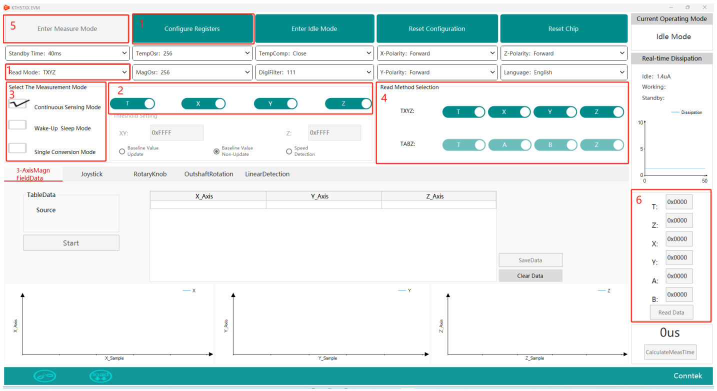


Figure 5: Magnetic Field Sensitivity Directions

- Step 1: Click **Configure Registers** to initialize the chip configuration. Ensure the reading mode is set to **TXYZ**.
- Step 2: Select the measurement items to be measured.
- Step 3: Choose the operating mode for the chip.
- Step 4: Select the measurement items to be read by the chip.
- Step 5: Click **Enter Measurement Mode** to start the measurement.

- Step 6: Click **Read Data** to obtain the measured values selected in Step 4. It is important to note that if you select a measurement item for reading in Step 4, you must choose to measure that item in Step 2. Measurement items can be measured without being read, but items selected for reading must be measured.



Note: In single measurement mode, only one measurement is performed. If multiple data sets are needed, click **Enter Measurement Mode** multiple times. In continuous sensing mode and wake-up sleep mode, only one click is required to start the measurement. To modify the configuration afterward, switch to idle mode first to stop the measurement; otherwise, the modification will fail.

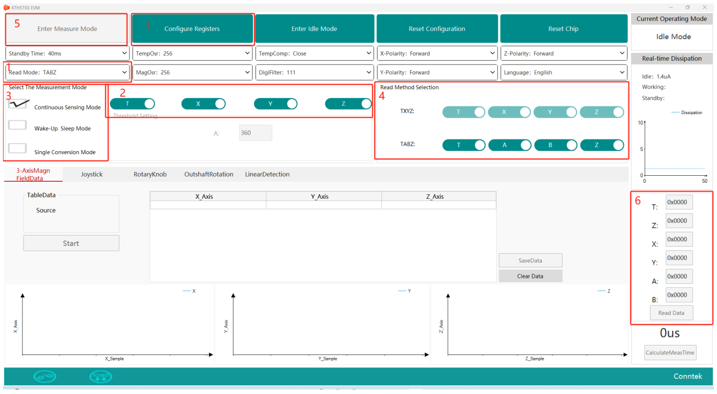
3.3 Steps to Obtain Angle Output (TABZ)

The EVM kit is designed to quickly get users familiar with the KTH5701. The steps in the GUI represent the general procedure for enabling measurement mode and obtaining measurement data.

In the term TABZ, T represents the current temperature, A indicates the magnetic field angle of the selected plane, B corresponds to the magnetic field strength of the selected plane, and Z denotes the magnetic field strength along the Z-axis.

In the data reading section of this evaluation kit, the default selection is to read the magnetic field angle and magnetic field strength of the XY plane. For register configuration methods of other planes, refer to the KTH5701 datasheet. The sensitivity directions of each axis can be found in Figure 5, and details on the output code can be found in the KTH5701 datasheet.

- Step 1: Click **Configure Registers** to initialize the chip configuration. Ensure the reading mode is set to **TABZ**.
- Step 2: Select the measurement items to be measured.
- Step 3: Choose the operating mode for the chip.
- Step 4: Select the measurement items to be read by the chip.
- Step 5: Click **Enter Measurement Mode** to start the measurement.
- Step 6: Click **Read Data** to obtain the measured values.



Note: To read the XY plane angle A and XY plane magnetic field strength, ensure both X and Y axis measurements are enabled in Step 2. If either axis is not selected, the calculation cannot be performed.

4 Configurable Registers Description

The following table provides an overview of the configurable registers available in the GUI, along with their names, addresses, and descriptions.

Configuration Name	Register Address	Register Name	Description
Standby Time	29	measTime	Controls the standby time interval in continuous sensing mode or wake-up sleep mode.
Temperature Oversampling	28	tempOsr	Controls the oversampling rate of the temperature signal. A higher configuration value results in a longer measurement time and higher precision.
Magnetic Field Oversampling	28	magnOsr	Controls the oversampling rate of the magnetic field signal. A higher configuration value results in a longer measurement time and higher precision.
Digital Filtering	28	digCtrl	Controls the intensity of digital filtering for the magnetic field signal. A higher configuration value increases the measurement time and precision.
Temperature Compensation Enable	29	tcmpEn	Enables the magnetic field temperature compensation function.
X-Axis Polarity	29	xPol	Controls the output polarity of the X-axis relative to the output value when there is no magnetic field.
Y-Axis Polarity		yPol	Controls the output polarity of the Y-axis relative to the output value when there is no magnetic field.
Z-Axis Polarity		zPol	Controls the output polarity of the Z-axis relative to the output value when there is no magnetic field.

Table 2: Configurable Registers Overview

5 GUI Functions Description

5.1 Hardware Fasteners

This kit includes fasteners used for securing the structural components. The specifications for the cylindrical head hexagon socket bolts are listed below.

Parameter	Specification
Thread Diameter (M)	M3
Nominal Length	8 mm
Pitch	0.5 mm
Hexagon Socket Width	2.5 mm
Material	304 Stainless Steel

Table 3: Cylindrical Head Hexagon Socket Bolt Specifications

The functionality of the structural components in this kit has been verified through magnetic simulation. If you need assistance with magnetic simulation, please contact us.

5.2 Magnet Specifications

The specifications for the magnets used in this kit are shown below. Figure 6 illustrates a magnet magnetized along the diameter.

Parameter	Specification
Magnet Shape	Cylindrical
Magnet Material	NdFeB N52
Magnetization Direction	Along the diameter
Magnet Thickness	5 mm
Magnet Diameter	6 mm

Table 4: Radial Magnet Specifications

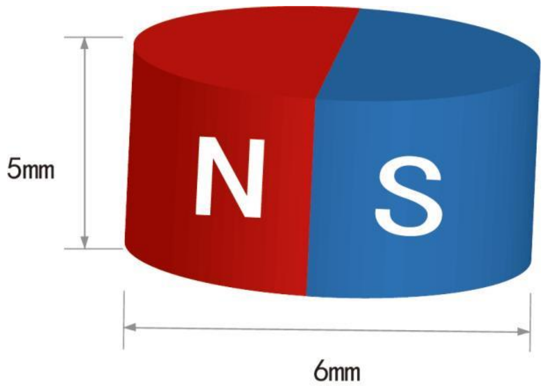


Figure 6: Radial Magnetization Direction

Figure 7 illustrates a magnet magnetized along the thickness direction.

Parameter	Specification
Magnet Shape	Cylindrical
Magnet Material	NdFeB N52
Magnetization Direction	Along the thickness
Magnet Thickness	5 mm
Magnet Diameter	10 mm

Table 5: Axial Magnet Specifications

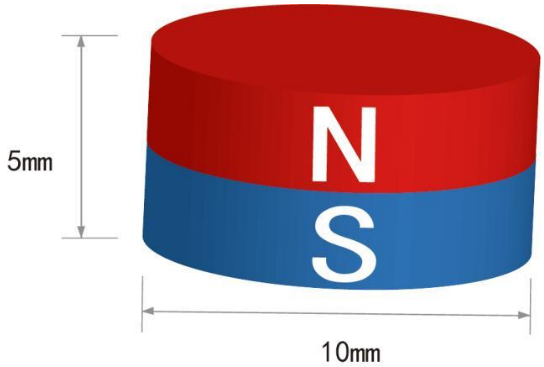


Figure 7: Axial Magnetization Direction

6 GUI Functions Description

6.1 Three-Axis Magnetic Field Data Output

The KTH5701 is a three-axis magnetic field sensor capable of outputting magnetic field strength data in the X, Y, and Z directions. Users can view and record these data in real-time using the GUI. The directions of the magnetic field strength are shown in Figure 8.

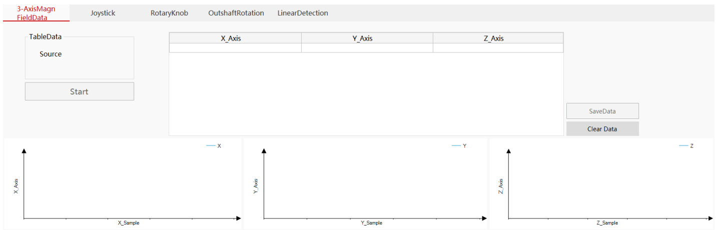


Figure 8: Three-Axis Magnetic Field Data Output

The output data for each axis can be configured and viewed individually. Any of the provided structural components or any magnetic material that falls within the KTH5701's magnetic field measurement range can be used. Follow the first five steps outlined in Section 3.2 for quick use of the chip's three-axis magnetic field output (TXYZ), and select continuous sensing mode. After clicking "START", the corresponding output values of the current magnetic field strength will be displayed in the table. Click "Save Data", the current output data of the chipset can be saved.

6.2 Joystick

The KTH5701 can also be used in applications where a joystick is employed. The joystick's movements are translated into changes in the magnetic field, which are detected by the sensor. The corresponding output data for the X, Y, and Z axes can be displayed in the GUI.

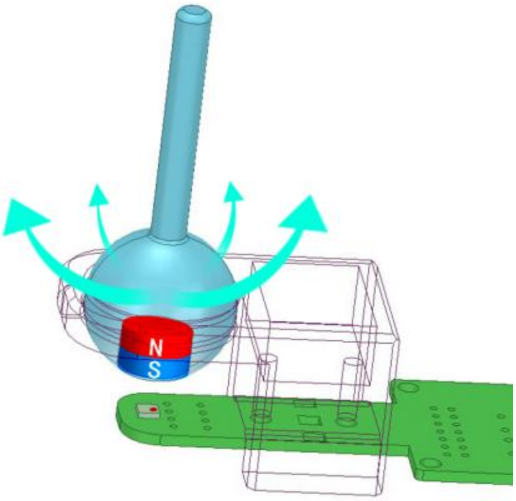


Figure 9: Joystick Mechanical Strucuture Illustration

Install the structural components as shown in the schematic diagram of the joystick in Figure 9.

If the chip is currently in certain operating modes, such as continuous sensing, please first click "Enter Idle Mode" before proceeding with the following operations.

Follow the first five steps outlined in Section 3.3 for quickly obtaining the chip's angle output (TABZ). When selecting measurement items, ensure that both the X and Y axis measurements are enabled, and choose continuous sensing mode, then click "Start".

As shown in Figure 10, the right side displays a 3D model of the joystick's rotation, while the bottom left corner shows its projection on the XY plane.

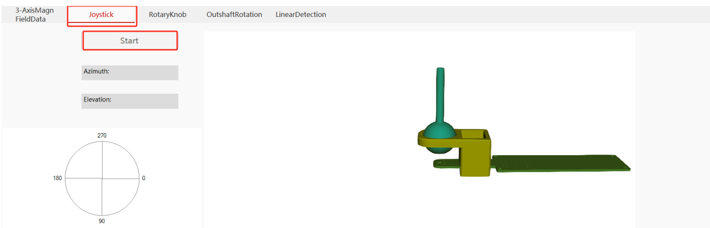


Figure 10: Joystick GUI Interface

In the magnetic sensor joystick application, magnets that are magnetized along the thickness direction are typically used, and the center axis of the magnet's thickness direction needs to be aligned with the geometric center of the chip. By detecting the changes in the XYZ three-axis magnetic fields, the chip can determine the user's movements of the joystick, including the direction of operation, thereby achieving the purpose of controlling specific devices through the joystick. The extent of changes in the three-axis magnetic fields, or the deviation from the central magnetic field, provides details about the user's manipulation of the joystick without the need for additional sensor chips or mechanical structure modifications. Unlike traditional potentiometer-based joysticks, magnetic sensor joysticks do not suffer from common issues such as measurement errors caused by device wear.

The KTH5701 also integrates a temperature sensor, which helps detect temperature changes in the usage environment, thereby improving the accuracy of the chip's detection data.

In the structural components provided in this kit, the joystick rotates around a rotation point located above the central axis of the magnet's thickness direction. This rotation point can be considered the center point of the joystick's movement trajectory as the user moves the joystick. As the joystick rotates, the magnet's movement trajectory corresponds to a hemispherical curve with a radius equal to the distance between the center point and the center of the magnet. Therefore, we use the polar angle θ and azimuthal angle ϕ in spherical coordinates to represent the specific position of the joystick, and the changes in θ and ϕ to indicate the direction of the joystick's movement.

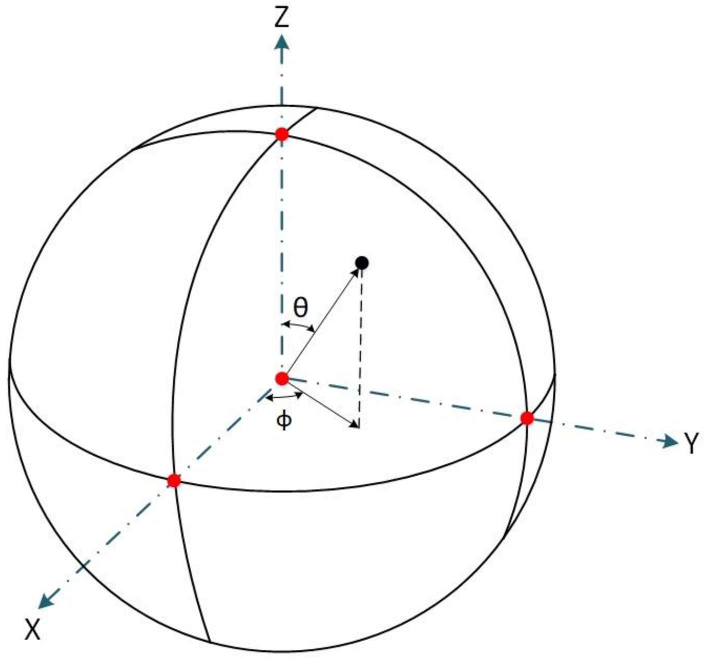


Figure 11: Joystick Application Calculation Illustration

As the joystick rotates, the direction and magnitude of the magnetic field change. The KTH5701 chip detects these changes, allowing for precise control over the device being operated by the joystick. The polar angle θ and the azimuthal angle ϕ in the spherical coordinate system describe the specific position of the joystick.

$$\theta = \arccos\left(\frac{B_z}{\sqrt{B_x^2 + B_y^2 + B_z^2}}\right)$$

When $B_x > 0$, the azimuthal angle ϕ is calculated using the following formula:

$$\phi = \text{arctan}\left(\frac{B_y}{B_x}\right)$$

When $B_x = 0$ and $B_y > 0$:

$$\phi = \frac{\pi}{2}$$

When $B_x = 0$ and $B_y < 0$:

$$\phi = -\frac{\pi}{2}$$

When $B_x < 0$ and $B_y \geq 0$:

$$\phi = \text{arctan}\left(\frac{B_y}{B_x}\right) + \pi$$

When $B_x < 0$ and $B_y < 0$:

$$\phi = \text{arctan}\left(\frac{B_y}{B_x}\right) - \pi$$

Alternatively, the azimuthal angle ϕ can be expressed using the `atan2` function:

$$\phi = \text{atan2}(B_y, B_x)$$

6.3 Rotary Knob

The KTH5701 can be utilized to measure the rotational angle of a rotary knob in the XY, YZ, or XZ planes. The evaluation kit includes a rotary knob structure designed specifically for this purpose.

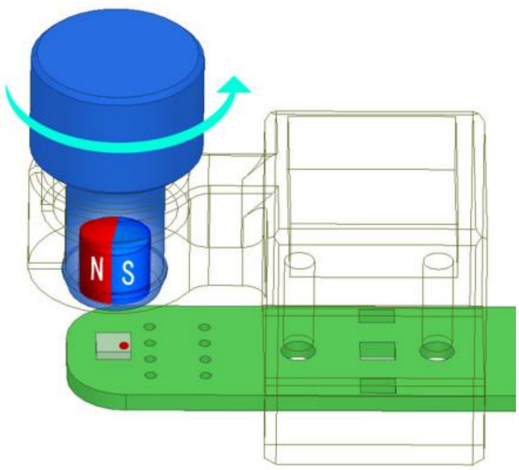


Figure 12: Rotary Knob Structure

The KTH5701 has the capability to detect rotational angles in the XY, YZ, and XZ planes. For simplicity and ease of installation, this evaluation kit only provides structural components and functionality for detecting the rotational angle in the XY plane. If you wish to detect the rotational angle of a magnet in other planes, please refer to the KTH5701 datasheet.

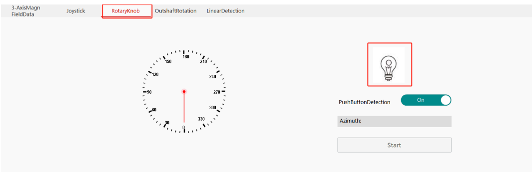


Figure 13: Rotary Knob GUI Illustration

Knob Functionality:

- Install the structural components as shown in the schematic diagram of the knob in Figure 13.
- To minimize data sampling errors caused by structural component wobbling during use, it is recommended to secure the component with two screws.
- If the chip is currently in certain operating modes, such as continuous sensing, please first click "Enter Idle Mode" before proceeding with the following operations.
- Follow the first five steps outlined in Section 3.3 to select the measurement items, ensuring that both the X and Y axis measurements are enabled. Choose continuous sensing mode, then click "Start." The pointer on the dial will rotate as the structural component rotates. The angle between the current magnetic field and the XY plane, as output by the chip, will be displayed in the "Plane Angle" section on the right.
- Click "Enter Idle Mode," enable the chip's "Button Detection," then follow the first five steps in Section 3.3 and select continuous sensing mode. Click "Start." When the structural component is pressed downward, the light in the GUI will turn on.

In the magnetic sensor knob application, there are two common configurations for the relative position of the magnet and the chip: on-axis and off-axis. On-axis means that the magnet's rotation axis is aligned with the geometric center of the chip. This knob structure component represents the on-axis rotation configuration, using the magnet shown in Figure 6, with a button travel of 2 mm.

When using a radially magnetized magnet with the chip on-axis, ideally, if the magnet rotates one full revolution, the magnetic field strength data collected by the chip, plotted as the angle between the magnetic field and the XY plane (as the horizontal axis) versus the magnetic field strength of the X and Y axes (as the vertical axis), will yield two orthogonal curves with equal amplitude and no offset, as shown in Figure 14. If the X-axis magnetic field strength is plotted on the horizontal axis and the Y-axis magnetic field strength on the vertical axis, a circle will be obtained, as shown in Figure 15. The radius of this circle represents the magnetic field strength detected in the XY plane, indicating that the XY plane magnetic field strength remains constant as the magnet rotates.

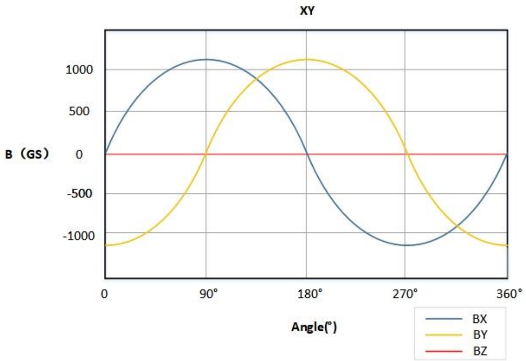


Figure 14: Illustration of X and Y Axis Magnetic Field Components for One Full Rotation of On-Axis Magnet

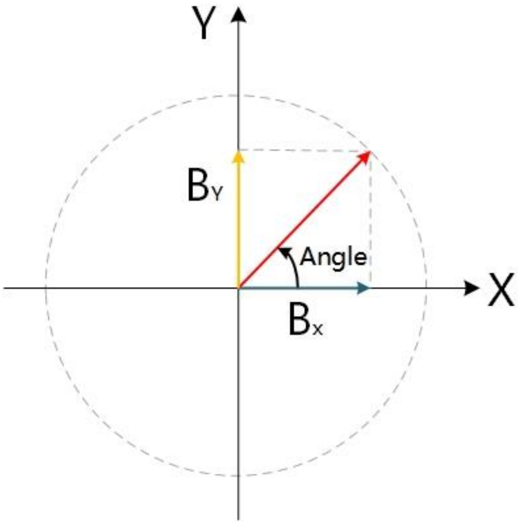


Figure 15: Angle Sensing Diagram

$$\text{Angle} = \arctan\left(\frac{B_y}{B_x}\right)$$

Therefore, even in non-ideal conditions, where factors such as uneven magnetization of the magnet or assembly tolerances prevent the exact alignment of the magnet and chip geometric centers, resulting in some angular deviation, the calculated angle remains fairly close to the actual rotation angle during on-axis rotation, as shown in Figure 15.

The detection of the chip's button functionality is based on two principles: first, in an ideal scenario, the total magnetic field in the XY plane does not change when the on-axis magnet rotates one full circle; second, when the user presses the knob, bringing the magnet closer to the chip, the magnetic field strength increases. Under ideal conditions, since the total magnetic field in the XY plane remains constant as the magnet rotates, any increase in the total magnetic field strength can be used to determine that the button has been pressed, regardless of the magnet's rotational angle, as shown in Figure 16.

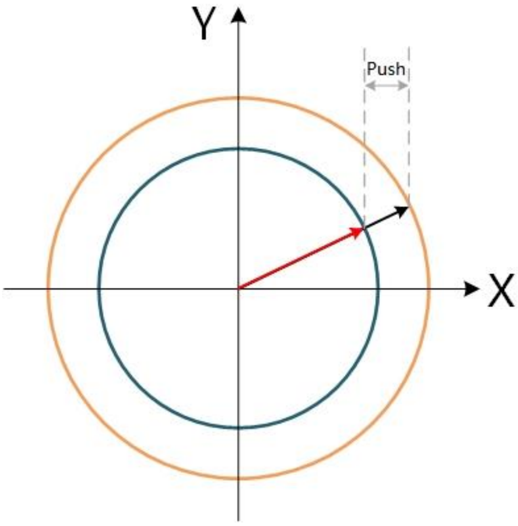


Figure 16: Illustration of Magnetic Field Changes During Button Functionality

6.4 Off-Axis Knob

The evaluation kit includes an off-axis knob structure that simulates scenarios where the magnet's rotation axis is offset from the sensor's geometric center. The KTH5701 is capable of accurately detecting the magnetic field and calculating the corresponding angle even with such offsets.

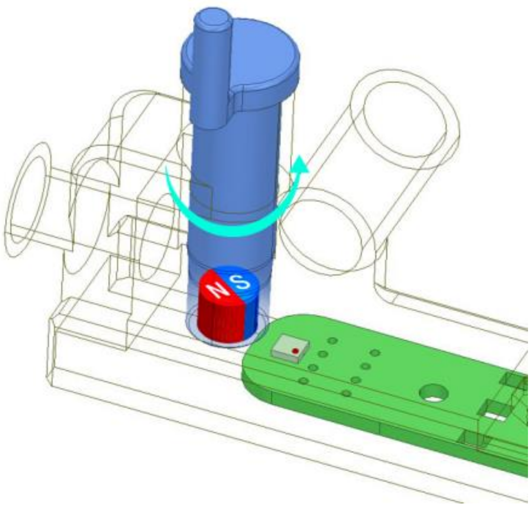


Figure 17: Off-Axis Knob Structure

The KTH5701 includes an off-axis amplitude adjustment register and integrates a CORDIC algorithm, allowing it to output a calibrated magnetic field angle for the selected plane (AplaneSel) through the TABZ function based on the values set in the user's registers (gainSel/gainValue). The values set in the amplitude adjustment register must be measured and calculated by the user.

If the user does not wish to use the chip's internal angle output function, they can also read the corresponding two-axis magnetic field strength for the desired plane and use an external algorithm to calibrate and calculate the current plane's magnetic field angle.

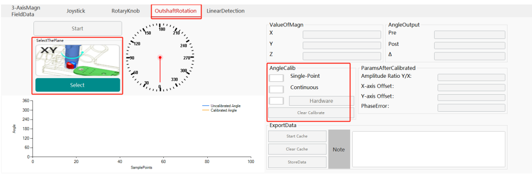


Figure 18: Off-Axis Knob GUI

Angle Calibration Instructions in the Above Interface (It is recommended to set "Standby Time" to 0 for a better calibration experience!):

Single Calibration: Select "Continuous Sensing Mode" as the measurement mode, choose "TXYZ" as the read method, check the box to open the calibration interface. The user performs a one-time calibration of the selected plane's magnetic field values according to the instructions in the sampling interface. The upper computer calibrates the magnetic field angle output values based on the calibration parameters obtained.

Continuous Calibration: Select "Continuous Sensing Mode" as the measurement mode, choose "TXYZ" as the read method, check the box to open the calibration interface. The user performs a one-time calibration of the selected plane's magnetic field values according to the instructions in the sampling interface. The upper computer calibrates the magnetic field angle output values based on the initial calibration parameters and continues to sample and update the calibration parameters during subsequent use.

Hardware Calibration: Select "Continuous Sensing Mode" as the measurement mode, choose "TXYZ" as the read method, click the "Hardware Calibration" button to open the calibration interface. The user performs a one-time calibration of the selected plane's magnetic field values according to the instructions in the sampling interface. The upper computer writes the obtained calibration parameters into the chip's amplitude adjustment register. Then, click "Enter Idle Mode" and switch the read method to "TABZ." Re-enter the off-axis interface; the output will be the uncalibrated angle. Check the box before "Hardware Calibration," and the output will be the calibrated angle.

Note: Switching the measurement plane will invalidate the calibration parameters.

- Install the structural components as shown in the schematic diagram of the off-axis knob in Figure 17.
- If the chip is currently in certain operating modes, such as continuous sensing, please first click "Enter Idle Mode" before proceeding with the following operations.
- Follow the first five steps in Section 3.2 to select the measurement items, ensuring that both the X and Y axis measurements are enabled, and select continuous sensing mode.
- Click "Select" to choose the measurement plane for off-axis angle calculation, and place the off-axis knob into the corresponding ro-

tation slot according to the relative position displayed in the GUI.

- Click "Start" to enable the off-axis calibration application. In the angle calibration section, choose a calibration method and slowly rotate the magnet according to the instructions in the GUI to perform the calibration.
- After calibration is complete, the pointer on the dial will rotate as the structural component rotates, and the GUI will display a comparison of the angle values before and after calibration.

In the magnetic sensor knob application, there are two common configurations based on the relative position of the magnet and the chip: on-axis and off-axis. Off-axis refers to the scenario where the magnet's rotation axis is offset from the geometric center of the chip. The off-axis knob structure provided in this kit can simulate three off-axis scenarios, where the magnetic field of the XY, YZ, and XZ axes is used to calculate the corresponding plane angles during the rotation of the structural component. The magnet shown in Figure 6 is used.

Taking XY plane detection as an example: When a radially magnetized magnet rotates one full circle, the magnetic field strength data collected by the chip can be plotted with the angle between the magnetic field and the XY plane coordinate axis as the horizontal axis and the magnetic field strength of the XY axis as the vertical axis. The resulting curves will no longer have the same amplitude and will no longer be orthogonal. If the magnetic field strength of the X-axis is plotted on the horizontal axis and the magnetic field strength of the Y-axis on the vertical axis, the result will be an ellipse, indicating that the magnetic field strength detected in the XY plane has changed during the rotation of the magnet.

If the angle value calculated using the formula Angle $= \arctan\left(\frac{B_y}{B_x}\right)$ is used to represent the actual rotation angle of the structural component in a knob application, there will be a mismatch. Specifically, in the off-axis scenario, the angle value calculated by this formula does not change uniformly. For example, if the structural component is rotated by $1°$, the change in the calculated angle may differ significantly from $1°$, affecting the application. Therefore, the purpose of the off-axis algorithm is to adjust the ellipse into a circle as much as possible, so that the calculated angle change closely matches the actual rotation angle.

6.5 Linear Displacement

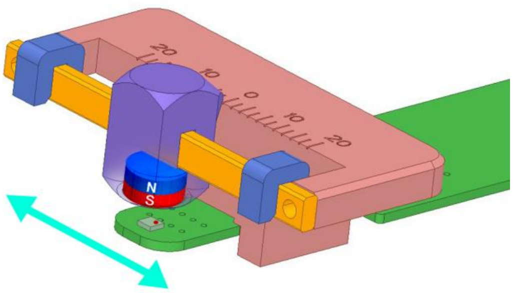


Figure 19: Linear Displacement Structure

Install the structural components as shown in the schematic diagram of the linear displacement structure in Figure 19.

- If the chip is currently in certain operating modes, such as continuous sensing, please first click "Enter Idle Mode" before proceeding with the following operations.
- Follow the first five steps in Section 3.2 to select the measurement items, ensuring that both the X and Y axis measurements are enabled, and turn on continuous sensing mode. Click "Start."
- Move the magnet on the structural component, and the cursor in the GUI interface will move accordingly.

In the magnetic sensor linear displacement application, when using the variation in a single-axis magnetic field to represent the magnet's movement trajectory, the desired outcome in the application scenario should be that the specific magnetic field strength corresponds one-to-one with the specific distance position. However, when using a magnet magnetized along the thickness direction, and as the magnet moves over the chip, there are situations where the same magnetic field strength corresponds to multiple magnet positions. Additionally, if the magnet is in an environment with significant temperature changes, the magnetic field strength may also vary with temperature.

Therefore, in the linear displacement detection structure used in this kit, the Bz and By magnetic field strengths are employed to represent the magnet's movement trajectory.

In linear displacement applications, the angle θ is calculated as:

$$\theta = \arctan\left(\frac{k \cdot B_z}{B_y}\right)$$

6.6 Power Consumption Display

The KTH5701 has three measurement operating modes: continuous sensing mode, wake-up sleep mode, and single measurement mode. In continuous sensing mode and wake-up sleep mode, the chip measures the currently selected items periodically at a certain frequency, depending on the ADC oversampling rate (magnOsr\tempOsr), filter depth (digCtrl), and measurement standby time (measTime) set in the chip's registers. When the chip is operating in continuous sensing mode or wake-up sleep mode, the measurement duration during each cycle is related to the settings for the ADC oversampling rate and filter depth, while the duration of the intervals between measurements, during which no measurement work is performed, is related to the setting of the measurement standby time. The chip's power consumption during these intervals is significantly lower than during active measurement periods, allowing for some adjustment of the chip's sampling rate and power consumption by tuning the ratio of these parameters. In single measurement mode, the chip returns to idle state after completing one measurement, and the method of calculating power consumption differs from that in the first two modes. For detailed register descriptions, please refer to the KTH5701 datasheet.

6.7 Measurement Time Calculation Method

Since the time required for the KTH5701 to perform a single measurement is related to the selected operating mode, ADC oversampling rate, filter depth, measurement standby time, and the number of measurement items gated during measurement, the GUI provides a quick calculation channel for determining the measurement time.

Once the chip has successfully configured the registers and entered the measurement mode, the specific measurement time can be calculated through the GUI.

The following are the specific calculation formulas. For detailed register descriptions, please refer to the KTH5701 datasheet.

- Let m represent the number of active magnetic field measurement items. For example, if only the X axis is active, $m = 1$; if XYZ are active, $m = 3$.
- Let n represent whether the temperature measurement is active. If active, $n = 1$; if inactive, $n = 0$.
- If continuous sensing mode is selected, the formula for the time required to complete one measurement is as follows:

$$t_{\text{continuous}} = m \times \left(69 + 32 \times 2^{\text{magnOsr}} \times \left(2 + 2^{\text{digCtrl}}\right)\right) + n \times \left(69 + 96 \times 2^{\text{tempOsr}}\right) + 108\,\mu s$$

- If single measurement mode is selected, the formula for the time required to complete one measurement is as follows:

$$t_{\text{single}} = m \times \left(69 + 32 \times 2^{\text{magnOsr}} \times \left(2 + 2^{\text{digCtrl}}\right)\right) + n \times \left(69 + 96 \times 2^{\text{tempOsr}}\right) + 328\,\mu s$$

In these formulas:

- magnOsr refers to the Hall sampling rate displayed in the GUI.
- tempOsr refers to the temperature sampling rate displayed in the GUI. The number selected in the GUI is the value to be substituted into the above formulas.
- digCtrl refers to the digital filter displayed in the GUI. The selected value is a binary number that needs to be converted to a decimal before being substituted into the above formulas. For example, if the digital filter is binary 100, then digCtrl $= 4$.

6.8 Wake-Up Sleep Mode

The KTH5701 supports two wake-up modes: magnetic field threshold wake-up and angle detection wake-up. The KTH5701 does not have a temperature threshold monitoring function, so if the temperature measurement item (T) is selected in sleep wake-up mode, it will not trigger a wake-up based on temperature threshold comparisons.

When the chip is configured for TXYZ reading mode, it operates in magnetic field threshold wake-up mode.

You can use any of the provided structural components or any magnetic material within the KTH5701's magnetic field measurement range.

- **Step 1:** Select TXYZ reading mode.
- **Step 2:** Select wake-up sleep mode.
- **Step 3:** Choose the measurement item to monitor for changes.
- **Step 4:** Choose the threshold monitoring mode.
- **Step 5:** Input the threshold value.
- **Step 6:** Click "Configure Registers," then click "Enter Measurement Mode."

If you want to configure the chip to set the INT pin high whenever there is a change of 0x0800 in the X-axis magnetic field, follow these steps:

- Step 1: Select wake-up sleep mode.
- Step 2: Select only the X-axis as the measurement item.
- Step 3: Choose to change the reference value.
- Step 4: Input 0x0800 in the XY field.

Move the magnet. If the difference between the current magnetic field and the set reference value exceeds the set threshold, the INT pin will be set high, and the USER_LED on the PCB will light up. The LED will turn off after one data read. Move the magnet again to change the current magnetic field, and if the difference again exceeds the set threshold, the USER_LED will light up again. For detailed information on setting reference values and thresholds, refer to the KTH5701 datasheet.

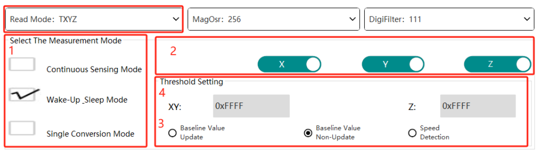


Figure 20: Wake UP Mode in TXYZ Operation Steps Illustration

When the chip is configured for TABZ reading mode, it operates in angle detection mode.

It is recommended to use the knob detection structure provided in the evaluation kit.

- **Step 1:** Select TABZ reading mode.
- **Step 2:** Select wake-up sleep mode.
- **Step 3:** Choose the measurement item to monitor for changes.
- **Step 4:** Input the threshold value.
- **Step 5:** Click "Configure Registers," then click "Enter Measurement Mode."

In angle detection mode, when the chip detects an angle that exceeds the value set in the register, the INT pin will be set high. For example, if in Step 4 you set A to 50, when the chip detects an angle greater than 50°C, the INT pin will be set high. The USER_LED on the PCB will light up. For detailed instructions, please refer to the relevant register descriptions in the KTH5701 datasheet.

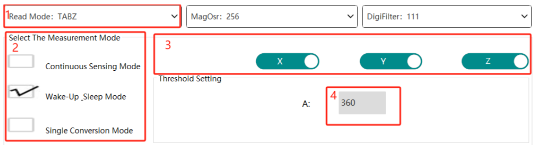


Figure 21: Wake UP Mode in TABZ Operation Steps Illustration

7 Evalutation Board Complementary Schematics

7.1 Power Consumption Measurement Module

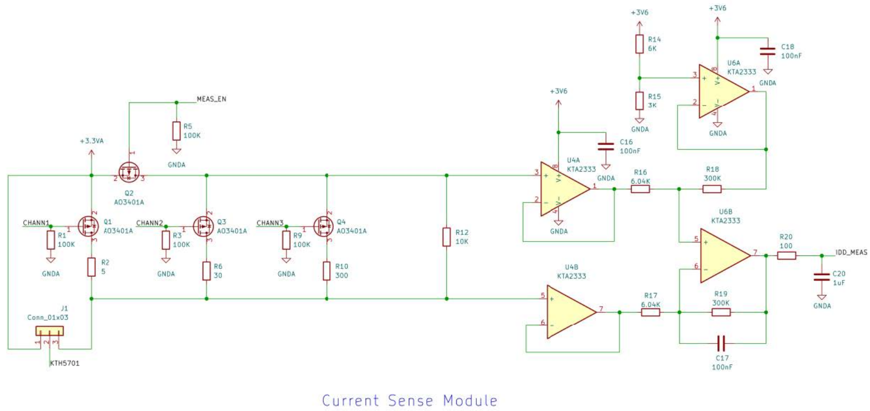


Figure 22: Power Consumption Measurement Module

7.2 KTH5701 Reference Circuit

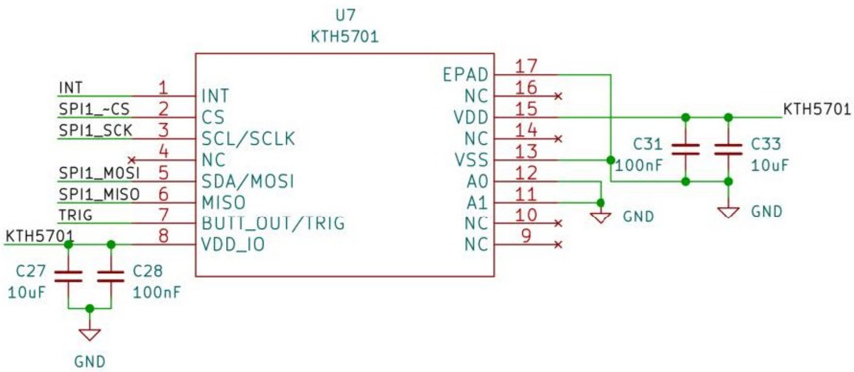


Figure 23: KTH5701 Reference Circuit

7.3 MCU Control Interface

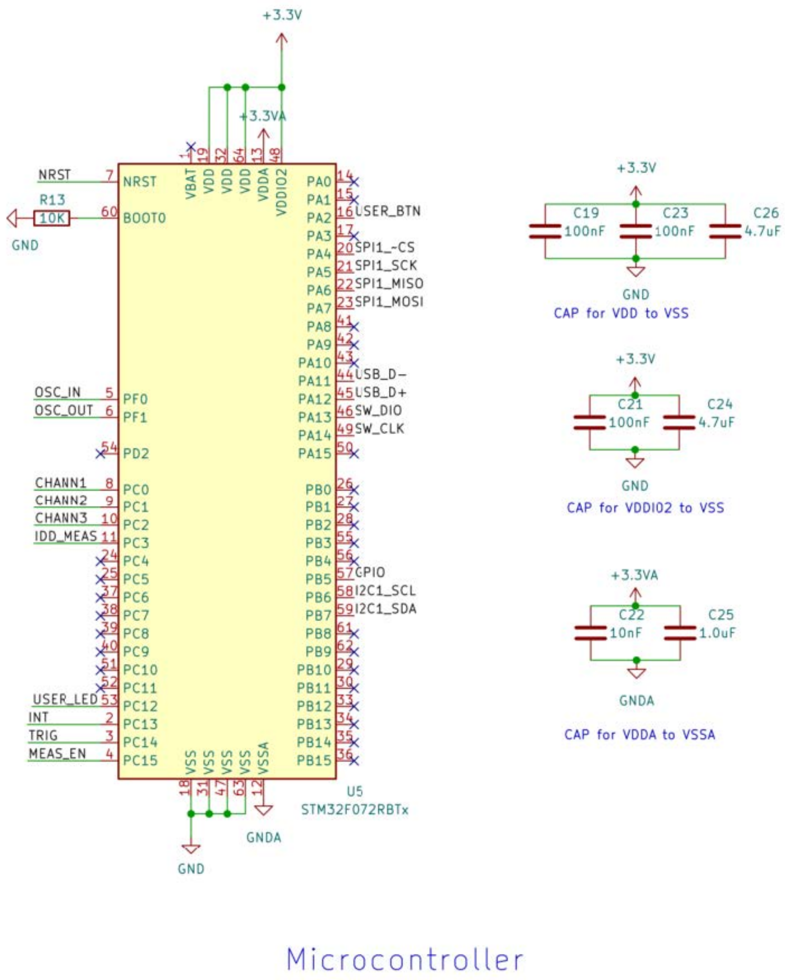


Figure 24: MCU Control Interface

7.4 Peripheral Interface

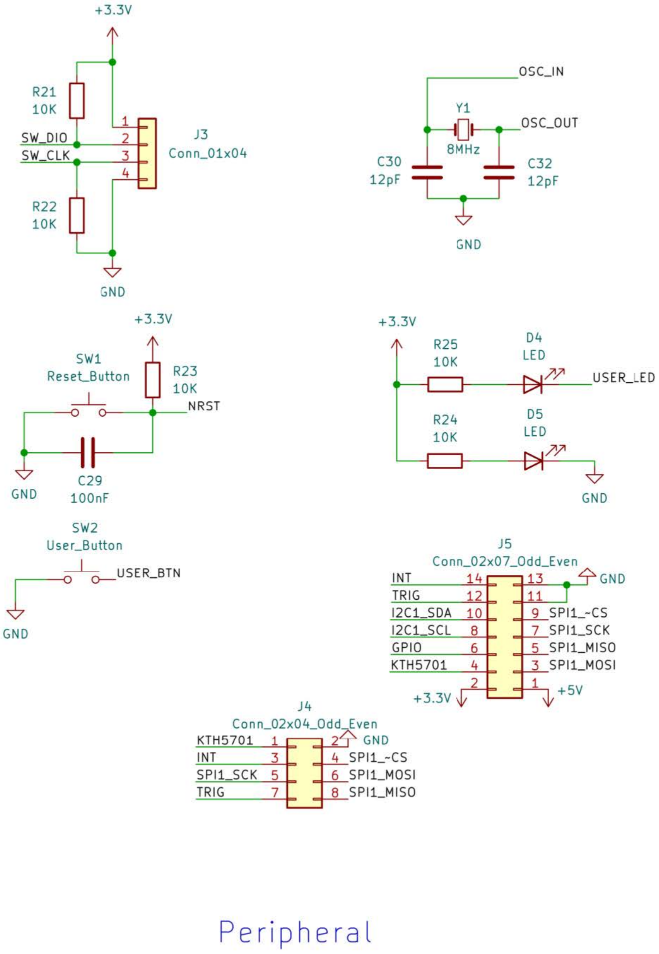


Figure 25: Peripheral Interface

7.5 USB Communication Interface and Power Consumption Measurement Module

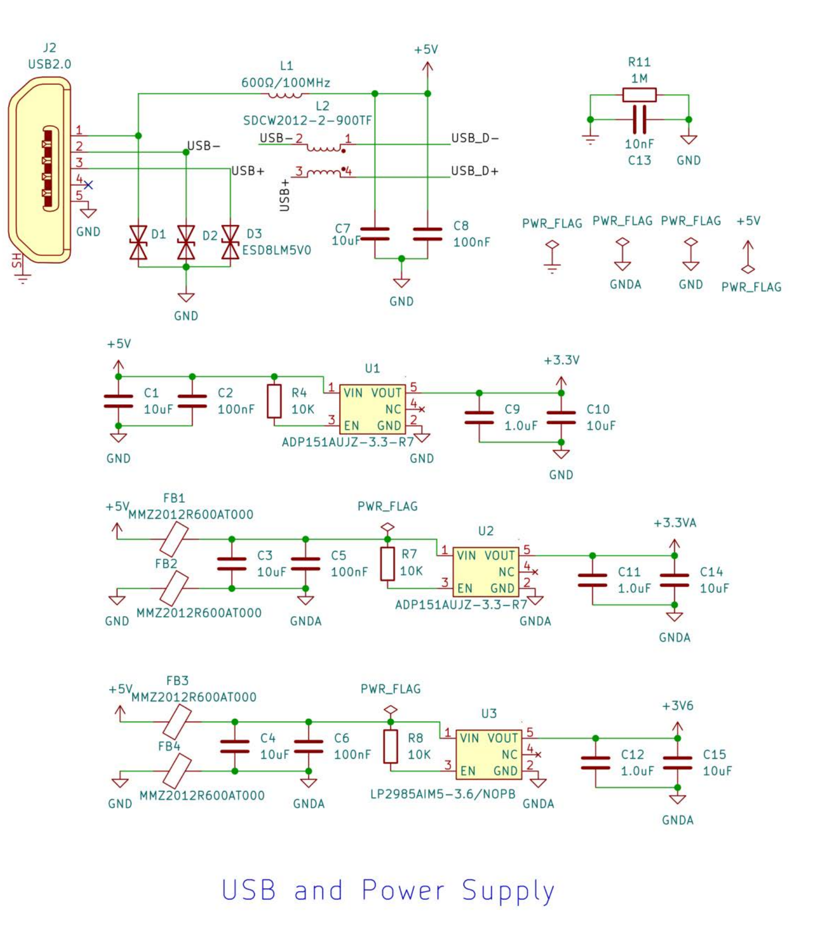


Figure 26: USB Communication Interface and Power Consumption Measurement Module

7.6 Bill of Materials for Evaluation Board

Item No.	Model	Package	Quantity
U7	KTH5701	QFN3×3-16L	1
Y1	X49SM8MSD2SC	SMD_HC49-SD	1
C1, C3, C4, C7, C10, C14, C15, C27, C33	10μF	0402	9
C2, C5, C6, C8, C16, C17, C18, C19, C21, C23, C28, C29, C31	100nF	0402	13
C9, C11, C12, C25, C20	1μF	0402	5
C13, C22	10nF	0402	2
C24, C26	4.7μF	0402	2
C30, C32	12pF	0402	2
D1, D2, D3	ESD8LM5V0	SOD-882	3
D4 (USER_LED), D5	LED	0603	2
FB1, FB2, FB3, FB4	MMZ2012R600AT000	0805	4
J2	USB2.0	MicroUSB	1
L1	GZ2012D601TF	0805	1
L2	SDCW2012-2-900TF	SDCW2012	1
Q1, Q2, Q3, Q4	AO3401A	SOT-23	4
R1, R3, R5, R9	100kΩ	0402	4
R2	5Ω	0402	1
R4, R7, R8, R12, R13, R21, R22, R23, R24, R25	10kΩ	0402	10
R6	30Ω	0402	1
R10	300Ω	0402	1
R11	1MΩ	0402	1
R14, R16, R17	6.04kΩ	0402	3
R15	3kΩ	0402	1
R18, R19	300kΩ	0402	2
R20	100Ω	0402	1
SW1, SW2	Button	–	–
U1, U2	ADP151AUJZ-3.3-R7	SOT-23-5	2
U3	LP2985AIM5-3.6/NOPB	SOT-23-5	1
U4, U6	KTA2333	MSOP-8	2
U5	APM32F072RBT6 or STM32F072RBTx	LQFP-64	1

Table 6: Bill of Materials for Evaluation Board

8 Recommendations and Warnings

The functionality of the structural components included in this kit has been verified through magnetic simulation. If you need assistance with magnetic simulation, please contact us.

Failure to set up, use, or operate the evaluation board kit within the recommended guidelines outlined in the KTH5701 Evaluation Board User Guide may result in personal injury, death, or property damage.