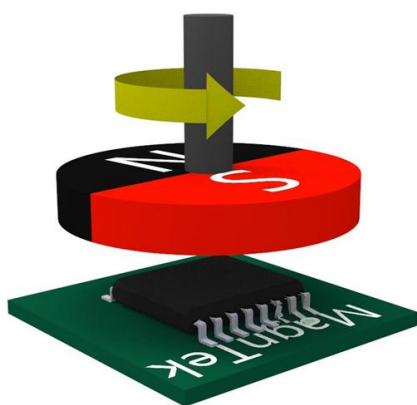


## 21-Bit High Accuracy Magnetic Angle Encoder IC

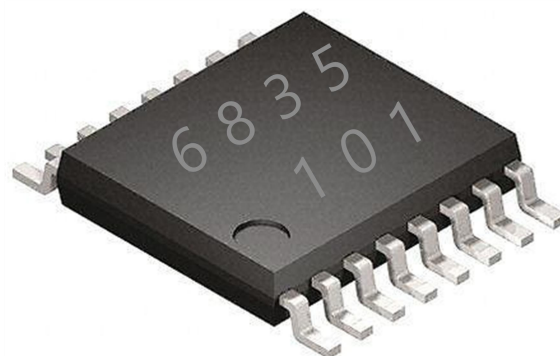
### Features and Benefits

- Based on advanced AMR Technology with 0~360° Full Range Angle Sensing
- 21-bit Core Resolution with Maximum Rotation Speed Up to 120,000 RPM
- Output Propagation Delay <10 us
- User Auto-Calibration and Distortion Compensation with Target INL < ±0.07°
- -40~125°C Operating Temperature Range
- Independent Output Interface: ABZ, UVW, PWM and SPI
- Incremental ABZ Resolution 1~16,384 Pulses per Revolution User Programmable
- UVW Output Resolution 1~16 Pole-Pairs per Revolution User Programmable
- 3.3~5.0V Programmable EEPROM



### Applications

- Absolute Angle Position Sensor
- BLDC Motor Control
- Servo Motor Control
- Stepping Motor Control
- Optical Encoder Replacement



### General Description

MagnTek's rotary position sensor MT6835 is an IC based on advanced AMR technology. A rotating magnetic field in the x-y sensor plane delivers two sinusoidal output signals which indicating the angle ( $\alpha$ ) between the sensor and the magnetic field direction.

The sensor is only sensitive to the magnetic field direction in x-y plane as the sensing element output is specially designed to be independent from the magnetic field strength. This allows the device to be less sensitive to magnet variations, stray magnetic fields, air gap changes and off-axis misalignment.

The incremental ABZ output mode is available in this sensor series, making the chip suitable to replace various optical encoders. The maximum resolution is 16,384 pulses or 65,536 steps per revolution

A 4-Wire SPI interface allows a host microcontroller to read out the 21-bit absolute angle position data from MT6835. The absolute angle position is also provided as a 12-bit PWM output.

## 21-Bit High Accuracy Magnetic Angle Encoder IC

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## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 1. Pin Configuration

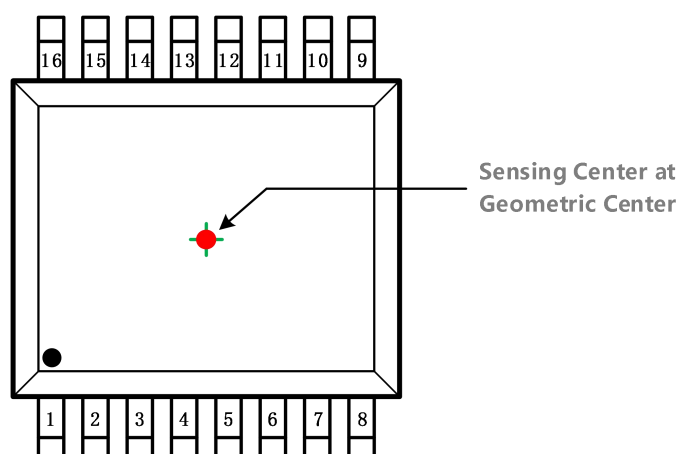


Figure 1: Pin Configuration of MT6835 (TSSOP-16) Package

#### I/O Pin List

| I/O Name | #  | I/O Type       | Description                         |
|----------|----|----------------|-------------------------------------|
| U        | 1  | Digital Output | Commutation Signal U or –A          |
| V        | 2  | Digital Output | Commutation Signal V or –B          |
| W        | 3  | Digital Output | Commutation Signal W or –Z          |
| CAL_EN   | 4  | Digital Input  | Auto-Calibration Enable Pin         |
| MISO     | 5  | Digital Output | SPI Data, Master Input Slave Output |
| MOSI     | 6  | Digital Input  | SPI Data, Master Output Slave Input |
| SCK      | 7  | Digital Input  | SPI Clock                           |
| CSN      | 8  | Digital Input  | SPI Chip Select                     |
| VDD      | 9  | Power Supply   | 3.3~5.0V Power Supply               |
| OUT      | 10 | Digital Output | PWM Output                          |
| TEST     | 11 | Analog Input   | Factory Test Pin                    |
| VSS      | 12 | Power Supply   | Ground                              |
| TEST_EN  | 13 | Digital Input  | Factory Test Enable                 |
| Z        | 14 | Digital Output | Incremental Signal Z                |
| B        | 15 | Digital Output | Incremental Signal B                |
| A        | 16 | Digital Output | Incremental Signal A                |

#### Family Members

| Part Number  | Description                                                  |
|--------------|--------------------------------------------------------------|
| MT6835GT-STD | TSSOP-16 Package, Tube (60 Pcs/Tube) or Reel (3000 Pcs/Reel) |

**\*TSSOP-16 Reflow Sensitivity Classification: MSL-3**

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 2. Functional Diagram

The MT6835 is manufactured in a CMOS standard process and uses advanced magnetic sensing technology to sense the magnetic field distribution across the surface of the chip. The integrated magnetic sensing element array is placed around the center of the device and delivers a voltage representation of the magnetic field at the surface of the IC.

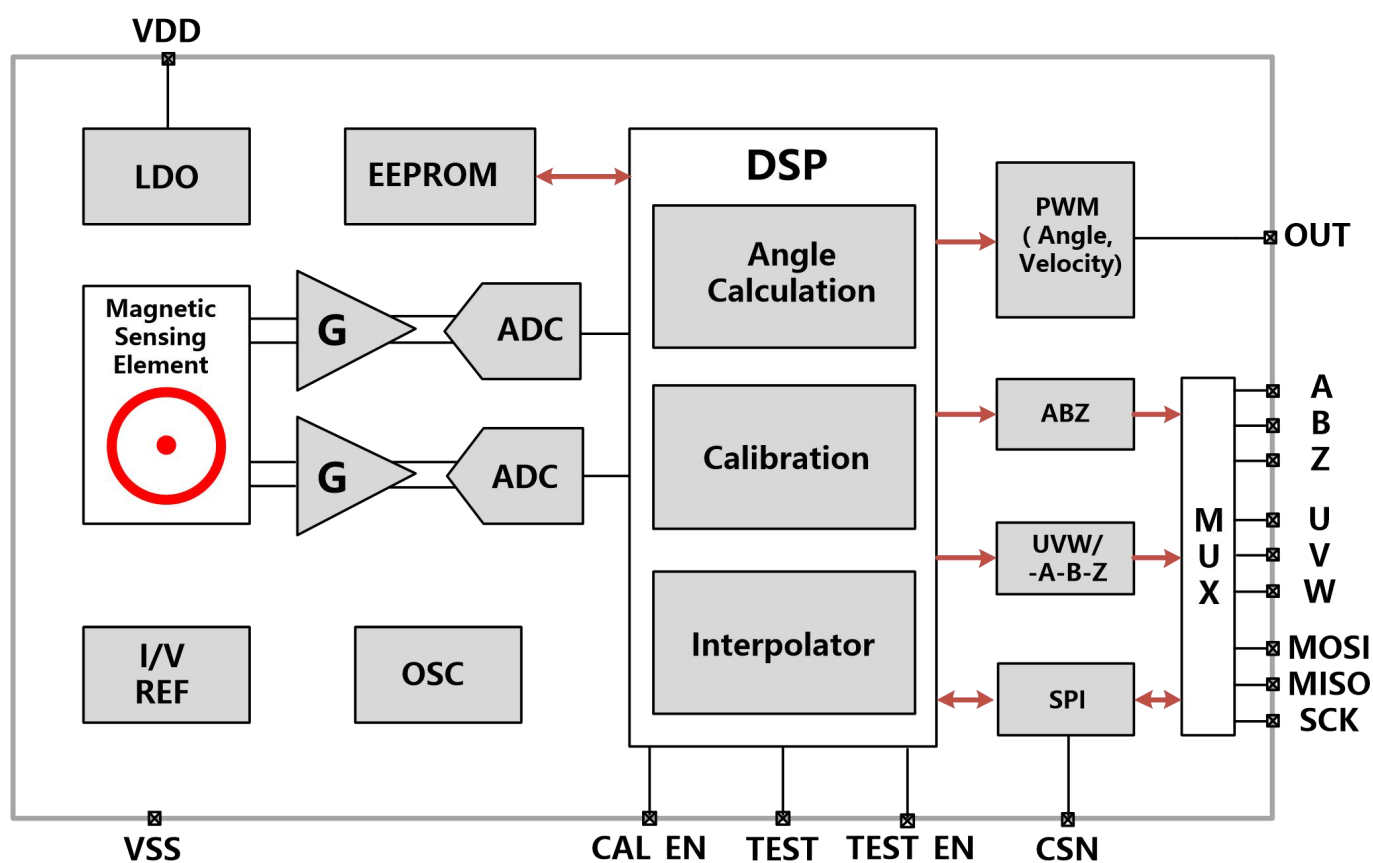


Figure 2: Block Diagram

Figure 2 shows a simplified block diagram of the chip, consisting of the magnetic sensing element modeled by two interleaved Wheatstone bridges to generate cosine and sine signals, gain stages, analog-to-digital converters (ADC) for signal conditioning, and a digital signal processing (DSP) unit for encoding. Other supporting blocks such as LDO, etc. are also included.

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 3. Absolute Maximum Ratings (Non-Operating)

Stresses beyond those listed under “Absolute Maximum Ratings” 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 | Notes                                                      |
|-------------------------------------------|------|------|------|------------------------------------------------------------|
| DC Voltage at Pin VDD                     | -0.5 | 6.5  | V    |                                                            |
| Terminal Voltage at Input and Output Pins | -0.5 | VDD  | V    | ABZ, UVW, MISO, MOSI, SCK, CSN, TEST_EN, OUT, CAL_EN, Test |
| Output Current at Output Pins             | -20  | 20   | mA   | ABZ, UVW, OUT, MISO                                        |
| Storage Temperature                       | -40  | 150  | °C   |                                                            |
| I <sub>SCR</sub> (Latch-up Input Current) | -    | ±100 | mA   | AEC-Q100-004                                               |
| V <sub>HBM</sub> (ESD Voltage)            | -    | ±8.0 | KV   | AEC-Q100-002                                               |
| V <sub>CDM</sub> (ESD Voltage)            | -    | ±1.5 | KV   | AEC-Q100-011                                               |

### 4. Operating Conditions

| Parameter                   | Min. | Max.    | Unit |
|-----------------------------|------|---------|------|
| DC Voltage at Pin VDD       | 3.0  | 5.5     | V    |
| Magnetic Flux Density Range | 30   | 1,000   | mT   |
| Rotation Speed              | -    | 120,000 | RPM  |
| Operating Temperature       | -40  | 125     | °C   |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

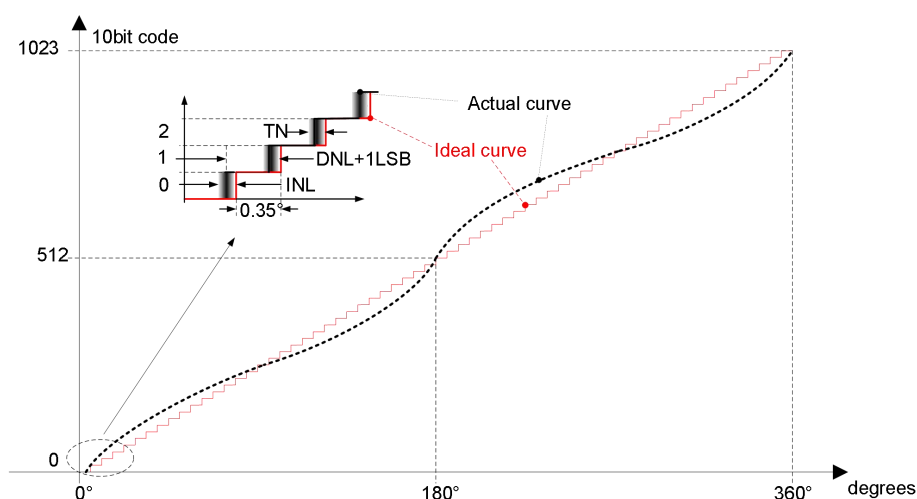
### 5. Electrical Characteristics

Operation conditions: Ta=-40 to 125°C, VDD=3.0~5.5V unless otherwise noted.

| Symbol             | Parameter                                         | Conditions/Notes  | Min. | Typ.    | Max. | Unit |
|--------------------|---------------------------------------------------|-------------------|------|---------|------|------|
| VDD                | Supply Voltage                                    | -                 | 3.0  | 3.3~5.0 | 5.5  | V    |
| Idd                | Supply Current                                    | -                 | 15   | 22      | 28   | mA   |
| LSB                | Resolution (ABZ Mode)                             | N Steps per Cycle | -    | 360°/N  | -    | °    |
| INL                | Integral Non-Linearity with Factory Calibration   | <b>Note[1]</b>    | -    | ±0.5    | ±1.0 | °    |
|                    | Integral Non-Linearity with User Auto-Calibration | <b>Note[2]</b>    | -    | ±0.07   | -    | °    |
| DNL                | Differential Non-Linearity (ABZ Mode), Figure 3   | @2500 PPR         | -    | ±0.005  | -    | °    |
| TN                 | Transition Noise (ABZ Mode)                       | 25°C with 'BW' =5 | -    | 0.0015  | -    | °rms |
| Hyst               | Hysteresis                                        | Programmable      | -    | 0.011   | -    | °    |
| T <sub>PwrUp</sub> | Power-Up Time                                     | VDD Ramp < 100us  | -    | 64      | -    | ms   |
| T <sub>Delay</sub> | Propagation Delay                                 | Constant Speed    | -    | 10      | -    | us   |
| T <sub>ST</sub>    | Step Response Time                                | Register 'BW' =5  | -    | 100     | -    | us   |

**Note[1]:** The typical error value can be achieved at room temperature and with no off-axis misalignment error. The maximum error value can be achieved over operation temperature range, at maximum air gap and with worst-case off-axis misalignment error.

**Note[2]:** Please follow chapter 9 for the detail of 'User Auto-Calibration'.



**Figure 3: Drawing Illustration INL, DNL and TN (for 10-bit case)**

## 21-Bit High Accuracy Magnetic Angle Encoder IC

## ABZ Output Characteristics

Operation conditions: Ta=-40 to 125°C, VDD=3.0~5.5V unless otherwise noted.

| Symbol             | Parameter        | Conditions/Notes | Min. | Typ. | Max.   | Unit        |
|--------------------|------------------|------------------|------|------|--------|-------------|
| AB <sub>RES</sub>  | AB Resolution    | Programmable     | 1    | -    | 16,384 | Pulse/Round |
| AB <sub>Freq</sub> | A or B Frequency | Note(3)          | -    | -    | 2.048  | MHz         |

**Note (3):** The AB<sub>Freq</sub> is the product of RS(Rotation Speed) and AB<sub>RES</sub>. So, for maximum AB resolution of 16,384 PPR, the maximum supported rotation speed RS is:

$$RS_{MAX} = \frac{AB_{Freq}}{AB_{Res}} = \frac{2.048MHz}{16,384} = 125Hz = 7,500RPM$$

Even >2MHz AB<sub>Freq</sub> is available, but the INL could not be guaranteed when AB<sub>Freq</sub> is >2MHz

## PWM Output Characteristics

Operation conditions: Ta=-40 to 125°C, VDD=3.0~5.5V unless otherwise noted.

| Symbol            | Parameter     | Conditions/Notes    | Min. | Typ.    | Max. | Unit |
|-------------------|---------------|---------------------|------|---------|------|------|
| F <sub>PWM</sub>  | PWM Frequency | Programmable        | -8%  | 497/994 | +8%  | Hz   |
| T <sub>Rise</sub> | Rising Time   | C <sub>L</sub> =1nF | -    | -       | 1    | us   |
| T <sub>Fall</sub> | Falling Time  | C <sub>L</sub> =1nF | -    | -       | 1    | us   |

## EEPROM Characteristics

Operation conditions: Ta=-40 to 125°C, VDD=3.0~5.5V unless otherwise noted.

| Symbol    | Parameter                            | Min.  | Typ. | Max. | Unit   |
|-----------|--------------------------------------|-------|------|------|--------|
| VDD       | Supply Voltage @Erase/Program EEPROM | 3.0   | -    | 5.5  | V      |
| Endurance | Erase/Program Cycles                 | 1,000 | -    | -    | Cycles |
| Retention | Data Retention @150°C                | 10    | -    | --   | Years  |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### Digital I/O Characteristics

Operation conditions: Ta=-40 to 125°C, VDD=3.0~5.5V unless otherwise noted.

| Symbol            | Parameter                                                                   | Conditions/Notes          | Min.    | Typ. | Max.    | Unit |
|-------------------|-----------------------------------------------------------------------------|---------------------------|---------|------|---------|------|
| V <sub>IH</sub>   | Digital I/O Input Voltage<br>High Level Voltage<br>(CSN, MOSI, CLK, CAL_EN) | -                         | 0.8*VDD | -    | -       | V    |
| V <sub>IL</sub>   | Digital I/O Input Voltage<br>Low Level Voltage<br>(CSN, MOSI, CLK, CAL_EN)  | -                         | -       | -    | 0.2*VDD | V    |
| V <sub>OH</sub>   | Digital I/O Output High<br>Level Voltage<br>(ABZ, UVW, MISO, OUT)           | Push-Pull<br>(@Iout=-2mA) | VDD-0.4 | -    | -       | V    |
| V <sub>OL</sub>   | Digital I/O Output Low<br>Level Voltage<br>(ABZ, UVW, MISO, OUT)            | Push-Pull<br>(@Iout=2mA)  | -       | -    | 0.4     | V    |
| T <sub>Rise</sub> | Rising Time                                                                 | C <sub>L</sub> =20pf      | -       | -    | 50      | ns   |
| T <sub>Fall</sub> | Falling Time                                                                | C <sub>L</sub> =20pf      | -       | -    | 50      | ns   |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 6. Magnetic Input Specifications

Operation conditions: Ta=-40 to 125°C, VDD=3.0~5.5V unless otherwise noted, two-pole cylindrical diametrically magnetized source.

| Symbol | Parameter                                                           | Conditions/Notes                                                                         | Min. | Typ.   | Max.    | Unit   |
|--------|---------------------------------------------------------------------|------------------------------------------------------------------------------------------|------|--------|---------|--------|
| Dmag   | Diameter of Magnet                                                  | Recommended Magnet:<br>Ø10mm x 2.5mm for<br>Cylindrical Magnets                          | -    | 10     | -       | mm     |
| Tmag   | Thickness of Magnet                                                 | -                                                                                        | -    | 2.5    | -       | mm     |
| Bpk    | Magnetic Input Field Amplitude                                      | Measure at the IC Surface                                                                | 30   | -      | 1,000   | mT     |
| AG     | Air Gap                                                             | Magnetic to IC Surface Distance                                                          | -    | 1.0    | 3.0     | mm     |
| RS     | Rotation Speed                                                      | Turn Rounds per Minute                                                                   | -    | -      | 120,000 | RPM    |
| DISP   | Off Axis Misalignment                                               | Misalignment Error<br>Between Sensor Sensing<br>Center and Magnet Axis<br>(See Figure 4) | -    | -      | 0.3     | mm     |
| TCmag1 | Recommended Magnet<br>Material and Temperature<br>Drift Coefficient | NdFeB (Neodymium Iron<br>Boron)                                                          | -    | -0.12  | -       | % / °C |
| TCmag2 |                                                                     | SmCo (Samarium Cobalt)                                                                   | -    | -0.035 | -       |        |

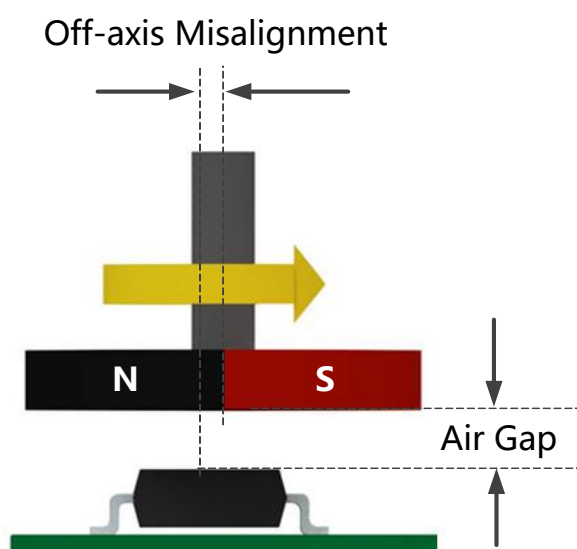


Figure 4: Magnet Arrangement

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 7. Output Mode

The MT6835 provides ABZ, UVW and PWM signals at output pins, and the 21-bit absolute angle position data could be transferred by the standard 4-Wire SPI interface.

#### 7.1 I/O Pin Configuration

For TSSOP-16 package, ABZ (Single-end or differential), UVW, PWM and SPI Interface are configured as below table.

*I/O Pin Configuration*

| Pin# | UVW+SPI+PWM+ABZ | -A-B-Z+SPI+PWM+ABZ |
|------|-----------------|--------------------|
| 1    | U               | -A                 |
| 2    | V               | -B                 |
| 3    | W               | -Z                 |
| 5    | MISO            | MISO               |
| 6    | MOSI            | MOSI               |
| 7    | SCK             | SCK                |
| 8    | CSN             | CSN                |
| 10   | OUT(PWM)        | OUT(PWM)           |
| 14   | Z               | Z                  |
| 15   | B               | B                  |
| 16   | A               | A                  |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 7.2 Reference Circuit

The MT6835 is powered by a single supply VDD (3.3~5.0V), so a decoupling capacitor no less than 0.1uf between VDD and GND is necessary. For better EMC performance, we highly recommend adding a TVS between VDD and GND. The default reference circuit is shown in Figure. 5.

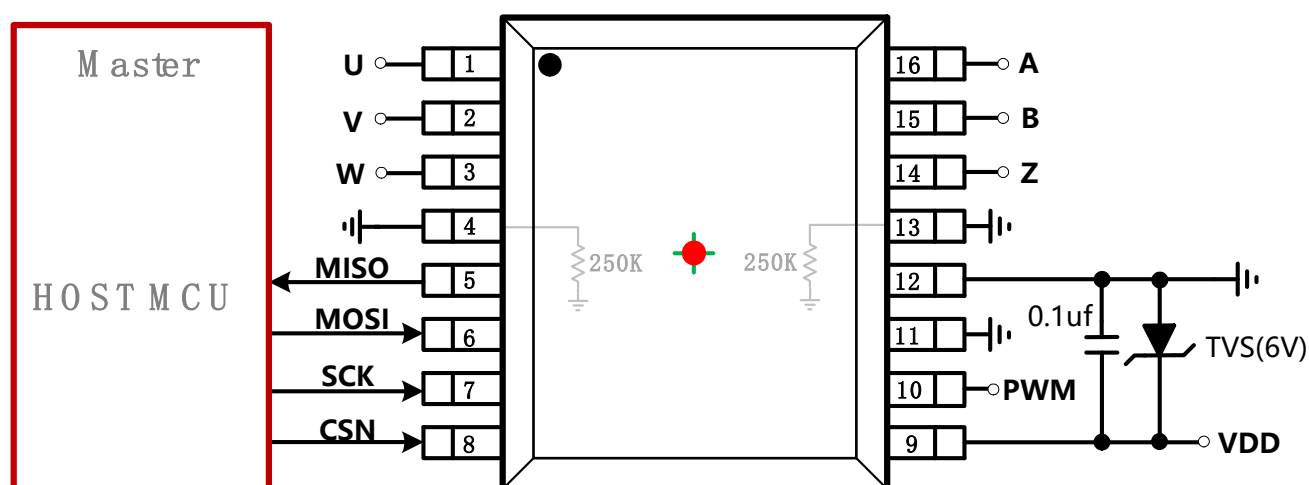


Figure 5: Reference Circuit without User Auto-Calibration

The reference circuit for User Auto-Calibration is shown in Figure. 6, the detail of User Auto-Calibration please refer to Chapter 9.2.

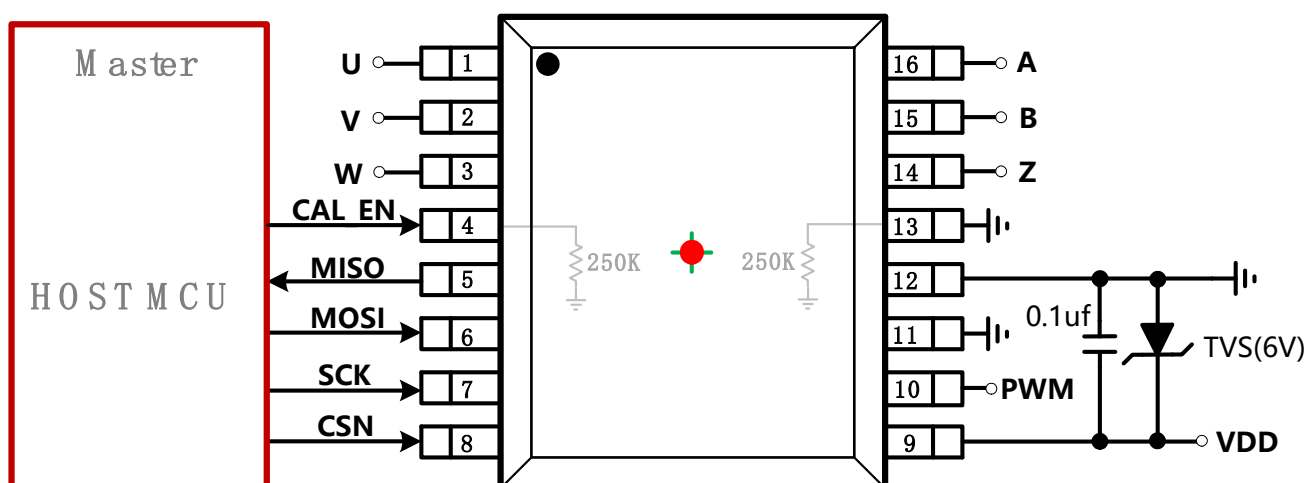


Figure 6: Reference Circuit with User Auto-Calibration

21-Bit High Accuracy Magnetic Angle Encoder IC

7.3 Quadrature A,B and Zero-Position Output (ABZ Mode)

As shown in Figure 7, when the magnet rotates counter-clock-wise (CCW), the rising edge of output B leads output A by 1/4 cycle, when the magnet rotates clock-wise (CW), the rising edge of output A leads output B by 1/4 cycle (or 1 LSB). Output Z indicates the zero position of the magnet. After chip power-on, the ABZ output is blocked for 64ms to guarantee proper output.

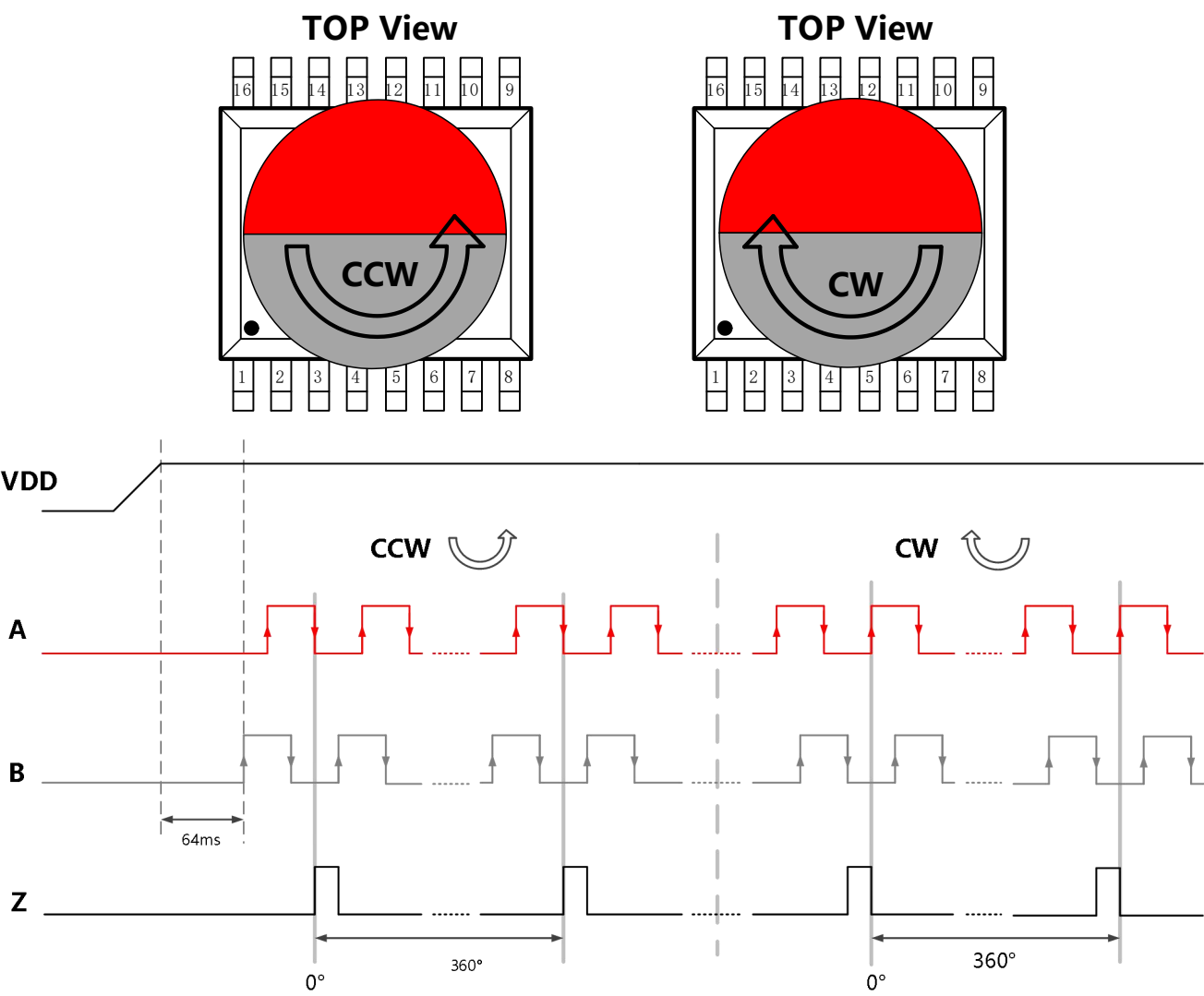


Figure 7: ABZ output with VDD power on

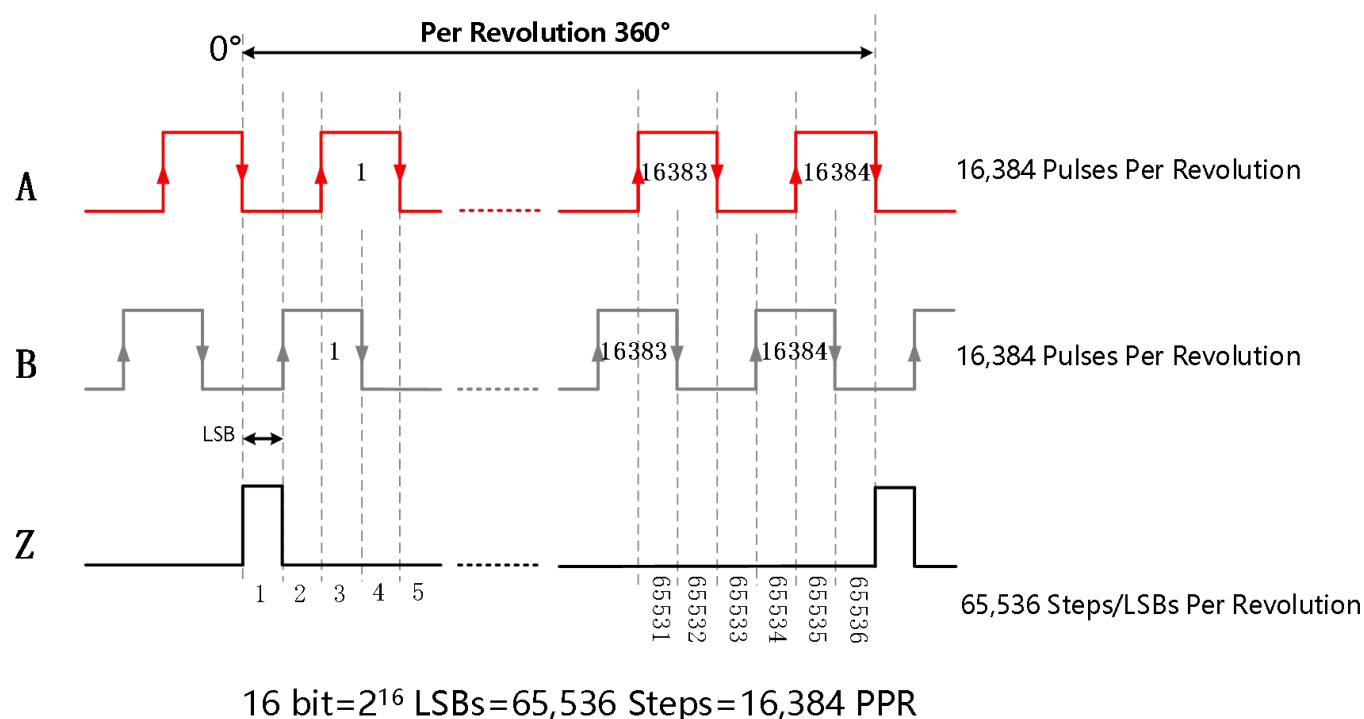
‘ROT\_DIR’ (CCW or CW) Register (EEPROM)

| Reg. ROT_DIR | Rotation Direction                          |
|--------------|---------------------------------------------|
| 0x0          | Counter-Clock-wise, Output B leads Output A |
| 0x1          | Clock-wise, Output B leads Output A         |

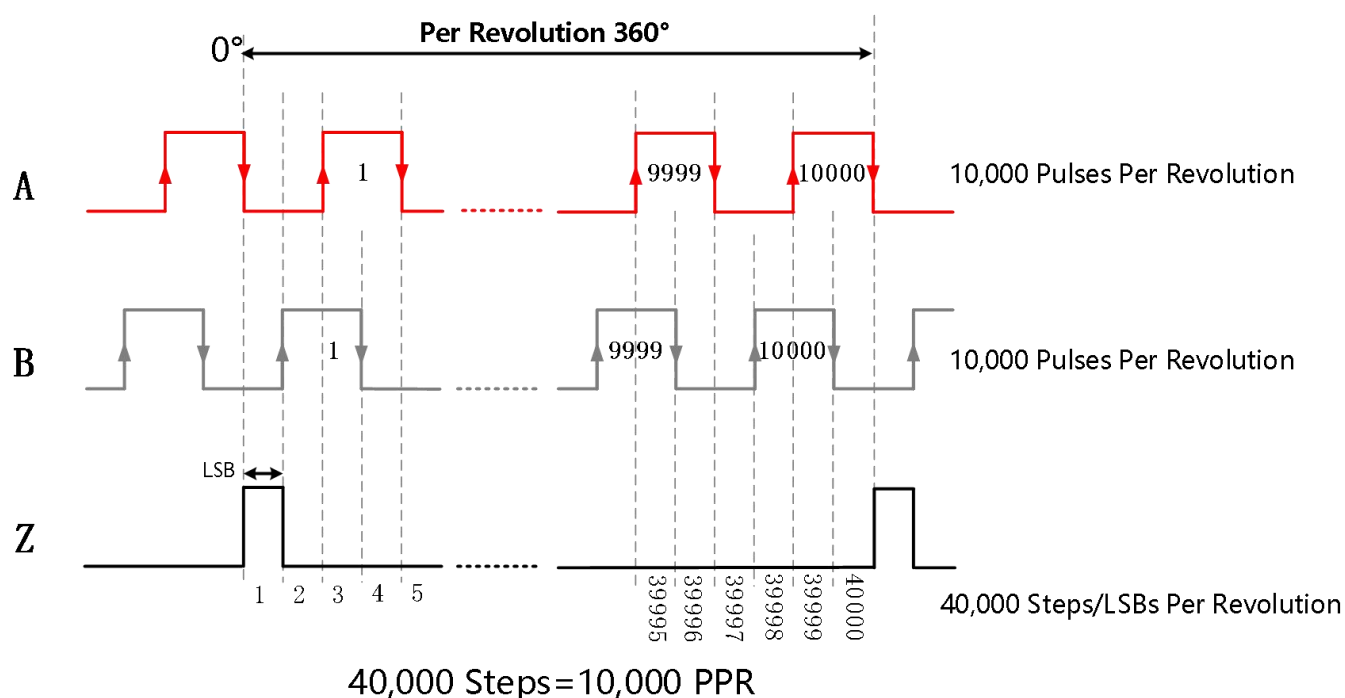
‘ ROT\_DIR ’ is effective for all output types as ABZ, UVW, PWM and SPI Angle data

## 21-Bit High Accuracy Magnetic Angle Encoder IC

ABZ resolution is user programmable from 1~16,384 PPR. The relationship between binary bits, LSBs and PPR resolution of ABZ output are shown in Figure 8 & Figure 9.



**Figure 8: ABZ Output Resolution = 16 bit = 16,384 PPR**



**Figure 9: ABZ Output Resolution = 10,000 PPR**

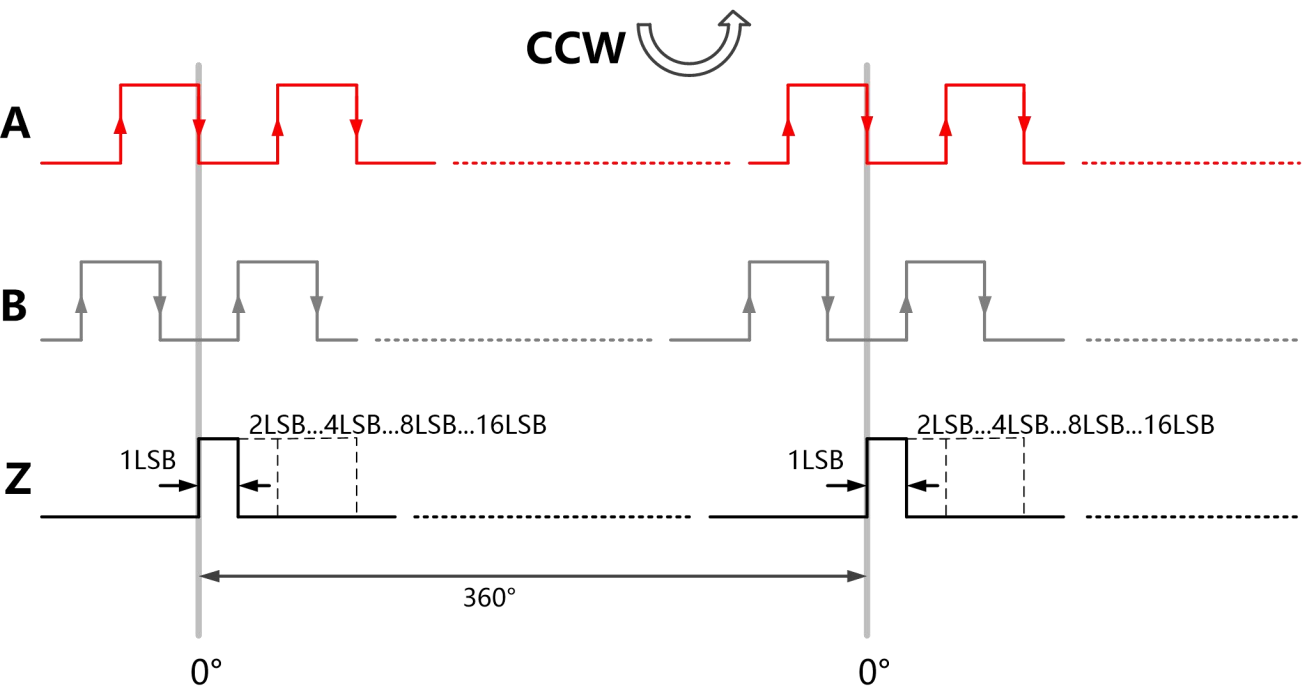
## 21-Bit High Accuracy Magnetic Angle Encoder IC

The resolution of ABZ is defined by a 14-bit register 'ABZ\_RES[13:0]' ;

**'ABZ\_RES[13:0]' Register (EEPROM)**

| Reg. ABZ_RES[13:0] | AB Resolution (Pulse per. Round) |
|--------------------|----------------------------------|
| 0x0000             | 1                                |
| 0x0001             | 2                                |
| 0x0002             | 3                                |
| ⋮                  | ⋮                                |
| 0x3FFC             | 16,381                           |
| 0x3FFD             | 16,382                           |
| 0x3FFE             | 16,383                           |
| 0x3FFF             | 16,384                           |

Output Z indicates the zero position of the magnet which is user programmable, and the pulse width of Z is selectable as 1, 2, 4, 8, 16 LSBs or 60°, 120°, 180° as shown in Figure 10 and Figure 11. It is guaranteed that one Z pulse is generated for every rotation.



**Figure 10: Typical ABZ Output with Z pules width=1,2,4,8 and 16 LSBs**

21-Bit High Accuracy Magnetic Angle Encoder IC

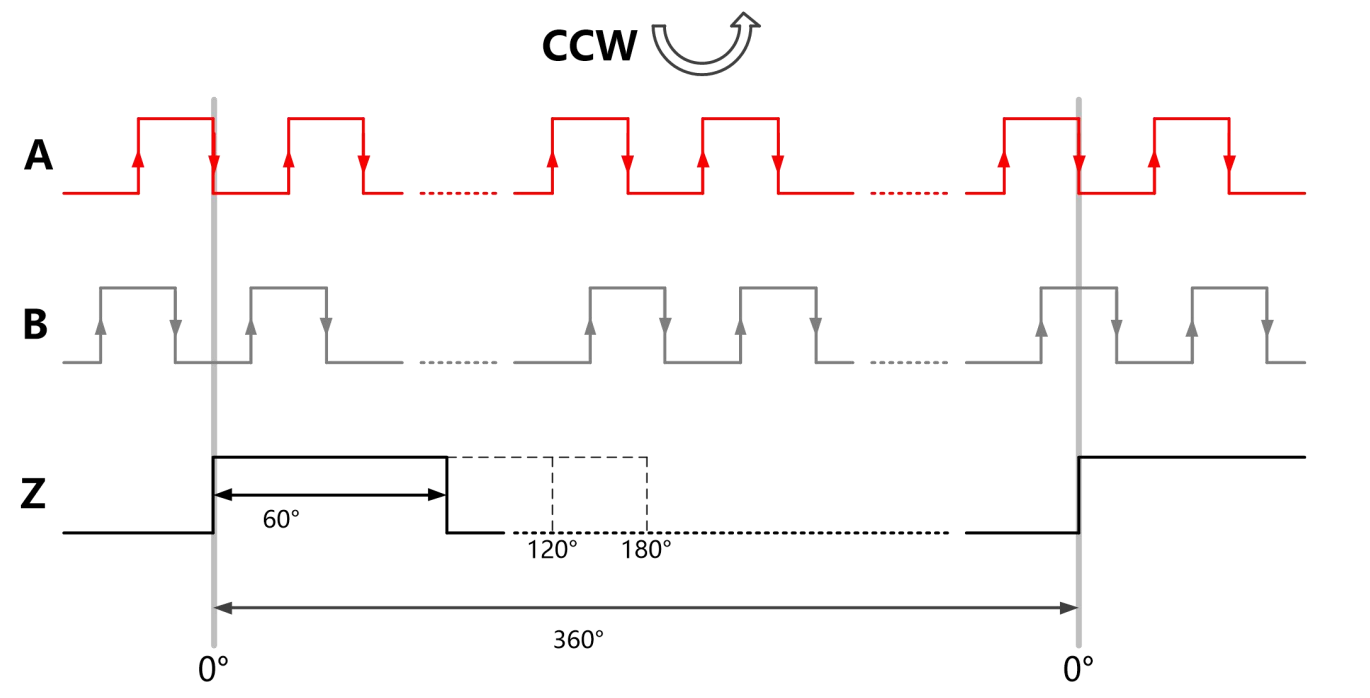


Figure 11: Typical ABZ Output with Z pulses width=60°, 120° and 180°

The width of Z pulse is defined by the 3-bit register 'Z\_PUL\_WID[2:0]' ;

'Z\_PUL\_WID[2:0]' Register (EEPROM)

| Reg. Z_PUL_WID[2:0] | Width (LSBs/°) | Reg. Z_PUL_WID[2:0] | Width (LSBs/°) |
|---------------------|----------------|---------------------|----------------|
| 0x0                 | 1              | 0x4                 | 16             |
| 0x1                 | 2              | 0x5                 | 60°            |
| 0x2                 | 4              | 0x6                 | 120°           |
| 0x3                 | 8              | 0x7                 | 180°           |

The absolute position of Z pulse is defined by the 12-bit register 'ZERO\_POS[11:0]' ;

'ZERO\_POS[11:0]' Register (EEPROM)

| Reg. ZERO_POS[11:0] | Absolute Position (°) |
|---------------------|-----------------------|
| 0x000               | 0                     |
| 0x001               | 0.088                 |
| 0x002               | 0.176                 |
| ⋮                   | ⋮                     |
| ⋮                   | ⋮                     |
| ⋮                   | ⋮                     |
| 0xFFE               | 359.824               |
| 0xFFF               | 359.912               |

21-Bit High Accuracy Magnetic Angle Encoder IC

Also, Z pulse phase could be user programmable by 'Z\_PHASE[1:0]' register as shown in Figure 12.

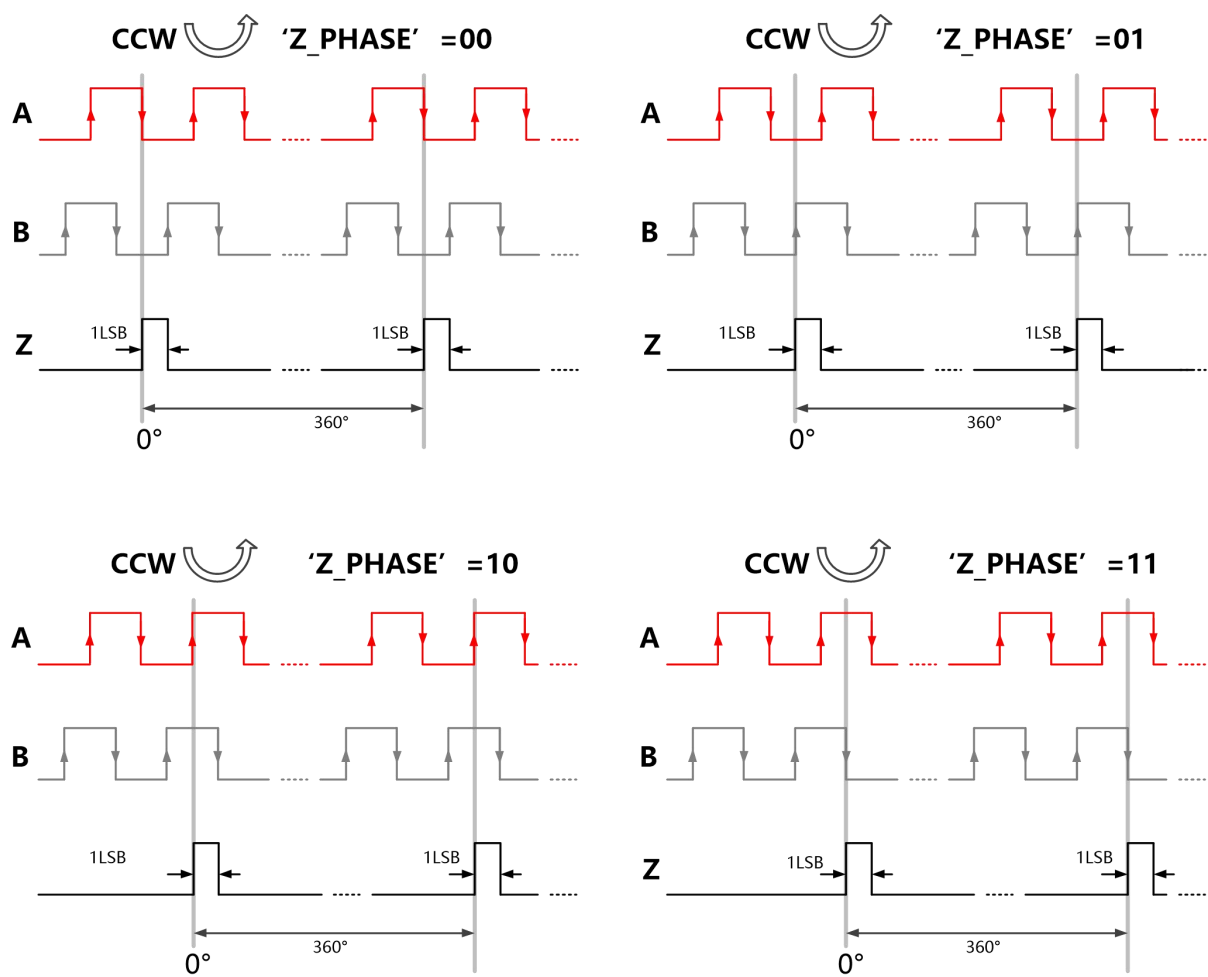


Figure 12: Z Pulse Phase with 'ROT\_DIR' = 0, 'SWAP\_AB' = 0, 'Z\_EDGE' = 0

The relationship of 0° and Z pulse edge is defined by register 'Z\_EDGE'

'Z\_EDGE' Register (EEPROM)

| Reg. Z_EDGE | Description                                   |
|-------------|-----------------------------------------------|
| 0x0         | Z Pulse Rising Edge Aligned with Zero-Degree  |
| 0x1         | Z Pulse Falling Edge Aligned with Zero-Degree |

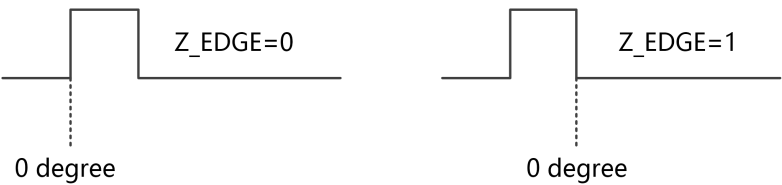


Figure 13: Z Pulse Edge with 0 degree

21-Bit High Accuracy Magnetic Angle Encoder IC

7.4 UVW Output Mode

The MT6835 provides U, V and W pulses which are 120° (electrical angle) out of phase as shown in Figure 14. The cycles of UVW per rotation can be programmed.

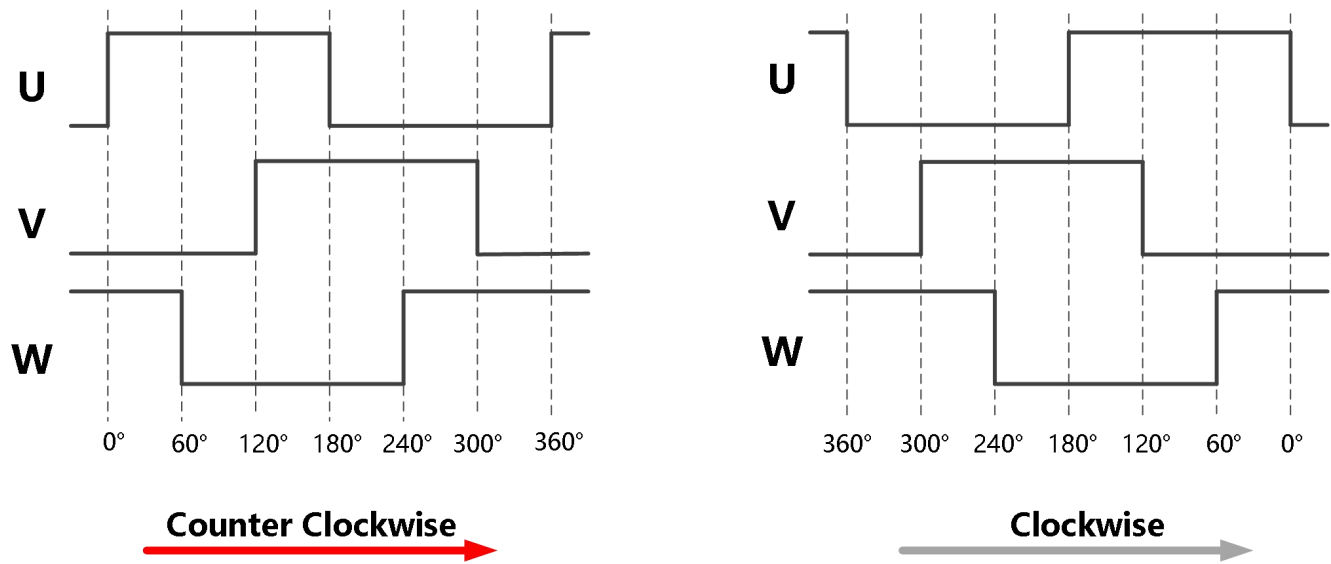


Figure 14: Typical Output Waveform for UVW Mode

'UVW\_RES' Register (EEPROM)

| Reg. UVW_RES[3:0] | UVW Pole Pairs |
|-------------------|----------------|
| 0x0               | 1              |
| 0x1               | 2              |
| 0x2               | 3              |
| 0x3               | 4              |
| 0x4               | 5              |
| 0x5               | 6              |
| 0x6               | 7              |
| 0x7               | 8              |
| 0x8               | 9              |
| 0x9               | 10             |
| 0xA               | 11             |
| 0xB               | 12             |
| 0xC               | 13             |
| 0xD               | 14             |
| 0xE               | 15             |
| 0xF               | 16             |

21-Bit High Accuracy Magnetic Angle Encoder IC

7.5 Pulse Width Modulation (PWM) Output Mode

The MT6835 provides a digital Pulse Width Modulation (PWM) output, whose duty cycle is proportional to the measured angle as shown in Figure 15. PWM is a default output of Pin.10.

The PWM output consists of a frame of 4119 PWM clock periods. The angle data is represented with 12-bit resolution in the frame. One PWM clock period represents 0.088° and has a typical duration of 244ns which also could be programmed to be 488ns.

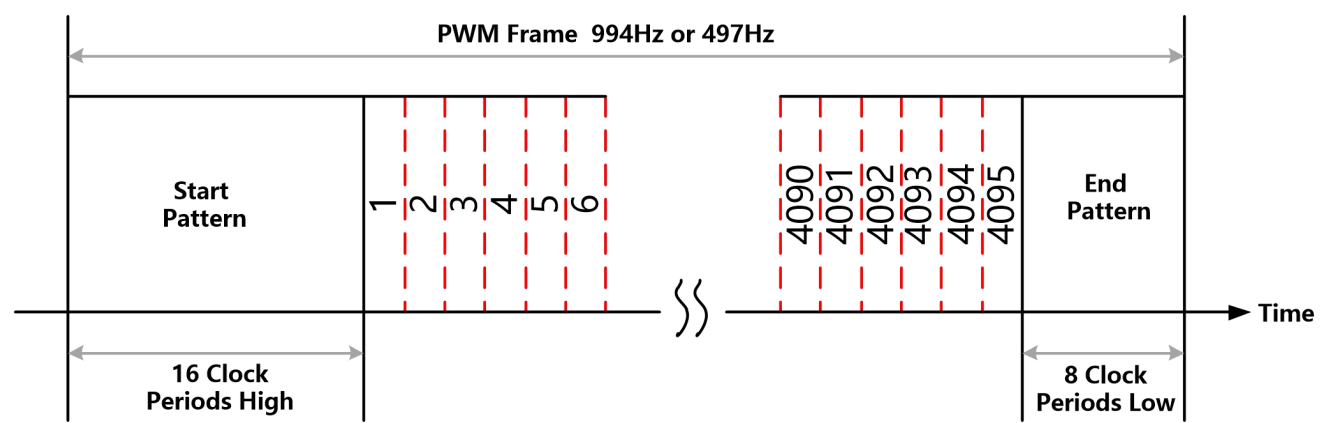


Figure 15: PWM Output Frame

‘PWM\_FQ’ Register (EEPROM)

| Reg. PWM_FQ | PWM Frame Frequency |
|-------------|---------------------|
| 0x0         | 994 Hz              |
| 0x1         | 497 Hz              |

‘PWM\_SEL[2:0]’ Register (EEPROM)

| Reg. PWM_SEL[2:0] | PWM Data Source      |
|-------------------|----------------------|
| 0x0               | 12-bit Angle Data    |
| 0x2               | 12-bit Velocity Data |
| Others            | Factory Test Data    |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 7.6 SPI Interface

The MT6835 also provides a 4-Wire SPI interface for a host MCU both to read back digital absolute angle information from its internal registers and to program its EEPROM.

#### 7.6.1 SPI Reference Circuit

The reference circuit for SPI interface of a single chip please refer to Figure 5 and Figure 6. The multi-chip application is shown in Figure 16.

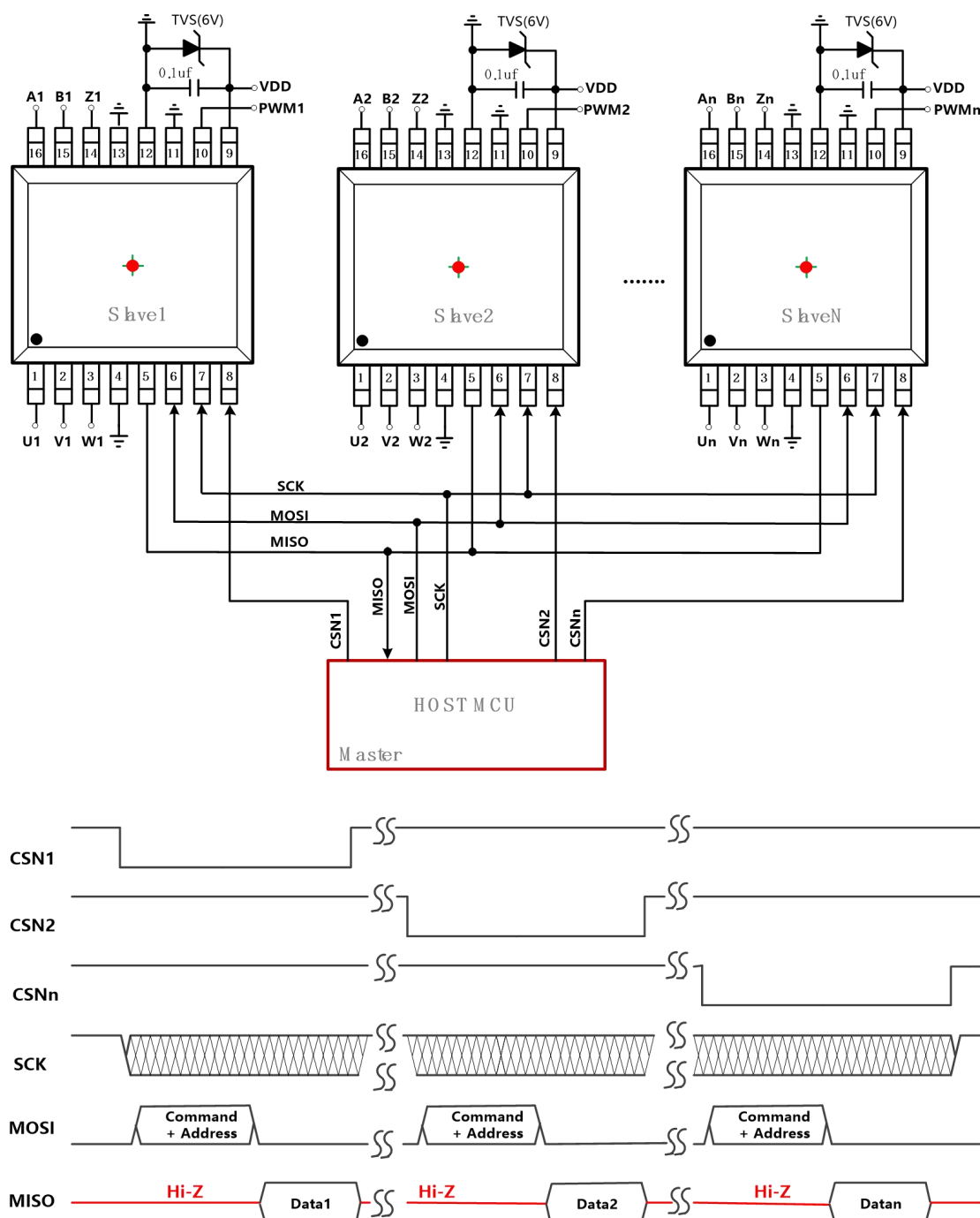


Figure 16: 4-Wire SPI Reference Circuit with multi-chips

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 7.6.2 SPI Timing Diagram

The MT6835 SPI uses mode3 (CPOL=1, CPHA=1) to exchange data. As shown in Figure 17, a data transfer starts with the falling edge of CSN. The MT6835 samples data on the rising edge of SCK, and the data transfer finally stops with the rising edge of CSN.

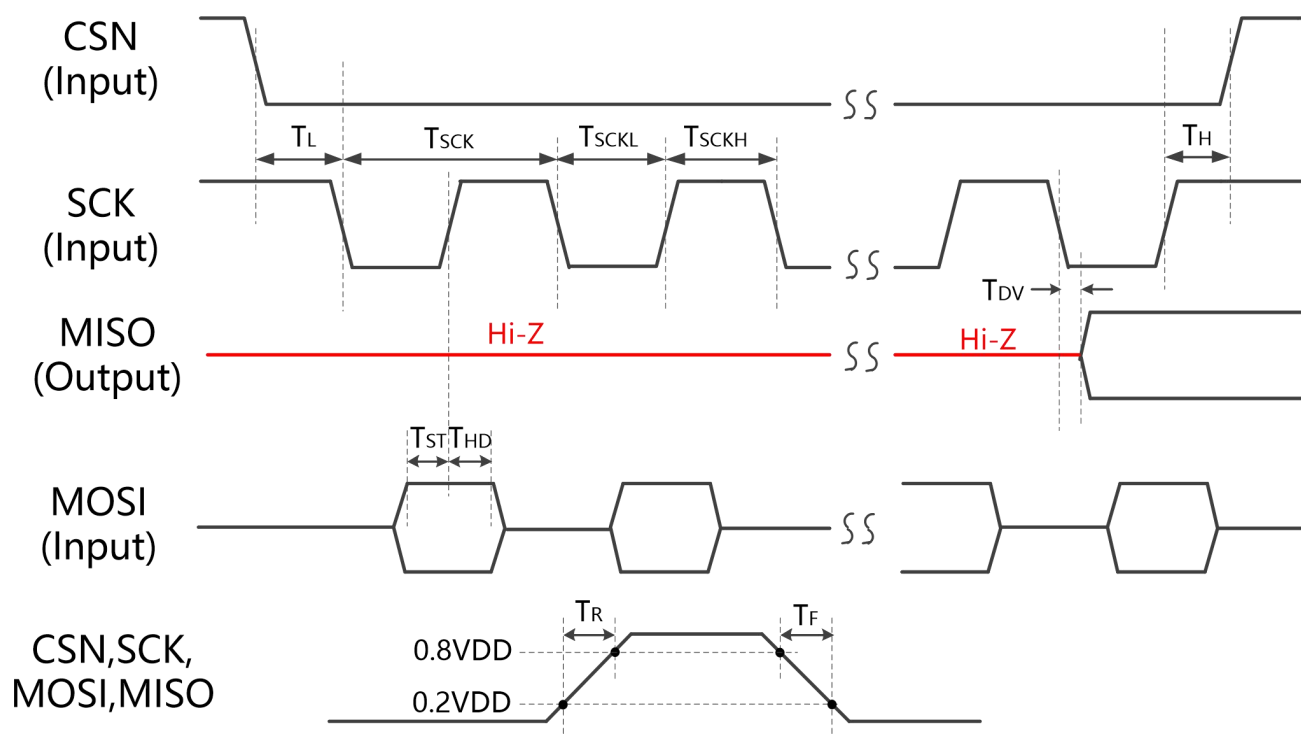


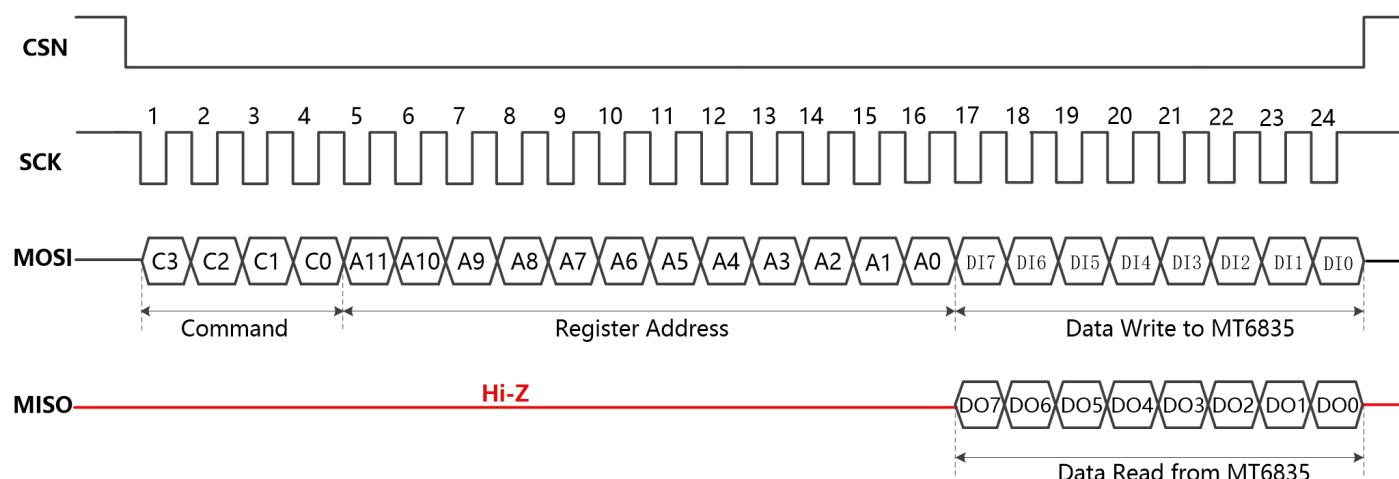
Figure 17: SPI Timing Diagram

#### SPI Timing Parameter

| Symbol     | Notes                                                     | Min.                | Typ. | Max. | Unit |
|------------|-----------------------------------------------------------|---------------------|------|------|------|
| $T_L$      | Time Between CSN Falling Edge and SCK Falling Edge        | 100                 |      | -    | ns   |
| $T_{SCK}$  | Clock Period                                              | 60                  |      | -    | ns   |
| $T_{SCKL}$ | Low Period of Clock                                       | 30                  |      | -    | ns   |
| $T_{SCKH}$ | High Period of Clock                                      | 30                  |      | -    | ns   |
| $T_H$      | Time Between SCK Last Rising Edge and CSN Rising Edge     | $0.5 \cdot T_{SCK}$ |      | -    | ns   |
| $T_R$      | Rise Time of Digital Signal (with 20pf Loading Condition) | -                   | 10   | -    | ns   |
| $T_F$      | Fall Time of Digital Signal (with 20pf Loading Condition) | -                   | 10   | -    | ns   |
| $T_{DV}$   | Data Valid Time of MISO (with 20pf Loading Condition)     | -                   | -    | 15   | ns   |
| $T_{ST}$   | Setup Time of MOSI Data                                   | 10                  | -    | -    | ns   |
| $T_{HD}$   | Hold Time of MOSI Data                                    | 10                  | -    | -    | ns   |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 7.6.3 SPI Protocol



**Figure 18: 4-Wire SPI Timing**

An SPI data transfer starts with the falling edge of CSN and stops at the rising edge of CSN. SCK is the Serial Port Clock, and it is controlled by the SPI master, it is high when there is no SPI transmission. MOSI (master output slave input) and MISO (master input slave output) is the Serial Port Data Input and Output, it is driven at the falling edge of SCK and should be captured at the rising edge of SCK. The 'MISO' keeps Hi-Z unless it drives data as shown in Figure 18.

**Bit 1-4:** Operation Command bits C3~C0.

| C3~C0  | Operation                  | Notes                                                      |
|--------|----------------------------|------------------------------------------------------------|
| 0011   | Read                       | User Read Registers                                        |
| 0110   | Write                      | User Write Registers                                       |
| 1100   | Program EEPROM             | User Erase and Program EEPROM                              |
| 0101   | Auto Setting Zero-Position | Auto Setting Current Position as Zero Position to Register |
| 1010   | Burst Angle Read           | Read Angle Registers Continuously                          |
| Others | N/A                        | -                                                          |

**Bit 5-16:** Address A11~A0. This is the address field of the indexed register.

**Bit 17-24:** Data DI7~DI0 (Write Operation). This is the data that will be written into the device.

**Bit 17-24:** Data DO7~DO0 (Read Operation). This is the data that will be read from the device.

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7.6.4 SPI Read One Byte Register

For single byte read, the operation command C3~C0= '0011' , and the target 12-bit register address A11~A0 please refer to Chapter 10.

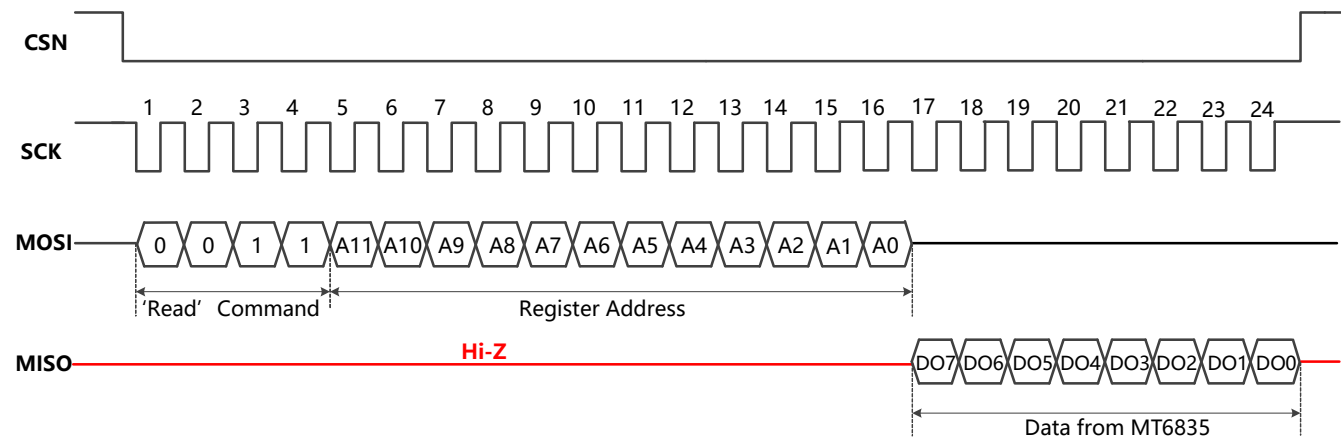


Figure 19: SPI Read One Byte Register

7.6.5 SPI Write One Byte Register

For single byte write, the operation command C3~C0= '0110' , and the target 12-bit register address A11~A0 please refer to Chapter 10.

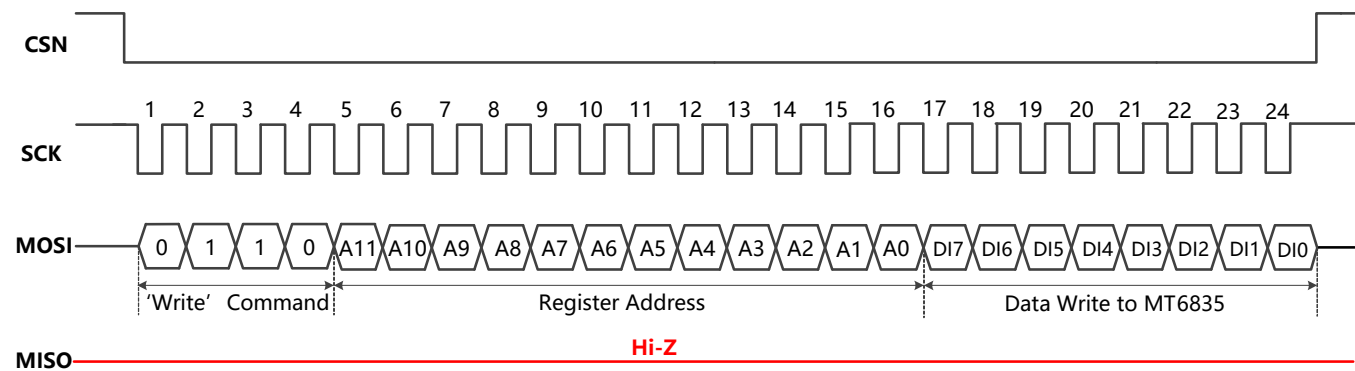
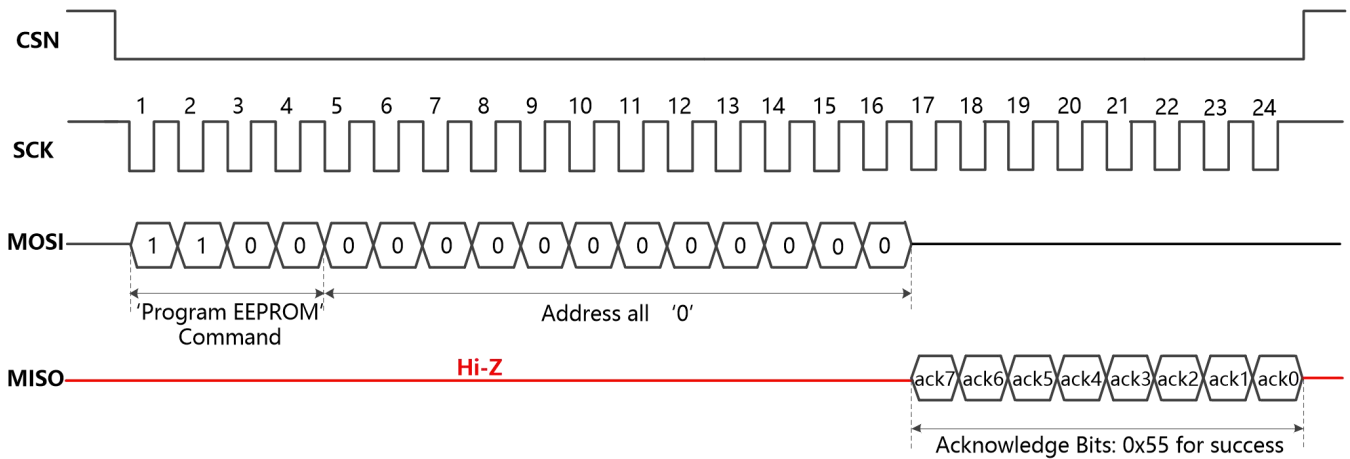


Figure 20: SPI Write One Byte Register

## 21-Bit High Accuracy Magnetic Angle Encoder IC

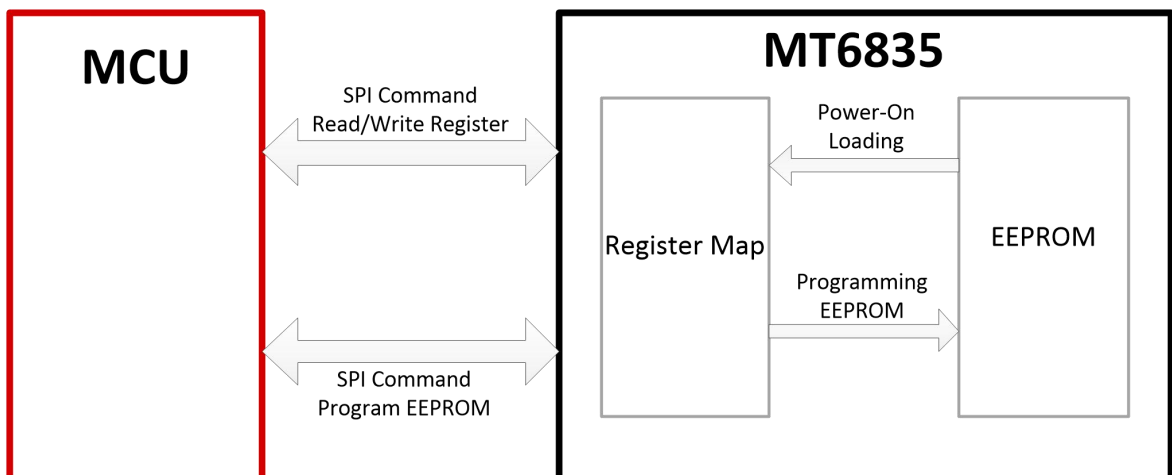
### 7.6.6 SPI Program EEPROM

For EEPROM programming, the operation command C3~C0= '1100' , and all the data in 'Register Map' will be programmed to EEPROM. When the command received successfully, the acknowledge bits ack7~ack0 will return value 0x55; any other value indicates the command received failed. Please **wait at least 6 seconds** before power-down MT6835 after EEPROM programming.



**Figure 21: SPI Program EEPROM**

When the data is programmed to EEPROM, they will be non-volatile; while the data in register map it is volatile, meaning it is lost when the power goes off. The user could read/write the register map through SPI interface and program the data of register map into EEPROM by SPI command.



**Figure 22: Register Map and EEPROM**

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7.6.7 SPI Auto Setting Zero Position

MT6835 provide an Auto Setting Zero Position command, which will automatically write current position as the new Zero Position to the register ‘ZERO\_POS[11:0]’ . The operation command is C3~C0= ‘0101’ , when the command is received successfully, the acknowledge bits ack7~ack0 will return value 0x55; any other value indicates the command received failed.

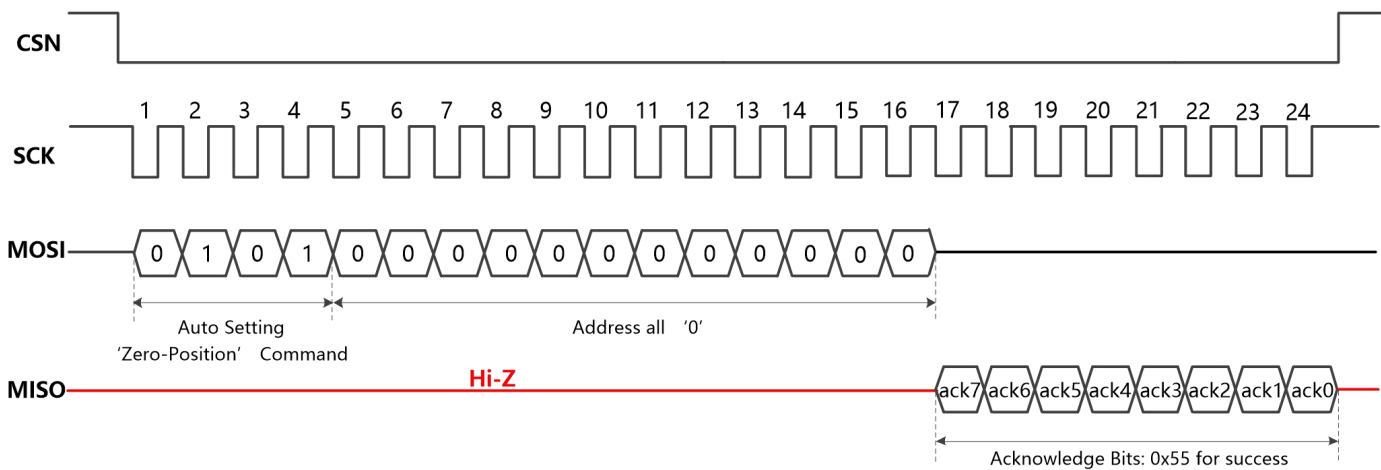


Figure 23: SPI Auto Setting Zero-Position Register

This command only stores the current position into ‘ZERO\_POS[11:0]’ register. If the user want to program it to EEPROM, an SPI program EEPROM operation (waiting >1ms after ‘Auto Setting Zero Position’ command) should be additionally done as shown in Figure 21.

7.6.8 SPI Single Byte Read Angle Registers

The 21-bit absolute angle data could be read by SPI interface as shown in Figure 24. In order to facilitate the user to synchronize the sampling of angle data, when CSN is pulled down, MT6835 internally latched the data of 0x003~0x006, which will not be refreshed until all 0x003~0x006 registers have been read out.

## 21-Bit High Accuracy Magnetic Angle Encoder IC

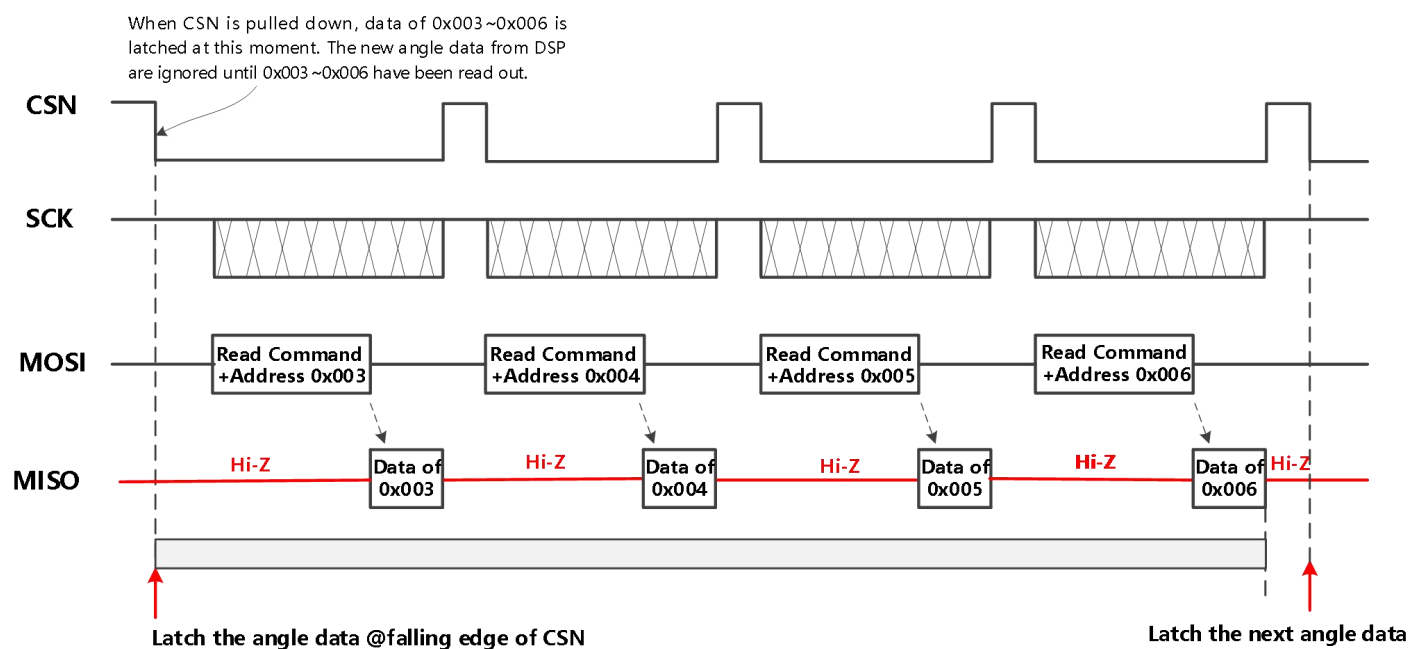


Figure 24: SPI Single Byte Read Angle Register

### 'ANGLE[20:0]' Angle Data Register (Read Only)

| Address | Bit7         | Bit6 | Bit5 | Bit4 | Bit3 | Bit2        | Bit1 | Bit0 |
|---------|--------------|------|------|------|------|-------------|------|------|
| 0x003   | ANGLE[20:13] |      |      |      |      |             |      |      |
| 0x004   | ANGLE[12:5]  |      |      |      |      |             |      |      |
| 0x005   | ANGLE[4:0]   |      |      |      |      | STATUS[2:0] |      |      |
| 0x006   | CRC[7:0]     |      |      |      |      |             |      |      |

0~360° absolute angle  $\theta$  could be calculated by the below formula with ANGLE[20:0]:

$$\theta = \frac{\sum_{i=0}^{20} \text{ANGLE} \langle i \rangle \cdot 2^i}{2^{21}} \cdot 360^\circ$$

### 'STATUS[2:0]' Register (Read Only)

| STATUS[2:0] | Notes                                                            |
|-------------|------------------------------------------------------------------|
| Bit [0]     | Rotation Over Speed Warning; Default '0' , Logic '1' for Warning |
| Bit [1]     | Weak Magnetic Field Warning; Default '0' , Logic '1' for Warning |
| Bit [2]     | Under Voltage Warning; Default '0' , Logic '1' for Warning       |

CRC Data Range: ANGLE[20:0] and STATUS[2:0] total 24bits

CRC polynomial:  $X^8+X^2+X+1$ , MSB (ANGLE[20]) shifts in first.

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 7.6.9 SPI Burst Read Angle Registers

The MT6835 provides an SPI burst read angle registers mode for faster data transfer than single byte read mode as shown in Figure 25. The operation command of this mode is C3~C0= '1010' , after MCU sends this command with address 0x003, MT6835 continuously outputs angle data of register 0x003~0x006.

In order to facilitate the user to synchronize the sampling of angle data, when CSN is pulled down, MT6835 internally latches the data of 0x003~0x006, which will not be refreshed until all 0x003~0x006 registers have been read out.

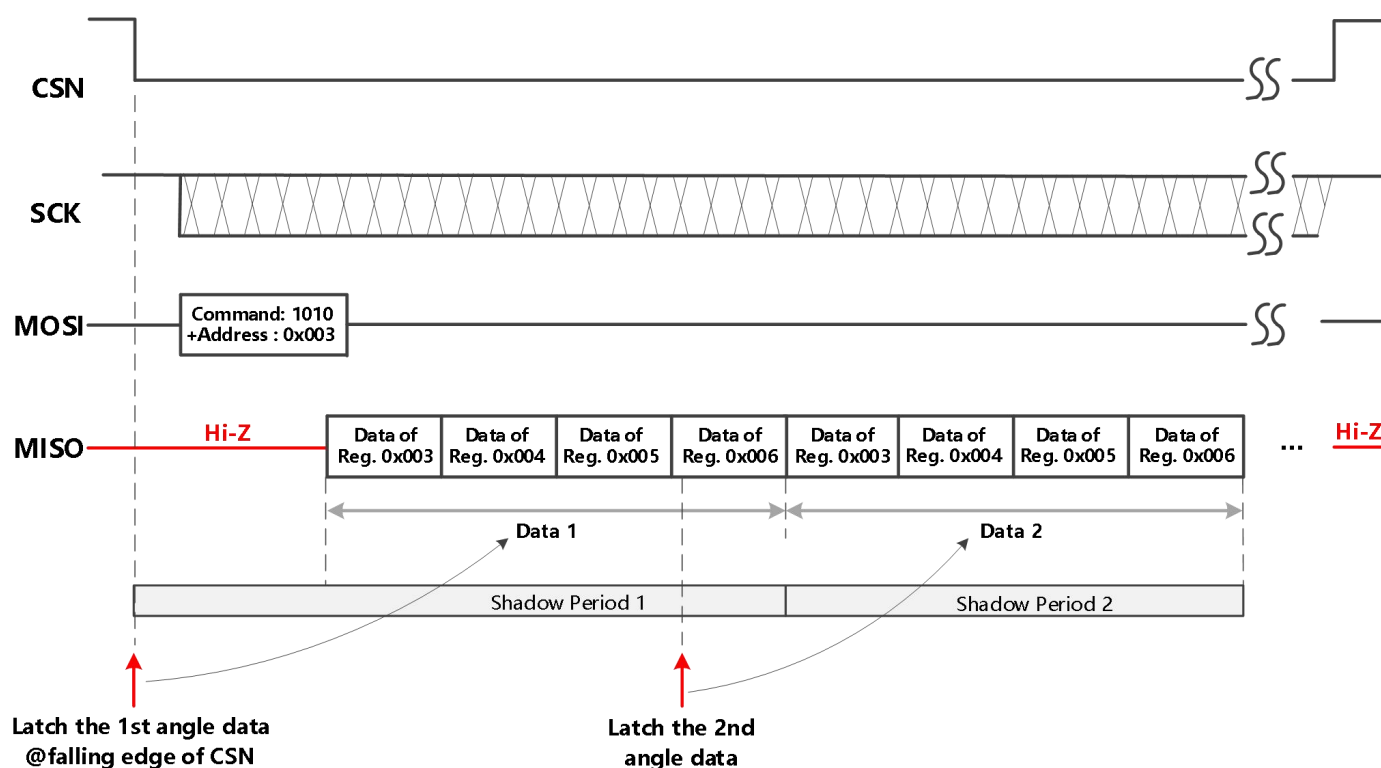


Figure 25: SPI Burst Read Angle Registers

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 8. Change & Program Zero-Position to EEPROM

The 'ZERO\_POS[11:0]' register defines the zero degree of MT6835, the default zero degree of MT6835 with a two-pole magnet is shown in Chapter 12. There are two methods to change the register 'ZERO\_POS[11:0]' as shown in Figure 26.

| Address | Bit7           | Bit6 | Bit5 | Bit4 | Bit3   | Bit2           | Bit1 | Bit0 | Type   |
|---------|----------------|------|------|------|--------|----------------|------|------|--------|
| 0x009   | ZERO_POS[11:4] |      |      |      |        |                |      |      | EEPROM |
| 0x00A   | ZERO_POS[3:0]  |      |      |      | Z_EDGE | Z_PUL_WID[2:0] |      |      | EEPROM |

#### (1) Auto Setting by SPI with 'Auto Setting Zero-Position' Command

This method can only change the zero-position to current mechanical position.

#### (2) Manual Calculate Zero Degree and Write Register by SPI

- Write data 0x000 to register 'ZERO\_POS[11:0]' by SPI;
- Read out the angle data of current position by SPI;
- Calculate the target Zero-Position value, write it to 'ZERO\_POS[11:0]' by SPI;

For both auto and manual methods, an extra SPI '**Program EEPROM**' operation is necessary for storing the new zero-position value into EEPROM, and at least to wait 6 seconds for the EEPROM programming without any other operation.

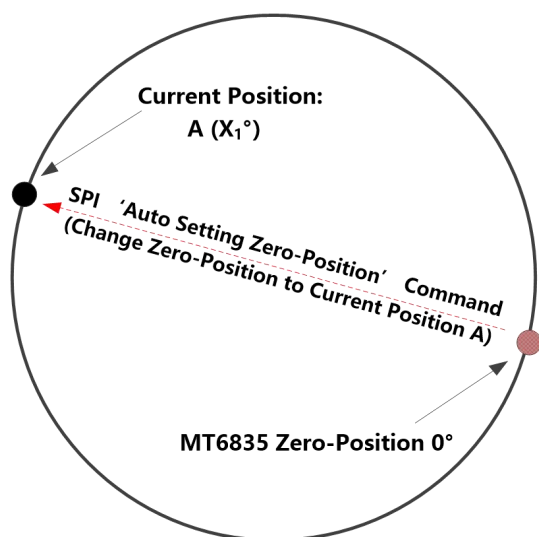


Figure 26-1: Auto Setting

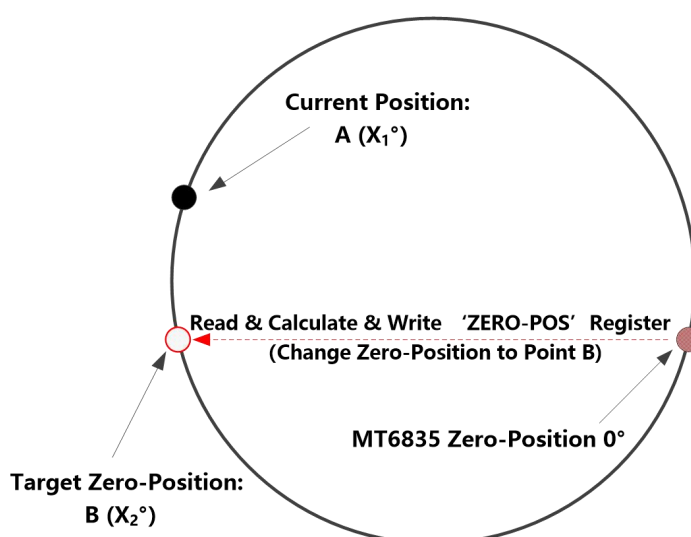


Figure 26-2: Manual Change

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 9. Calibration

Three calibration levels are designed in MT6835: the first level of Factory Calibration is done by MagnTek before the chip is delivered to the user; The second level of User Auto-Calibration could be optionally done by the user at a constant rotation speed; The third level User NLC Calibration could be optionally done by the user with SPI interface and external precision angle reference such as a precision optical encoder.

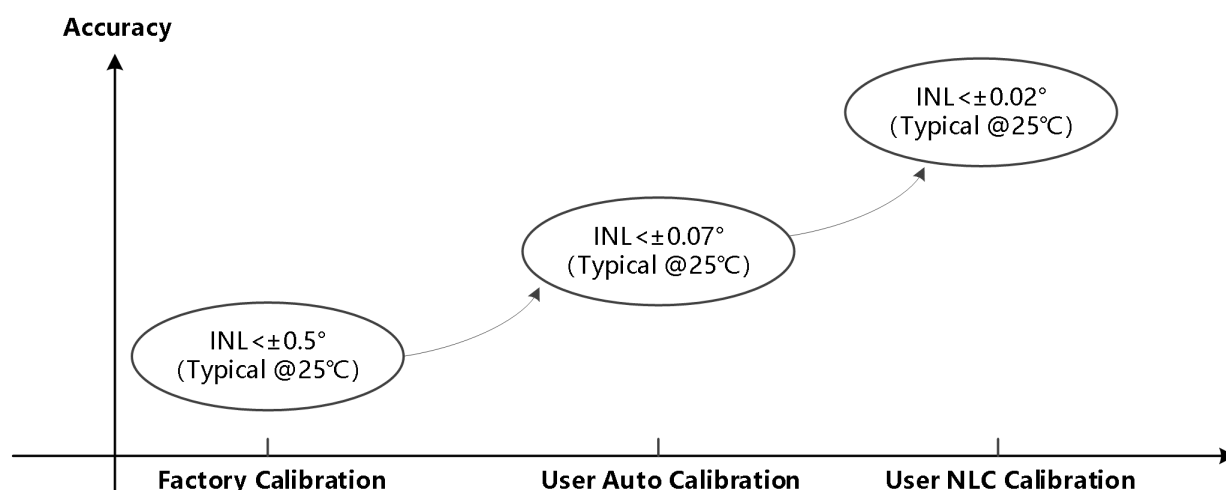


Figure 27: Three Calibration Levels

#### 9.1 Factory Calibration

MT6835 is factory calibrated before it is delivered to the user. The original offset, gain-mismatch and phase-error of sine/cosine signals are calibrated by FT testing as shown in Figure 28, thus the INL could be reduced to less than  $\pm 0.5^\circ$  (typical case).

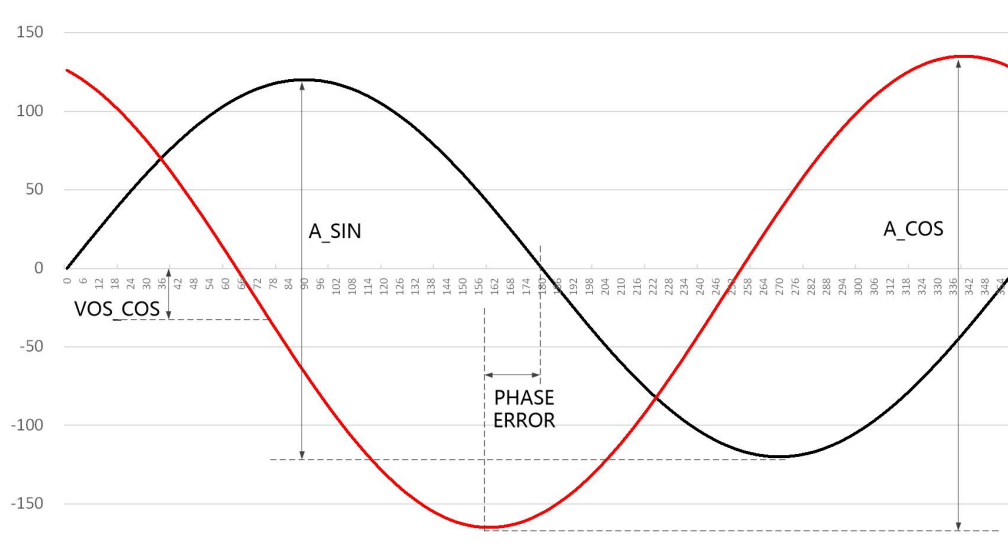


Figure 28: Offset, Gain-Mismatch and Phase-Error

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 9.2 User Auto-Calibration

User Auto-Calibration allows the user to configure MT6835 to fit with a specific magnetic field and assembling condition in an application system. Let the motor rotate at a constant speed and pull up Pin.4 (CAL\_EN) to VDD will enable this calibration, then the DSP of MT6835 will automatically calculate compensation coefficients compensate the calibration process. Typically, INL will be reduced to less than  $\pm 0.07^\circ$  when User Auto-Calibration has been done successfully.

The operation steps:

- (1) Setting the rotation speed register for User Auto-Calibration;

#### *User Auto-Calibration Rotation Speed Register (EEPROM)*

| Reg. AUTOCAL_FREQ[2:0] | Description (Rotation Speed: RPM) |
|------------------------|-----------------------------------|
| 0x0                    | $3200 \leq \text{Speed} < 6400$   |
| 0x1                    | $1600 \leq \text{Speed} < 3200$   |
| 0x2                    | $800 \leq \text{Speed} < 1600$    |
| 0x3                    | $400 \leq \text{Speed} < 800$     |
| 0x4                    | $200 \leq \text{Speed} < 400$     |
| 0x5                    | $100 \leq \text{Speed} < 200$     |
| 0x6                    | $50 \leq \text{Speed} < 100$      |
| 0x7                    | $25 \leq \text{Speed} < 50$       |

- (2) Rotating the system at a constant speed with the present range;
- (3) Pull up CAL\_EN (Pin.4) to VDD to start User Auto-Calibration. Keep the system rotating at the set speed for more than 64 rounds. Monitor PWM (Pin.10) Output (When Pin.4 tied to VDD, Pin.10 is also configured as calibration status output).

| PWM Output Duty-Cycle | Description              |
|-----------------------|--------------------------|
| 50%                   | Running Auto Calibration |
| 25%                   | Calibration Failed       |
| >99%                  | Calibration Successful   |

The calibration status also could be read from register 0x113[7:6]:

0x113[7:6]=00, No Calibration ;      0x113[7:6]=01, Running Calibration;  
0x113[7:6]=10, Calibration Failed;      0x113[7:6]=11, Calibration Successful;

- (4) If calibration has failed, please check the system and then re-calibration again;
- (5) When calibration is successful, please wait >6s and power-down the chip;
- (6) Other operations cannot be performed until the chip is powered on again;

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 9.3 User NLC Calibration

The User NLC (Non-Linearity Compensation) Calibration of MT6835 provides a 256-point look-up table for further INL improvement as shown in Figure 29. A possible calibration system is shown in Figure 30, a high precision optical encoder ( $\geq 21$ -bit) is needed to provide the ideal angle reference when doing the User NLC Calibration.

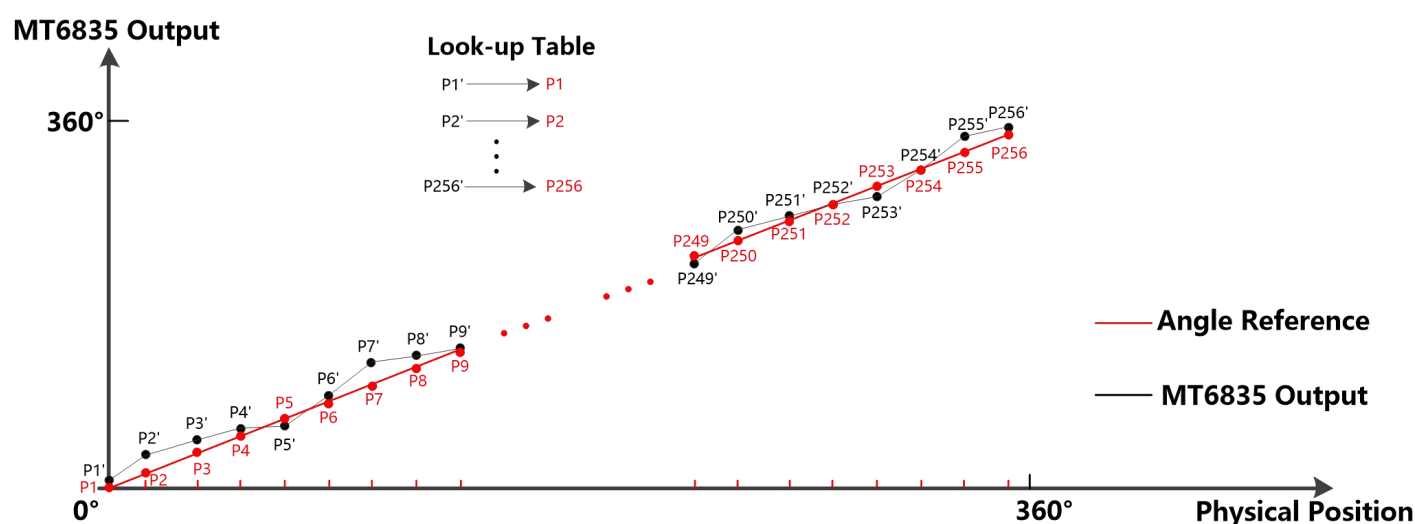


Figure 29: User NLC Calibration

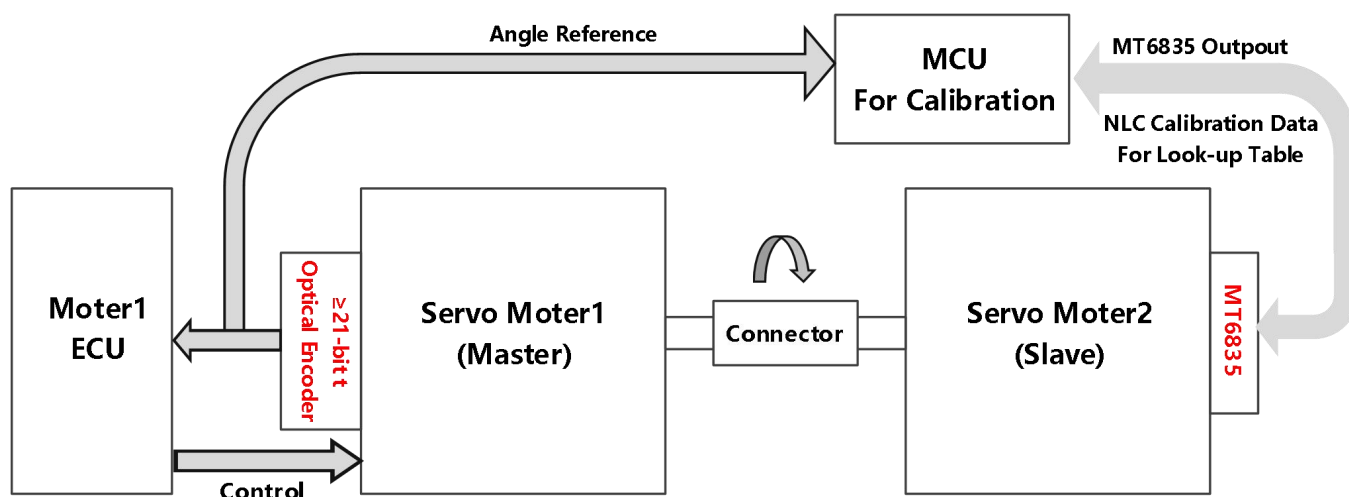


Figure 30: Possible User NLC Calibration System

## 21-Bit High Accuracy Magnetic Angle Encoder IC

## 10. Register Map

| Address             | Bit7                                 | Bit6              | Bit5    | Bit4    | Bit3             | Bit2         | Bit1           | Bit0    | Type      |
|---------------------|--------------------------------------|-------------------|---------|---------|------------------|--------------|----------------|---------|-----------|
| 0x001               | USER_ID[7:0]                         |                   |         |         |                  |              |                |         | EEPROM    |
| 0x002               | Not Used                             |                   |         |         |                  |              |                |         | NA        |
| 0x003               | ANGLE[20:13]                         |                   |         |         |                  |              |                |         | Read Only |
| 0x004               | ANGLE[12:5]                          |                   |         |         |                  |              |                |         | Read Only |
| 0x005               | ANGLE[4:0]                           |                   |         |         |                  | STATUS[2:0]  |                |         | Read Only |
| 0x006               | CRC[7:0]                             |                   |         |         |                  |              |                |         | Read Only |
| 0x007               | ABZ_RES[13:6]                        |                   |         |         |                  |              |                |         | EEPROM    |
| 0x008               | ABZ_RES[5:0]                         |                   |         |         |                  |              | ABZ_OFF        | AB_SWAP | EEPROM    |
| 0x009               | ZERO_POS[11:4]                       |                   |         |         |                  |              |                |         | EEPROM    |
| 0x00A               | ZERO_POS[3:0]                        |                   |         |         |                  | Z_EDGE       | Z_PUL_WID[2:0] |         | EEPROM    |
| 0x00B               | Z_PHASE[1:0]                         |                   | UVW_MUX | UVW_OFF | UVW_RES[3:0]     |              |                |         | EEPROM    |
| 0x00C               | MagnTek Use Only                     |                   | NLC_EN  | PWM_FQ  | PWM_POL          | PWM_SEL[2:0] |                |         | EEPROM    |
| 0x00D               | MagnTek Use Only                     |                   |         |         |                  | ROT_DIR      | HYST[2:0]      |         | EEPROM    |
| 0x00E               | GPIO_DS                              | AUTOCAL_FREQ[2:0] |         |         | MagnTek Use Only |              |                |         | EEPROM    |
| 0x00F               | MagnTek Use Only                     |                   |         |         |                  |              |                |         | EEPROM    |
| 0x010               | MagnTek Use Only                     |                   |         |         |                  |              |                |         | EEPROM    |
| 0x011               | MagnTek Use Only                     |                   |         |         |                  | BW[2:0]      |                |         | EEPROM    |
| 0x012               | MagnTek Use Only                     |                   |         |         |                  |              |                |         | EEPROM    |
| 0x013<br>~<br>0x0D2 | NLC Byte 0x00~0xBF (Total 192 Bytes) |                   |         |         |                  |              |                |         | EEPROM    |

**Warning: Do Not Change the 'MagnTek Use Only' Bits**

## (1) 0x001 User\_ID (EEPROM)

| Address | Bit7         | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 | Type   |
|---------|--------------|------|------|------|------|------|------|------|--------|
| 0x001   | USER_ID[7:0] |      |      |      |      |      |      |      | EEPROM |

- 'USER\_ID[7:0]' is a free byte for the user.

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## (2) 0x003~ 0x006 Angle Data Register (Read Only)

| Address | Bit7         | Bit6 | Bit5 | Bit4 | Bit3 | Bit2        | Bit1 | Bit0 | Type      |
|---------|--------------|------|------|------|------|-------------|------|------|-----------|
| 0x003   | ANGLE[20:13] |      |      |      |      |             |      |      | Read Only |
| 0x004   | ANGLE[12:5]  |      |      |      |      |             |      |      | Read Only |
| 0x005   | ANGLE[4:0]   |      |      |      |      | STATUS[2:0] |      |      | Read Only |
| 0x006   | CRC[7:0]     |      |      |      |      |             |      |      | Read Only |

- 0~360° absolute angle  $\theta$  could be calculated by the below formula with ANGLE[20:0]:

$$\theta = \frac{\sum_{i=0}^{20} \text{ANGLE}[i] \cdot 2^i}{2^{21}} \cdot 360^\circ$$

- 'STATUS[2:0]' indicates some warnings of the chip;

| STATUS[2:0] | Notes                                                            |
|-------------|------------------------------------------------------------------|
| Bit [0]     | Rotation Over Speed Warning; Default '0' , Logic '1' for Warning |
| Bit [1]     | Weak Magnetic Field Warning; Default '0' , Logic '1' for Warning |
| Bit [2]     | Under Voltage Warning; Default '0' , Logic '1' for Warning       |

- 'CRC[7:0]' gives the redundant check of bits ANGLE[20:0] and STATUS[2:0], totally 24bits. The CRC polynomial:  $X^8+X^2+X+1$ , MSB (ANGLE[20]) shifts in first.

## (3) 0x007~ 0x008 ABZ Resolution and Related Registers (EEPROM)

| Address | Bit7          | Bit6 | Bit5 | Bit4 | Bit3    | Bit2 | Bit1    | Bit0 |
|---------|---------------|------|------|------|---------|------|---------|------|
| 0x007   | ABZ_RES[13:6] |      |      |      |         |      |         |      |
| 0x008   | ABZ_RES[5:0]  |      |      |      | ABZ_OFF |      | AB_SWAP |      |

- 'ABZ\_RES[13:0]' configures the resolution of AB output, please refer to Chapter 7.3;

| Reg. ABZ_RES[13:0] | AB Resolution (Pulse per. Round) | Factory Default Setting |
|--------------------|----------------------------------|-------------------------|
| 0x0000             | 1                                | √                       |
| 0x0001             | 2                                |                         |
| ... ..             | ... ..                           |                         |
| 0x3FFE             | 16,383                           |                         |
| 0x3FFF             | 16,384                           |                         |

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- 'ABZ\_OFF' configures the on/off state of ABZ output;

| Reg. ABZ_OFF | ABZ Output | Factory Default Setting |
|--------------|------------|-------------------------|
| 0x0          | ON         | √                       |
| 0x1          | OFF        |                         |

- 'AB\_SWAP' configures the swapping of incremental output A and B;

| Reg. AB_SWAP | AB Output | Factory Default Setting |
|--------------|-----------|-------------------------|
| 0x0          | No Swap   | √                       |
| 0x1          | Swap      |                         |

## (4) 0x009~ 0x00A Z Pulse Related Registers (EEPROM)

| Address | Bit7           | Bit6 | Bit5 | Bit4 | Bit3   | Bit2           | Bit1 | Bit0 |
|---------|----------------|------|------|------|--------|----------------|------|------|
| 0x009   | ZERO_POS[11:4] |      |      |      |        |                |      |      |
| 0x00A   | ZERO_POS[3:0]  |      |      |      | Z_EDGE | Z_PUL_WID[2:0] |      |      |

- 'ZERO\_POS[11:0]' configures the Zero-Position of MT6835, it is effective for all outputs;

| Reg. ZERO_POS[11:0] | Absolute Position (°) | Factory Default Setting |
|---------------------|-----------------------|-------------------------|
| 0x000               | 0                     | √                       |
| 0x001               | 0.088                 |                         |
| ... ..              | ... ..                |                         |
| 0xFFE               | 359.824               |                         |
| 0xFFF               | 359.912               |                         |

- 'Z\_EDGE' configures the relationship of Z pulse edge and zero degree;

| Reg. Z_EDGE | Z Pulse Edge with 0°       | Factory Default Setting |
|-------------|----------------------------|-------------------------|
| 0x0         | Rising Edge Aligned to 0°  | √                       |
| 0x1         | Falling Edge Aligned to 0° |                         |

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- 'Z\_PUL\_WID[2:0]' configures the width of Z pulse.

| Reg. Z_PUL_WID[2:0] | Width (LSBs/°) | Factory Default Setting |
|---------------------|----------------|-------------------------|
| 0x0                 | 1              | √                       |
| 0x1                 | 2              |                         |
| 0x2                 | 4              |                         |
| 0x3                 | 8              |                         |
| 0x4                 | 16             |                         |
| 0x5                 | 60°            |                         |
| 0x6                 | 120°           |                         |
| 0x7                 | 180°           |                         |

## (5) 0x00B Z\_PHASE and UVW Related Registers (EEPROM)

| Address | Bit7         | Bit6 | Bit5    | Bit4    | Bit3         | Bit2 | Bit1 | Bit0 |
|---------|--------------|------|---------|---------|--------------|------|------|------|
| 0x00B   | Z_PHASE[1:0] |      | UVW_MUX | UVW_OFF | UVW_RES[3:0] |      |      |      |

- 'Z\_PHASE[1:0]' configures the phase between Z and A/B output, please refer to Figure 12 on Page-15;
- 'UVW\_MUX' configures UVW pins (Pin.1~Pin.3) output UVW or -A-B-Z ;

| Reg. UVW_MUX | UVW Output Pin | Factory Default Setting |
|--------------|----------------|-------------------------|
| 0x0          | UVW            | √                       |
| 0x1          | -A-B-Z         |                         |

- 'UVW\_OFF' configures the on/off state of the UVW output;

| Reg. UVW_OFF | UVW Output | Factory Default Setting |
|--------------|------------|-------------------------|
| 0x0          | ON         | √                       |
| 0x1          | OFF        |                         |

- 'UVW\_RES[3:0]' configures the resolution of UVW output;

| Reg. UVW_RES[3:0] | UVW Pole Pairs | Factory Default Setting |
|-------------------|----------------|-------------------------|
| 0x0               | 1              | √                       |
| 0x1               | 2              |                         |
| ... ..            | ... ..         |                         |
| 0xE               | 15             |                         |
| 0xF               | 16             |                         |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

## (6) 0x00C PWM and NLC Calibration Related Registers (EEPROM)

| Address | Bit7             | Bit6 | Bit5   | Bit4   | Bit3    | Bit2         | Bit1 | Bit0 |
|---------|------------------|------|--------|--------|---------|--------------|------|------|
| 0x00C   | MagnTek Use Only |      | NLC_EN | PWM_FQ | PWM_POL | PWM_SEL[2:0] |      |      |

- 'NLC\_EN' enables NLC Calibration

| Reg. NLC_EN | NLC Calibration | Factory Default Setting |
|-------------|-----------------|-------------------------|
| 0x0         | Disabled        | √                       |
| 0x1         | Enabled         |                         |

- 'PWM\_FQ' configures the PWM frame frequency ;

| Reg. PWM_FQ | PWM Frame Frequency | Factory Default Setting |
|-------------|---------------------|-------------------------|
| 0x0         | 994 Hz              | √                       |
| 0x1         | 497 Hz              |                         |

- 'PWM\_POL' configures PWM effective voltage level;

| Reg. PWM_POL | PWM Polarity           | Factory Default Setting |
|--------------|------------------------|-------------------------|
| 0x0          | High Voltage Effective | √                       |
| 0x1          | Low Voltage Effective  |                         |

- 'PWM\_SEL[2:0]' configures the PWM output source;

| Reg. PWM_SEL[2:0] | PWM Data Source      | Factory Default Setting |
|-------------------|----------------------|-------------------------|
| 0x0               | 12-bit Angle Data    | √                       |
| 0x2               | 12-bit Velocity Data |                         |
| Others            | Factory Test Data    |                         |

## (7) 0x00D (EEPROM)

| Address | Bit7             | Bit6 | Bit5 | Bit4 | Bit3    | Bit2      | Bit1 | Bit0 |
|---------|------------------|------|------|------|---------|-----------|------|------|
| 0x00D   | MagnTek Use Only |      |      |      | ROT_DIR | HYST[2:0] |      |      |

- 'ROT\_DIR' configures the rotation direction (logic 0 for CCW), please refer to Figure 7;

| Reg. ROT_DIR | Rotation Direction | Factory Default Setting |
|--------------|--------------------|-------------------------|
| 0x0          | Counter-Clockwise  | √                       |
| 0x1          | Clockwise          |                         |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

- 'HYST[2:0]' configures the hysteresis window for angle output

| Reg. HYST[2:0] | Hysteresis Window | Factory Default Setting |
|----------------|-------------------|-------------------------|
| 0x0            | 0.022°            |                         |
| 0x1            | 0.044°            |                         |
| 0x2            | 0.088°            |                         |
| 0x3            | 0.176°            |                         |
| 0x4            | 0                 |                         |
| 0x5            | 0.003°            |                         |
| 0x6            | 0.006°            |                         |
| 0x7            | 0.011°            | √                       |

## (8) 0x00E (EEPROM)

| Address | Bit7    | Bit6              | Bit5 | Bit4 | Bit3             | Bit2 | Bit1 | Bit0 |
|---------|---------|-------------------|------|------|------------------|------|------|------|
| 0x00E   | GPIO_DS | AUTOCAL_FREQ[2:0] |      |      | MagnTek Use Only |      |      |      |

- 'GPIO\_DS' configures the GPIO drive capability;

| Reg. GPIO_DS | GPIO Drive Capability | Factory Default Setting |
|--------------|-----------------------|-------------------------|
| 0x0          | Default Level         | √                       |
| 0x1          | Doubled Level         |                         |

- 'AUTOCAL\_FREQ[2:0]' configures the rotation speed for Auto Calibration;

| Reg. AUTO_CAL_FREQ[2:0] | Description (Rotation Speed: RPM) | Factory Default Setting |
|-------------------------|-----------------------------------|-------------------------|
| 0x0                     | 3200≤Speed<6400                   |                         |
| 0x1                     | 1600≤Speed<3200                   |                         |
| 0x2                     | 800≤Speed<1600                    |                         |
| 0x3                     | 400 ≤Speed< 800                   | √                       |
| 0x4                     | 200≤Speed<400                     |                         |
| 0x5                     | 100≤Speed<200                     |                         |
| 0x6                     | 50≤Speed<100                      |                         |
| 0x7                     | 25≤Speed<50                       |                         |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### (8) 0x011 System Bandwidth (EEPROM)

| Address | Bit7             | Bit6 | Bit5 | Bit4 | Bit3 | Bit2     | Bit1 | Bit0 |
|---------|------------------|------|------|------|------|----------|------|------|
| 0x011   | MagnTek Use Only |      |      |      |      | BW [2:0] |      |      |

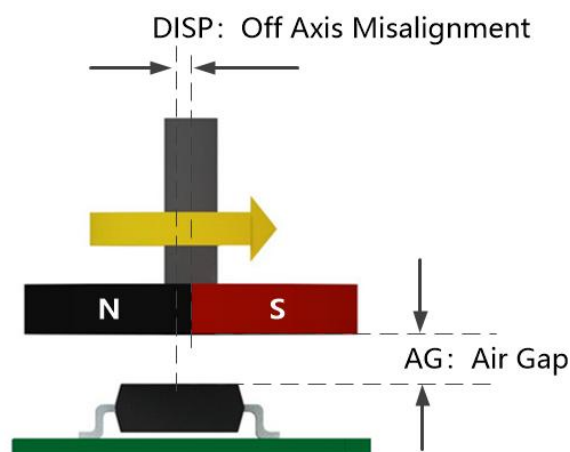
- 'BW[2:0]' configures the MT6835's system bandwidth.

| Reg. BW[2:0] | Description               | Response            | Factory Default Setting |
|--------------|---------------------------|---------------------|-------------------------|
| 0x0          | System Bandwidth Baseline | Slow (Better Noise) |                         |
| 0x1          | Baseline x 2              |                     |                         |
| 0x2          | Baseline x 4              |                     |                         |
| 0x3          | Baseline x 8              |                     |                         |
| 0x4          | Baseline x 16             |                     |                         |
| 0x5          | Baseline x 32             |                     | √                       |
| 0x6          | Baseline x 64             |                     |                         |
| 0x7          | Baseline x 128            | Fast (Worse Noise)  |                         |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 11. Magnet Placement

It is required that the magnet's center axis be aligned with the sensing element center of MT6835 with the air-gap as small as possible. Any misalignment introduces additional angle error and big air-gap also weakens the magnetic field which could be sensed by the device. Magnets with larger diameter are more tolerant to DISP (off-axis misalignment) and big AG (air-gap between Magnet and device).



INL vs. DISP for  $\Phi 10$  magnet

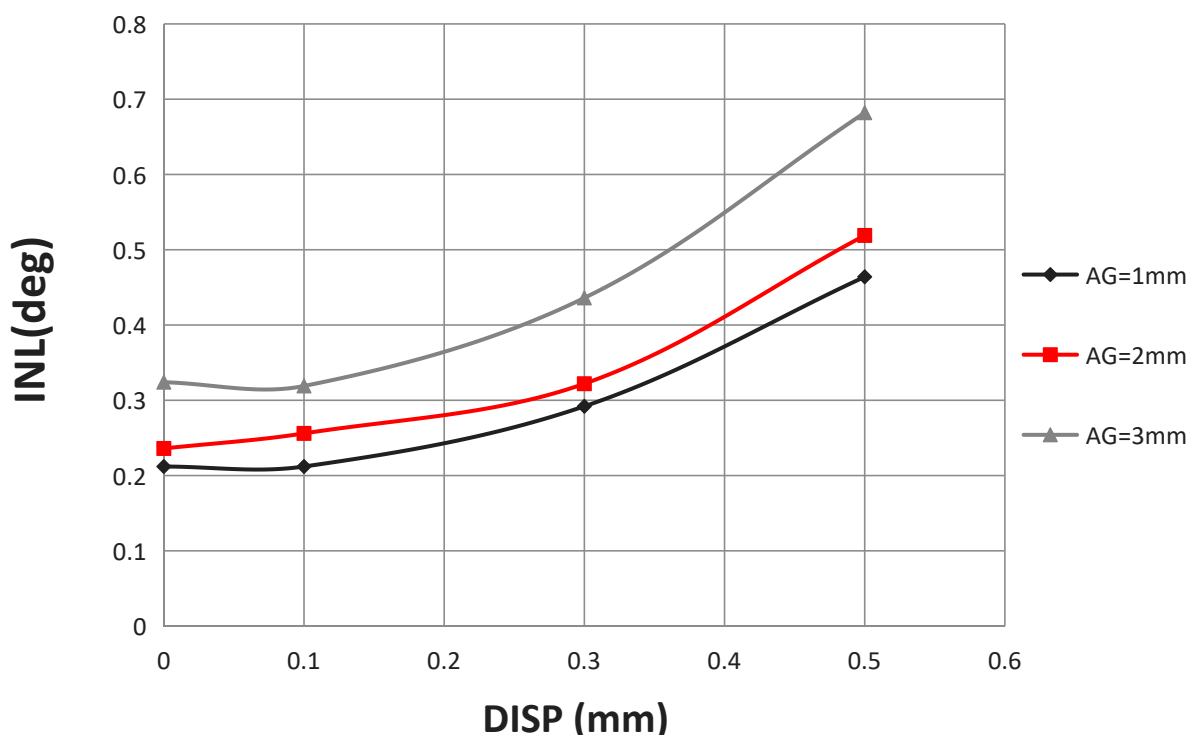
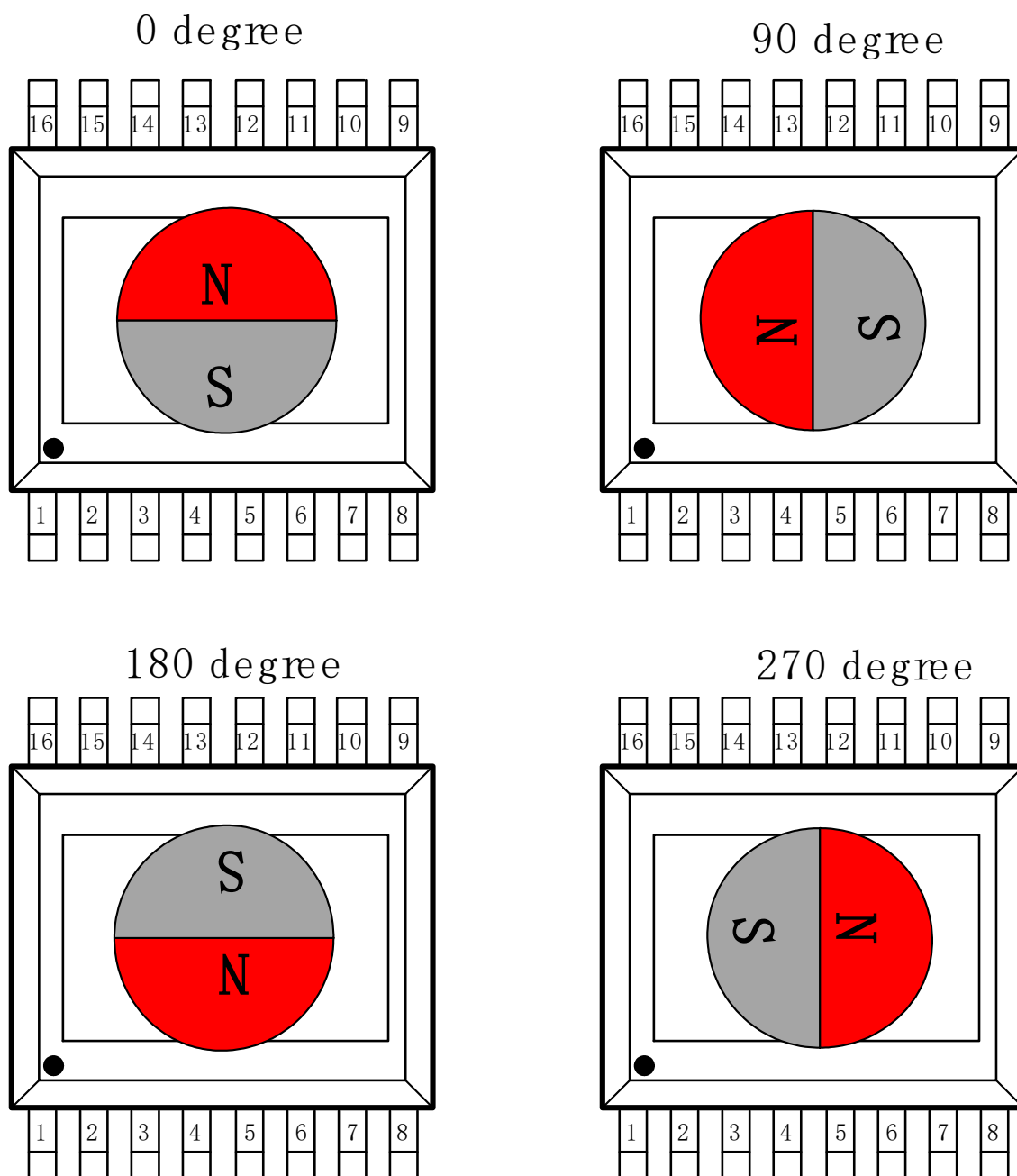


Figure 31: INL vs DISP and AG with Factory Calibration Only

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 12. Mechanical Angle Direction

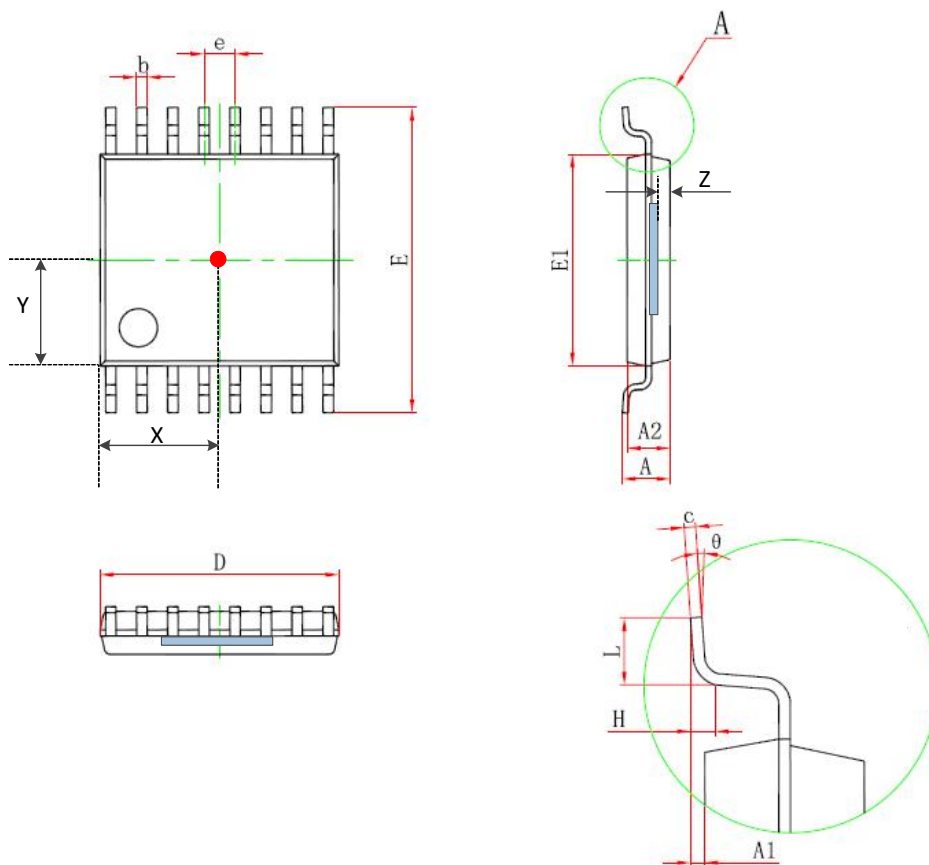
#### Top View



**Counter-Clockwise Rotation (CCW)**  
( with Register 'ROT-DIR' =0)

## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 13. Package Information



| Symbol                     | Dimensions in Millimeters |       | Dimensions in Inches |       |
|----------------------------|---------------------------|-------|----------------------|-------|
|                            | Min.                      | Max.  | Min.                 | Max.  |
| <b>D</b>                   | 4.900                     | 5.100 | 0.193                | 0.201 |
| <b>E</b>                   | 6.250                     | 6.550 | 0.246                | 0.258 |
| <b>b</b>                   | 0.190                     | 0.300 | 0.007                | 0.012 |
| <b>c</b>                   | 0.090                     | 0.200 | 0.004                | 0.008 |
| <b>E1</b>                  | 4.300                     | 4.500 | 0.169                | 0.177 |
| <b>A</b>                   |                           | 1.200 |                      | 0.047 |
| <b>A2</b>                  | 0.800                     | 1.000 | 0.031                | 0.039 |
| <b>A1</b>                  | 0.050                     | 0.150 | 0.002                | 0.006 |
| <b>e</b>                   | 0.65 (BSC)                |       | 0.026 (BSC)          |       |
| <b>L</b>                   | 0.500                     | 0.700 | 0.020                | 0.028 |
| <b>H</b>                   | 0.25 (TYP)                |       | 0.01 (TYP)           |       |
| <b><math>\theta</math></b> | 1°                        | 7°    | 1°                   | 7°    |
| <b>X</b>                   | 2.450                     | 2.550 | 0.097                | 0.101 |
| <b>Y</b>                   | 2.150                     | 2.250 | 0.085                | 0.089 |
| <b>Z</b>                   | 0.210                     | 0.370 | 0.016                | 0.024 |

## 21-Bit High Accuracy Magnetic Angle Encoder IC

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## 21-Bit High Accuracy Magnetic Angle Encoder IC

### 15. Revision History

| Revision | Date    | Comments                                                              |
|----------|---------|-----------------------------------------------------------------------|
| 0.5      | 2021.01 | Initial Release as Draft                                              |
| 1.0      | 2021.04 | Formal Release                                                        |
| 1.1      | 2022.02 | Update Figure 24 Timing<br>Add AB Maximum Frequency                   |
| 1.2      | 2022.05 | Update Chapter 7.6.7 & 7.6.8                                          |
| 1.3      | 2022.10 | Update Figure 7<br>Update Default Hyst=0.011°<br>Update Chapter 7.6.2 |