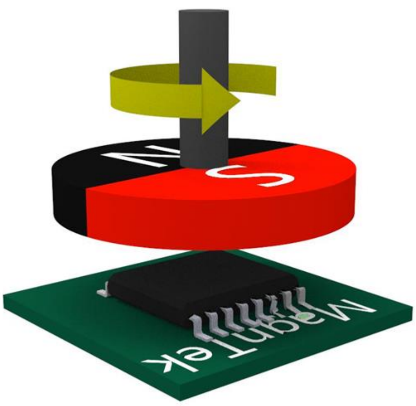
MT6826S

15-Bit High Accuracy Magnetic Angle Encoder IC

Features and Benefits

- Based on advanced AMR Technology with 0~360° Full Range Angle Sensing
- 15-bit Core Resolution with Maximum Rotation Speed Up to 120,000 RPM
- Output Propagation Delay 2~10 us
- User Auto-Calibration and Distortion Compensation with Target INL<±0.07°
- -40~125℃ Operating Temperature Range
- Independent Output Interface: ABZ, UVW, PWM and SPI
- Incremental ABZ Resolution 1~4,096 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
- Closed loop Stepping Motor Control
- Optical Encoder Replacement

General Description

MagnTek's rotary position sensor MT6826S 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 (α) between the sensor and the magnetic field direction.

The incremental ABZ output mode is available in this sensor series, making the chip suitable to replace various optical encoders. The maximum resolution is 4,096 pulses or 16,384 steps per revolution . The maximum resolution of incremental UVW is 16 Pole-Pairs per.

A 4-Wire SPI interface allows a host microcontroller to read out the 15-bit absolute angle position data from MT6826S. The absolute angle position is also provided as a 12-bit PWM output.

The core performance improvement of MT6826S is the self-calibration mode which can compensate for the non-linearity caused by the unsatisfactory magnet and the structure installation.

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1. Pin Configuration

1.1 TSSOP-16 Pin Configuration

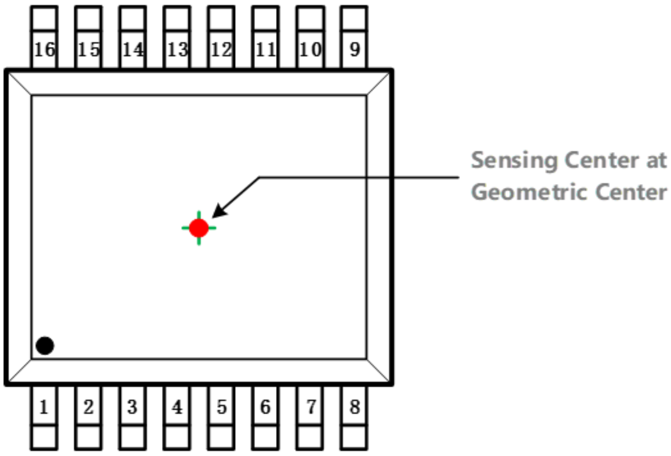


Figure 1: Pin Configuration of MT6826S (TSSOP-16) Package

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(MagnTek use only)
VSS	12	Power Supply	Ground
TEST_EN	13	Digital Input	Factory Test Enable(MagnTek use only)
Z	14	Digital Output	Incremental Signal Z
B	15	Digital Output	Incremental Signal B
A	16	Digital Output	Incremental Signal A

1.2. QFN4x4 Pin Configuration

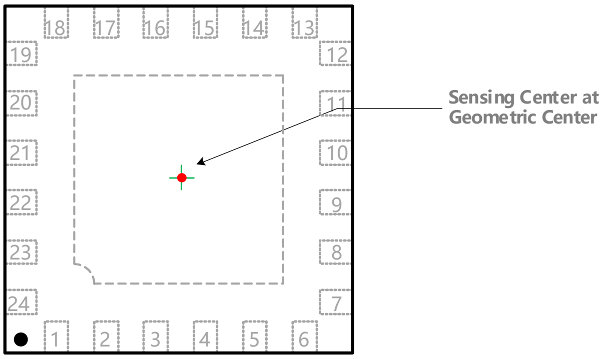


*Figure 2: Pin Configuration of MT6826S (QFN4*4) Package*

I/O Pin List

Name	#	Type	Description
W	1	Digital Output	Commutation Signal W
U	2	Digital Output	Commutation Signal U
V	3	Digital Output	Commutation Signal V
MISO	4	Digital Output	SPI MISO
MOSI	5	Digital Input	SPI MOSI
SCK	6	Digital Input	SPI Clock
CSN	7	Digital Input	SPI Chip Select
NA	8~10	-	Not Connected
VDD	11	Power Supply	3.3~5.0V Supply
OUT	12	Digital Output	PWM Output
TEST	13	Analog Input	Factory Test Pin
VSS	14	Power Supply	Ground
TEST_EN	15	Digital Output	Factory Test Enable
Z	16	Digital Output	Incremental Signal Z
B	17	Digital Output	Incremental Signal B
A	18	Digital Output	Incremental Signal A
NA	19	-	Not Connected
CAL_EN	20	Digital Input	Auto Calibration Enable Pin
NA	21~24	-	Not Connected

2. Family Members

MT6826SGT is available in TSSOP-16 package（***Reflow Sensitivity Classification: MSL-3***）, for Tube (60 Pcs/Tube) or Reel (3000 Pcs/Reel).

MT6826SJT is available in QFN4*4 package（**Reflow Sensitivity Classification: MSL-3**）, for Reel (1000 Pcs/Reel).

Part Number	Packing	Functional Description
MT6826SGT-STD-R	Reel	AB=1 PPR, Z=1 LSB; PWM=994 Hz; CCW
MT6826SGT-STD	Tube	AB=1 PPR, Z=1 LSB; PWM=994 Hz; CCW
MT6826SGT-AKD-R	Reel	AB=1,000 PPR, Z=4 LSB; PWM=994 Hz; CCW
MT6826SGT-AKD	Tube	AB=1,000 PPR, Z=4 LSB; PWM=994 Hz; CCW
MT6826SGT-ACD-R	Reel	AB=1,024 PPR, Z=4 LSB; PWM=994 Hz; CCW
MT6826SGT-ACD	Tube	AB=1,024 PPR, Z=4 LSB; PWM=994 Hz; CCW
MT6826SJT-STD	Reel	AB=1 PPR, Z=1 LSB; PWM=994 Hz; CCW
MT6826SJT-AKD	Reel	AB=1,000 PPR, Z=4 LSB; PWM=994 Hz; CCW
MT6826SJT-ACD	Reel	AB=1,024 PPR, Z=4 LSB; PWM=994 Hz; CCW

3. Functional Diagram

The MT6826S 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 3 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.

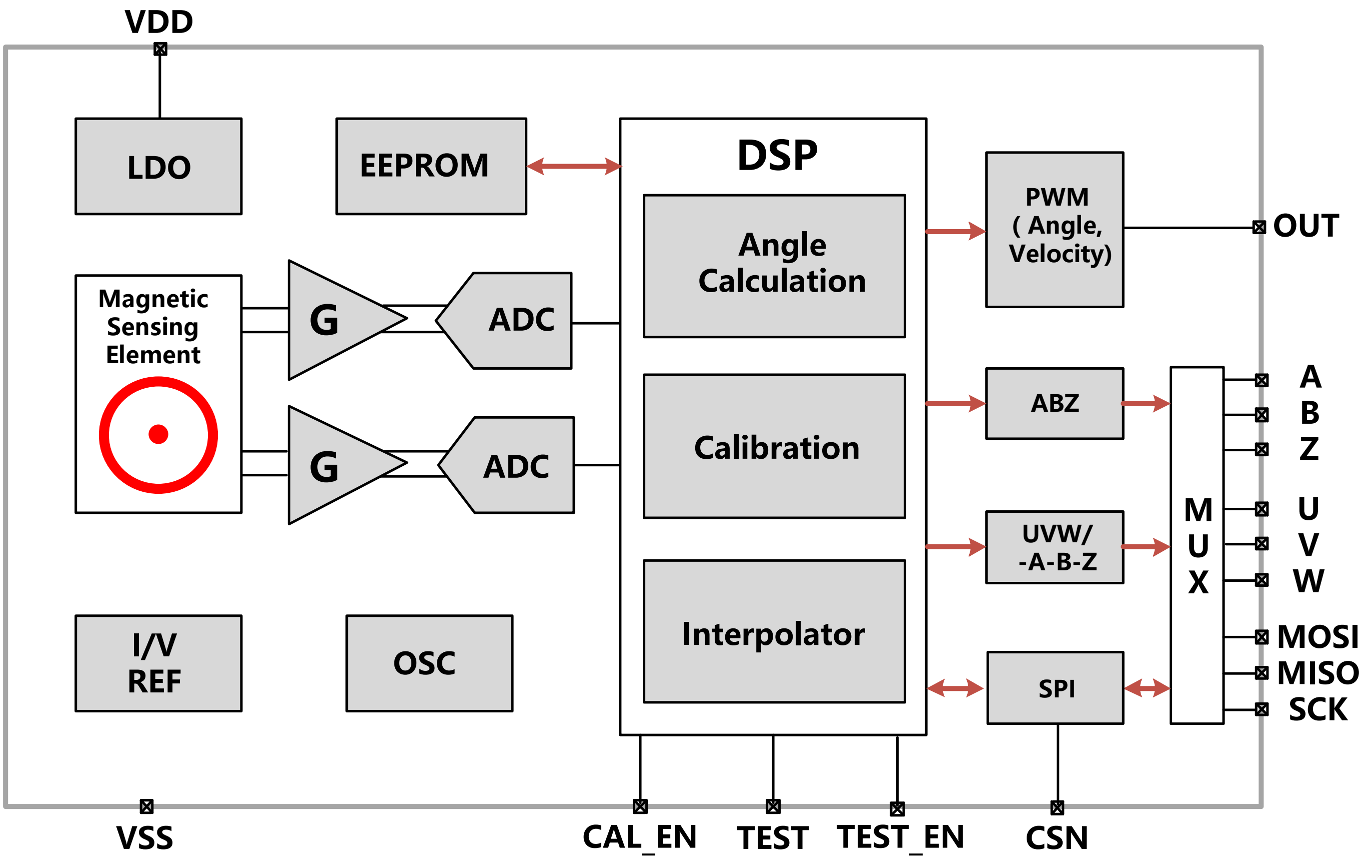


Figure 3: Block Diagram

4. 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	℃	
I_{SCR} (Latch-up Input Current)	-	±100	mA	AEC-Q100-004
V_{HBM} (ESD Voltage)	-	±8.0	KV	AEC-Q100-002
V_{CDM} (ESD Voltage)	-	±1.5	KV	AEC-Q100-011

5. 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	℃

6. Electrical Characteristics

Operation conditions: Ta=-40 to 125℃, 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	**Note[1]**	-	±0.5	±1.0	°
	Integral Non-Linearity with User Auto-Calibration	**Note[2]**		±0.1		°
DNL	Differential Non-Linearity (ABZ Mode), **Figure 4**	@2500 PPR	-	±0.005	-	°
TN	Transition Noise (ABZ Mode)	25℃ with 'BW' =5	-	0.0015	-	°rms
Hyst	Hysteresis	Programmable	-	0.044	-	°
T_{PwrUp}	Power-Up Time, **Figure 8**	VDD Ramp<100us	-	3	-	ms
T_{Delay}	Propagation Delay	Constant Speed	-	10	-	us
T_{ST}	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.10 for the detail of 'User Auto-Calibration'.

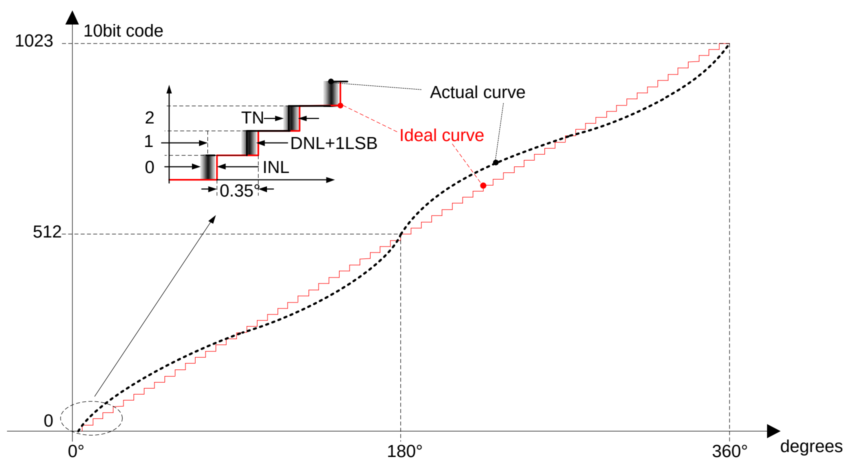


Figure 4: Drawing Illustration INL, DNL and TN (for 10-bit case)

ABZ Output Characteristics

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

Symbol	Parameter	Conditions/Notes	Min.	Typ.	Max.	Unit
AB_{RES}	AB Resolution	Programmable	1	-	4,096	Pulse/Round
AB_{Freq}	A or B Frequency	Note(3)	-	-	2.048	MHz

Note (3): The AB_{Freq} is the product of RS(Rotation Speed) and AB_{RES}. So, for maximum AB resolution of 4,096 PPR, the maximum supported rotation speed RS is:

$$RS_{MAX} = \frac{AB_{Freq}}{AB_{Res}} = \frac{2.048MHz}{4,096} = 500Hz = 30,000RPM$$

Even >2MHz AB_{Freq} is available, but the INL could not be guaranteed when AB_{Freq} is >2MHz

PWM Output Characteristics

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

Symbol	Parameter	Conditions/Notes	Min.	Typ.	Max.	Unit
F_{PWM}	PWM Frequency	Programmable	-8%	497/994	+8%	Hz
T_{Rise}	Rising Time	C_L=1nF	-	-	1	us
T_{Fall}	Falling Time	C_L=1nF	-	-	1	us

EEPROM Characteristics

Operation conditions: Ta=-40 to 125℃, 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℃	10	-	--	Years

Digital I/O Characteristics

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

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

7. Magnetic Input Specifications

Operation conditions: Ta=-40 to 125℃, 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: Ø10mm x 2.5mm for Cylindrical Magnets	-	10	-	mm
Tmag	Thickness of Magnet	-	-	2.5	-	mm
Bpk	Magnetic Input Field Amplitude (Horizontal Direction)	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 Between Sensor Sensing Center and Magnet Axis (See Figure 5)	-	-	0.3	mm
TCmag1	Recommended Magnet Material and Temperature Drift Coefficient	NdFeB (Neodymium Iron Boron)	-	-0.12	-	%/℃
TCmag2		SmCo (Samarium Cobalt)	-	-0.035	-	

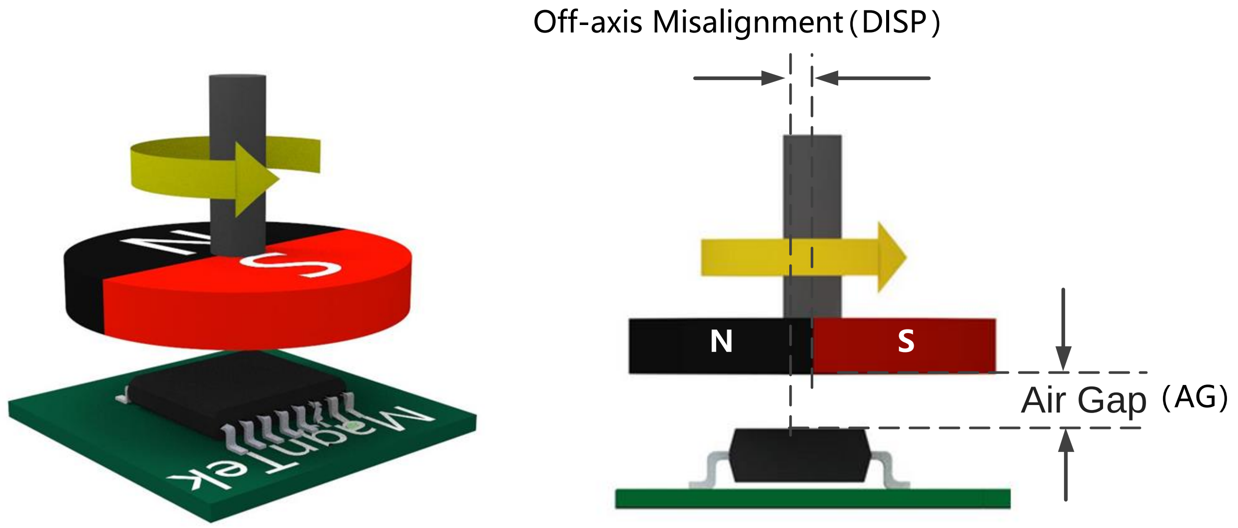


Figure 5: Magnet Arrangement

8. Output Mode

The MT6826S provides ABZ, UVW and PWM signals at output pins, and the 15-bit absolute angle position data could be transferred by the standard 4-Wire SPI interface.

8.1 I/O Pin Configuration

For MT6826S, 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	
	TSSOP-16	QFN4x4	TSSOP-16	QFN4x4
1	U	W	-A	-Z
2	V	U	-B	-A
3	W	V	-Z	-B
4	CAL_EN	MISO	CAL_EN	MISO
5	MISO	MOSI	MISO	MOSI
6	MOSI	SCK	MOSI	SCK
7	SCK	CSN	SCK	CSN
8	CSN	-	CSN	-
10	OUT(PWM)	-	OUT(PWM)	-
12	VSS	OUT(PWM)	VSS	OUT(PWM)
14	Z	VSS	Z	VSS
15	B	TEST_EN	B	TEST_EN
16	A	Z	A	Z
17	-	B	-	B
18	-	A	-	A

8.2 Reference Circuit

The MT6826S 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. 6(Without user auto-calibration). There are 250KΩ pulldown-resistors built into PIN_CAL_EN(Pin.4 for TSSOP16 and Pin.20 for QFN4*4) and PIN_TEST (Pin.13 for TSSOP16 and Pin.15 for QFN4*4).

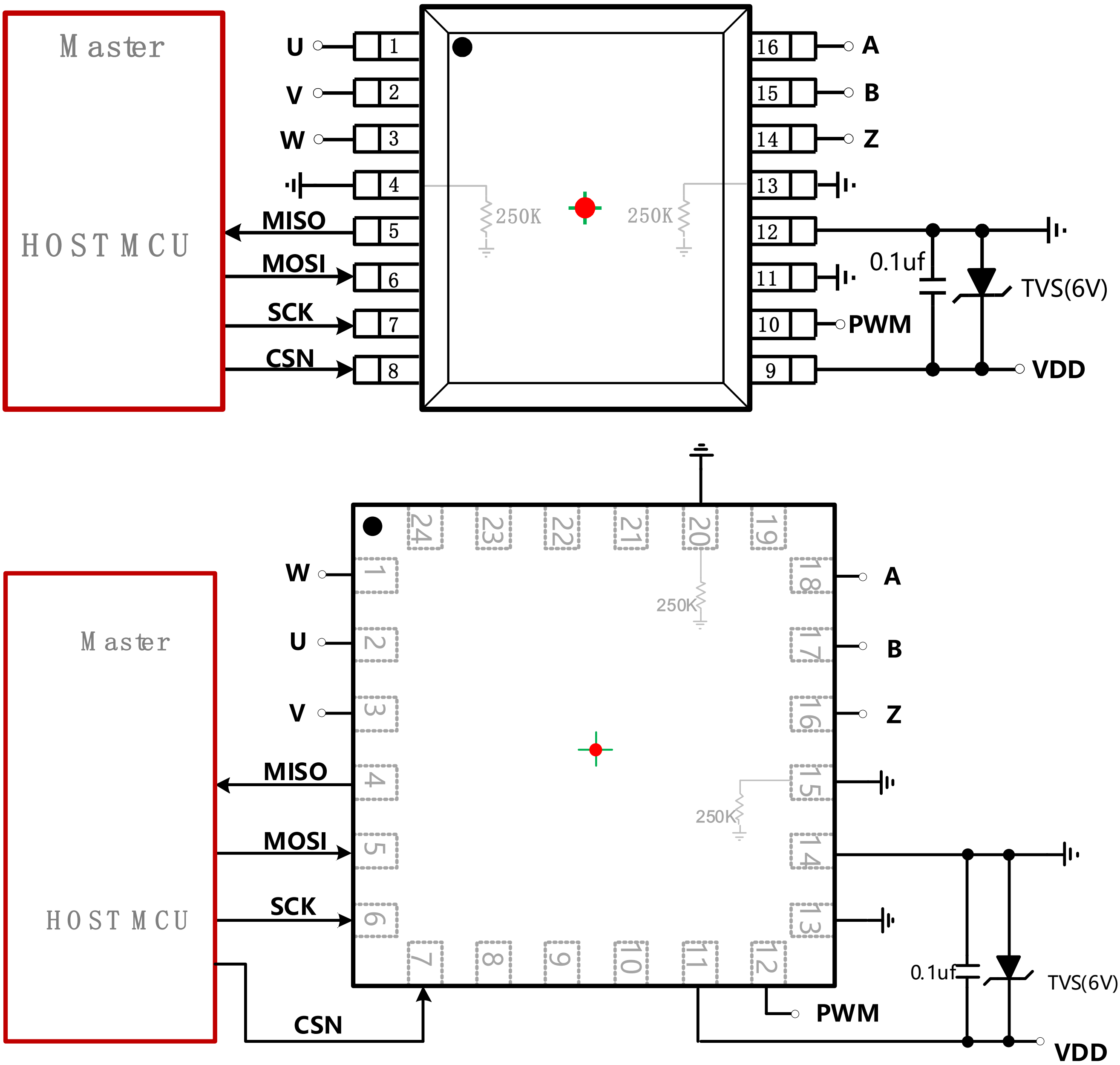


Figure 6: Reference Circuit without User Auto-Calibration

The reference circuit for User Auto-Calibration is shown in Figure. 7, the detail of User Auto-Calibration please refer to Chapter 10.2.

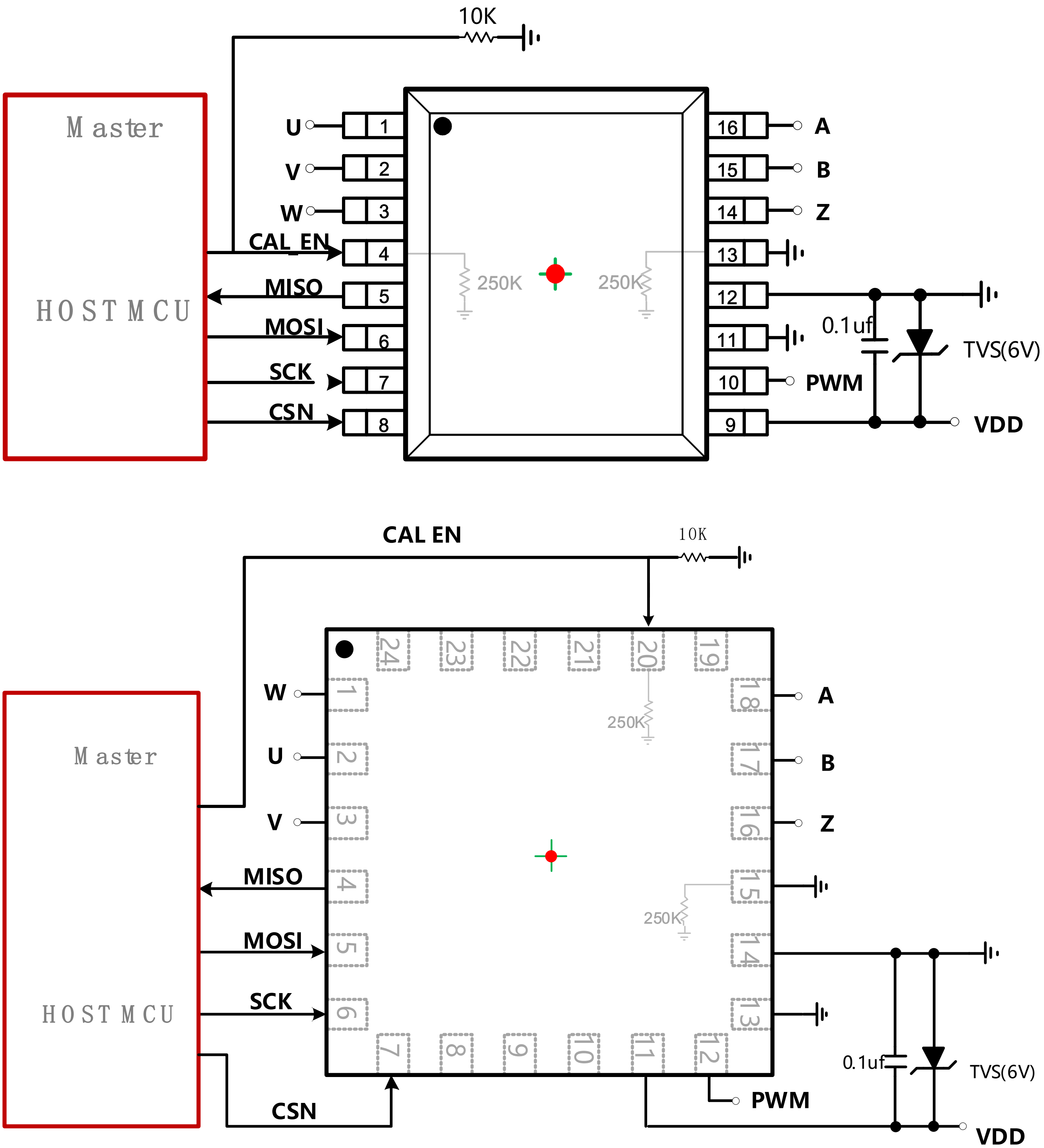


Figure 7: Reference Circuit with User Auto-Calibration

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

As shown in Figure 8, 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 3ms to guarantee proper output.

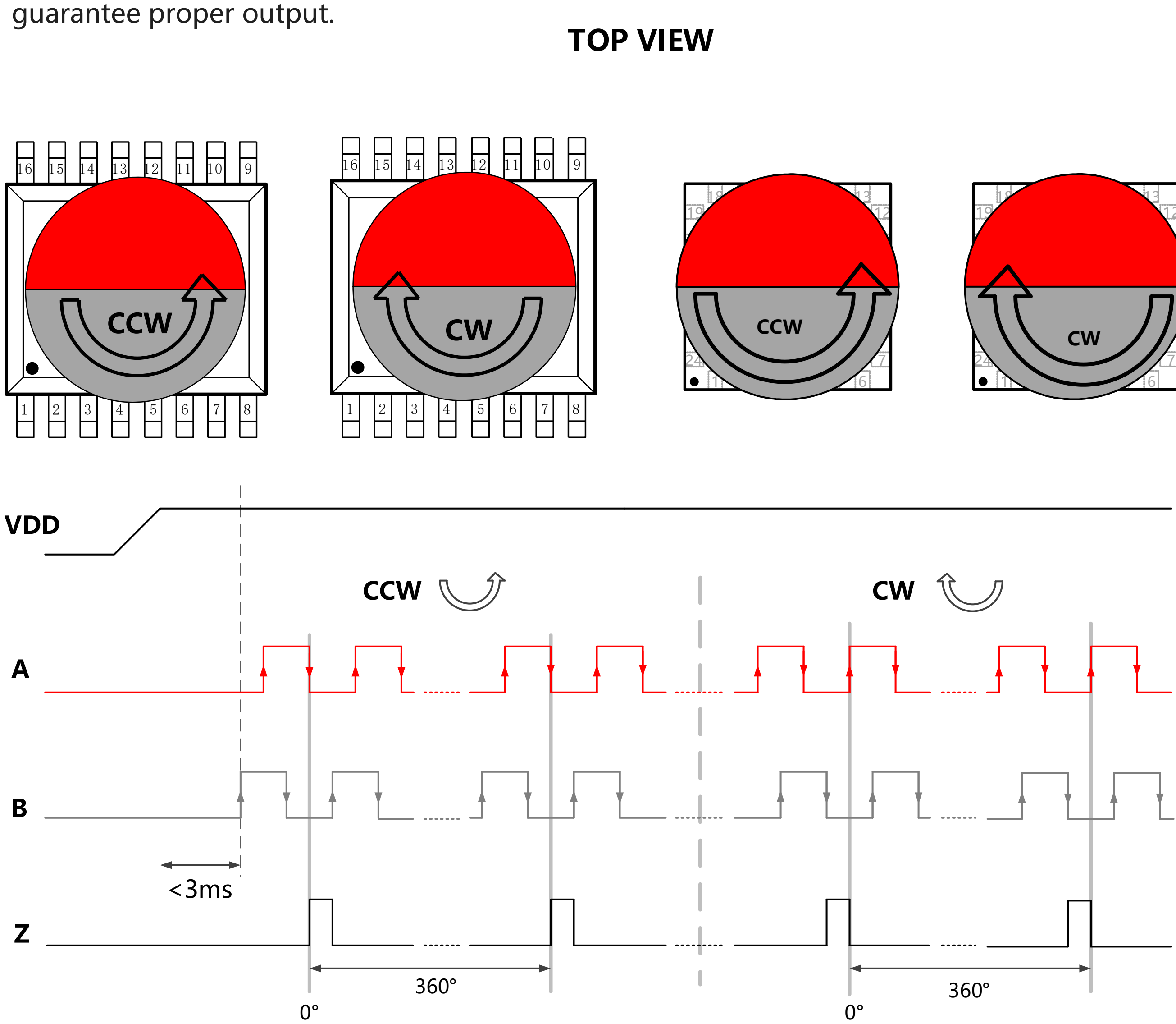


Figure 8: ABZ output with VDD power on

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

ABZ resolution is user programmable from 1~4,096 PPR. The relationship between binary bits, LSBs and PPR resolution of ABZ output are shown in Figure 9 & Figure 10.

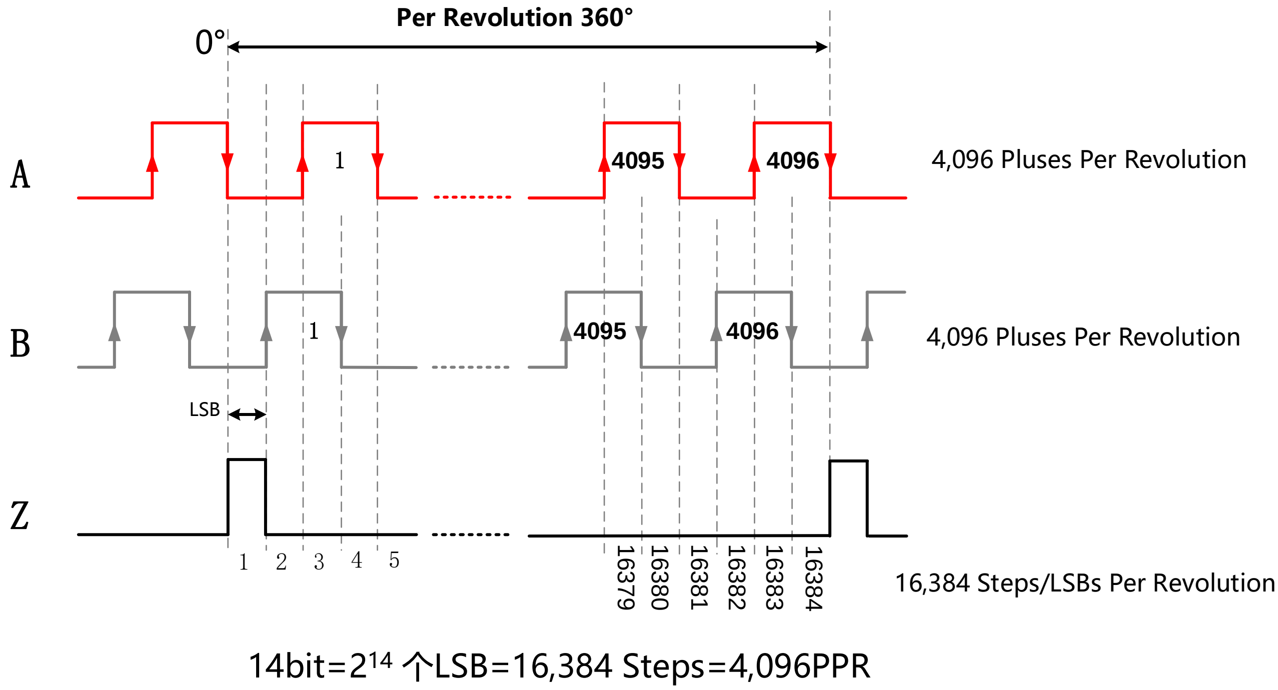


Figure 9:ABZ Output Resolution=14bit=4,096PPR

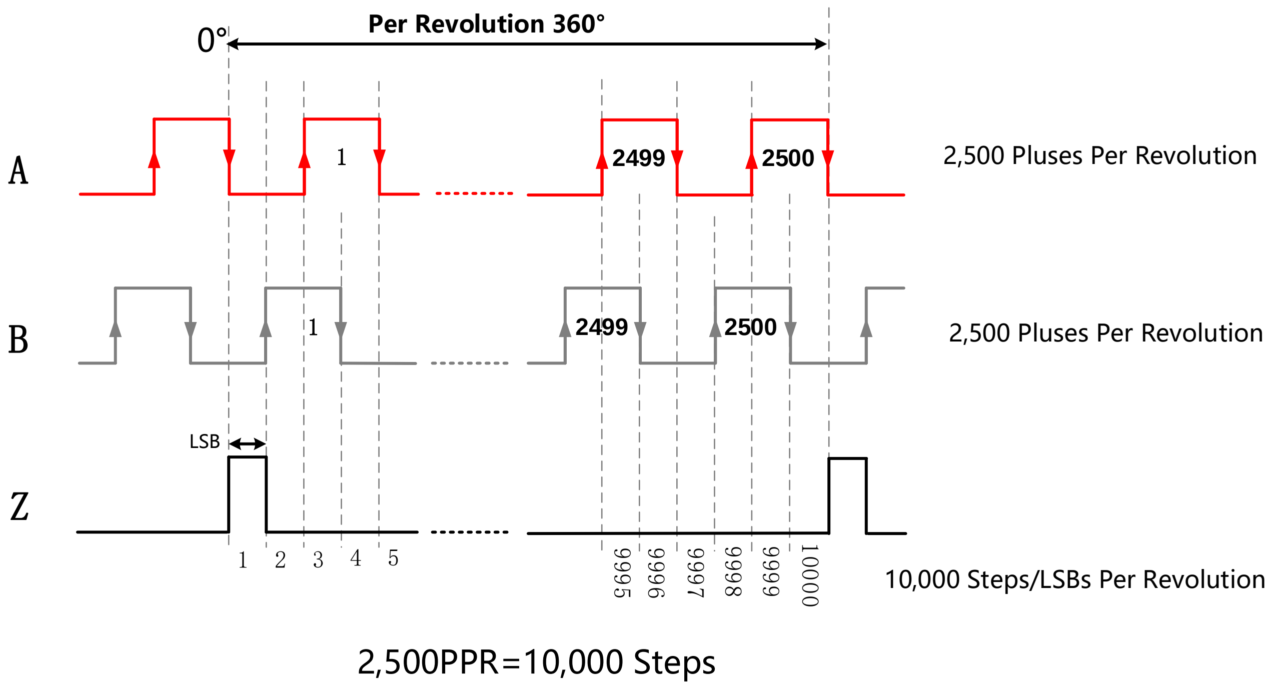


Figure 10: ABZ Output Resolution=2,500 PPR

The resolution of ABZ is defined by a 12-bit register ‘ABZ_RES[11:0]’;

‘ABZ_RES[11:0]’ Register (EEPROM)

Reg. ABZ_RES[11:0]	AB Resolution (Pulse per. Round)
0x000	1
0x001	2
0x002	3
. . .	. . .
0xFFC	4,093
0xFFD	4,094
0xFFE	4,095
0xFFF	4,096

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、32、64、128 LSBs or 45°、60°、90°、120°、135°、180°、240° as shown in Figure 11 and Figure 12. It is guaranteed that one Z pulse is generated for every rotation (with one-pair magnet).

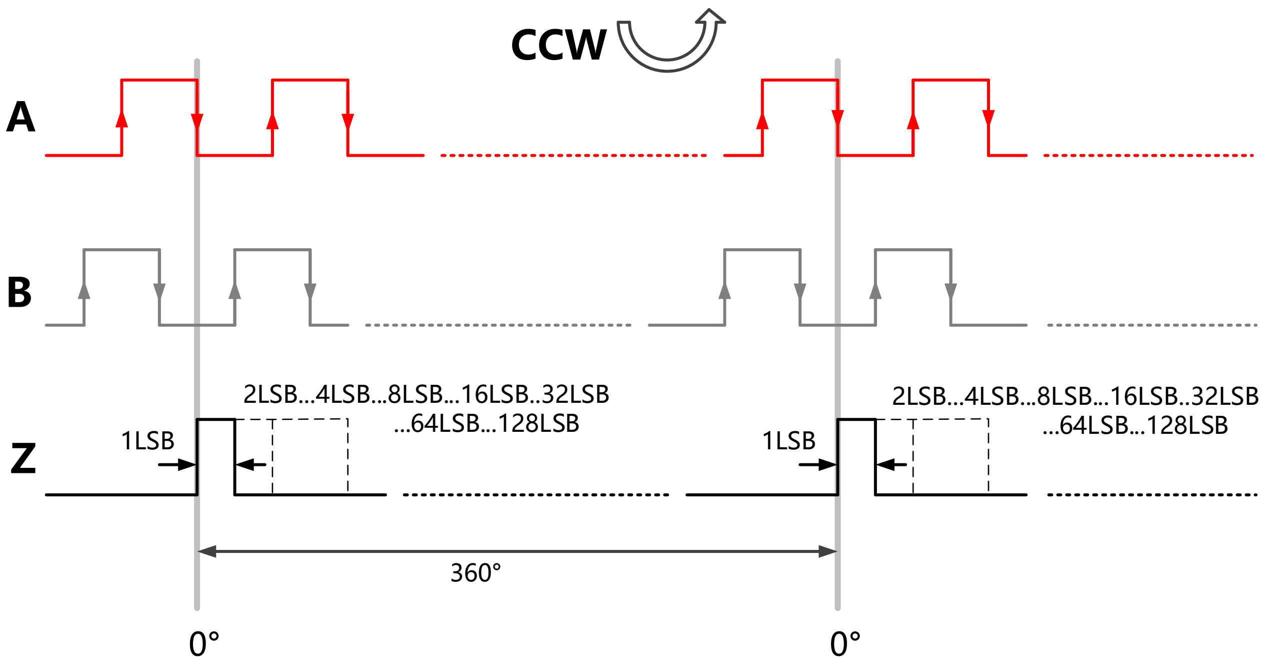


Figure 11: Typical ABZ Output with Z pules width =1、2、4、8、16、32、64、128LSBs

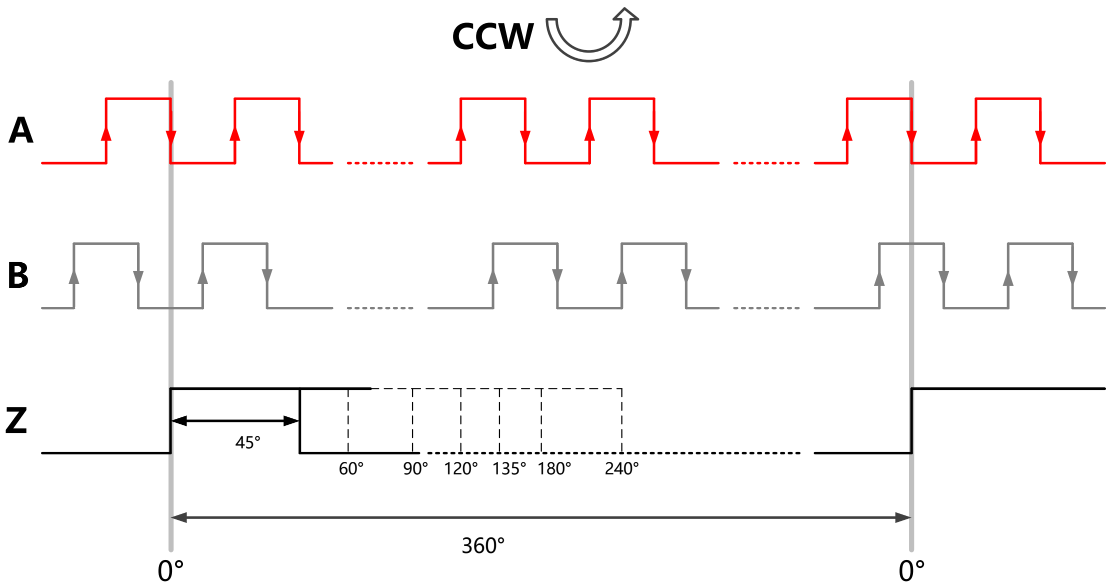


Figure 12: Typical ABZ Output with Z pules width =45°、60°、90°、120°、135°、180°、240°

The width of Z pulse is defined by the 4-bit register 'Z_PUL_WID[3:0]', as shown in the following table;

Z_PUL_WID[3:0]' Register (EEPROM)

Reg. Z_PUL_WID[3:0]	Width (LSBs/°)	Reg. Z_PUL_WID[3:0]	Width (LSBs/°)
0x0	1	0x8	32
0x1	2	0x9	64
0x2	4	0xA	128
0x3	8	0xB	45°
0x4	16	0xC	90°
0x5	60°	0xD	135°
0x6	120°	0xE	240°
0x7	180°	0xF	1

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

Also, Z pulse phase could be user programmable by 'Z_PHASE[1:0]' register as shown in Figure 13.

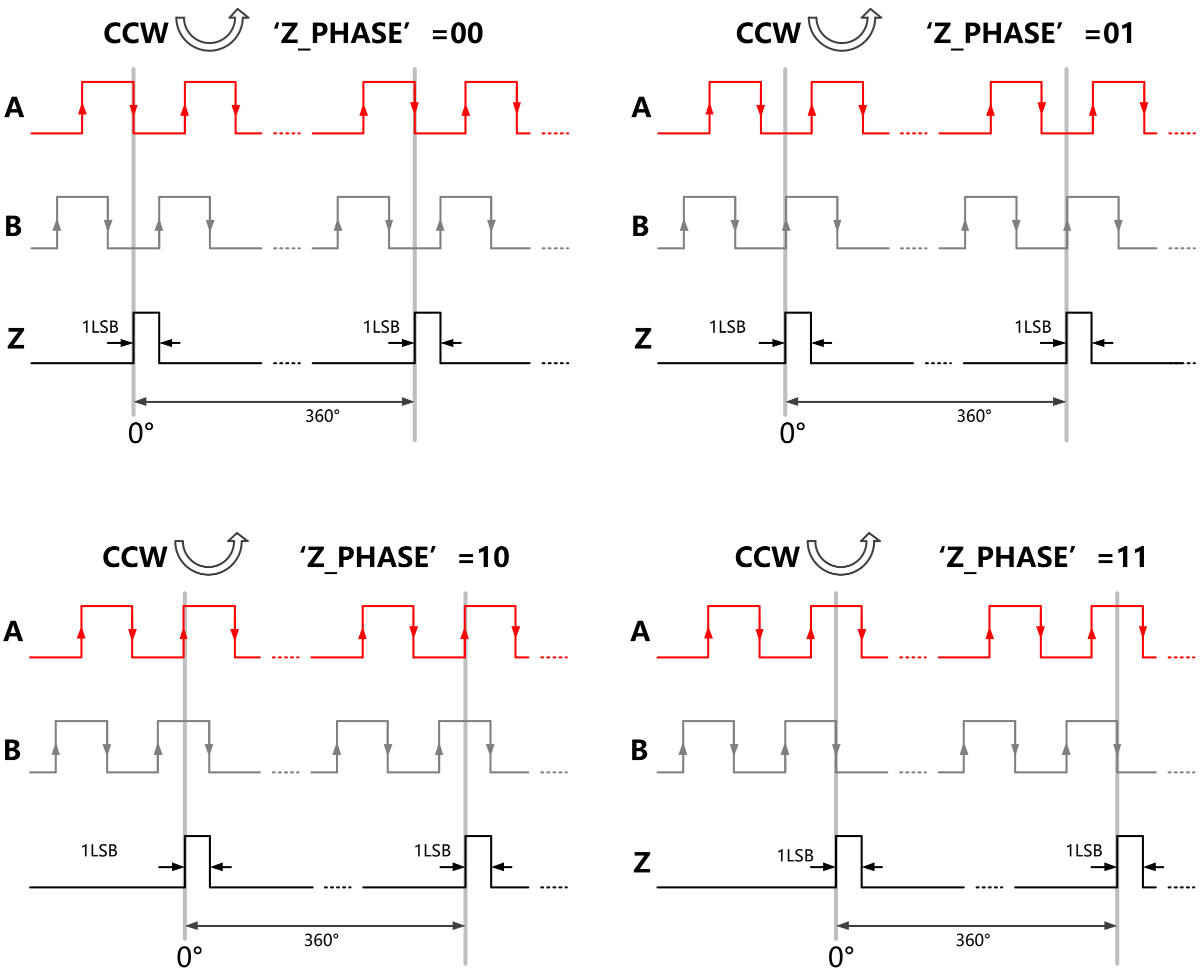


Figure 13: Z Pulse Phase with 'ROT_DIR' =0, 'SWAP_AB' =0, 'Z_EDGE' =0

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

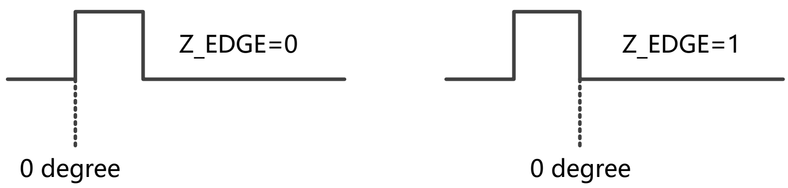


Figure 14: Z Pulse Edge with 0 degree

8.4 UVW Output Mode

The MT6826S provides U, V and W pulses which are 120° (electrical angle) out of phase as shown in Figure 15. The cycles of UVW per rotation can be programmed from 1 to 16.

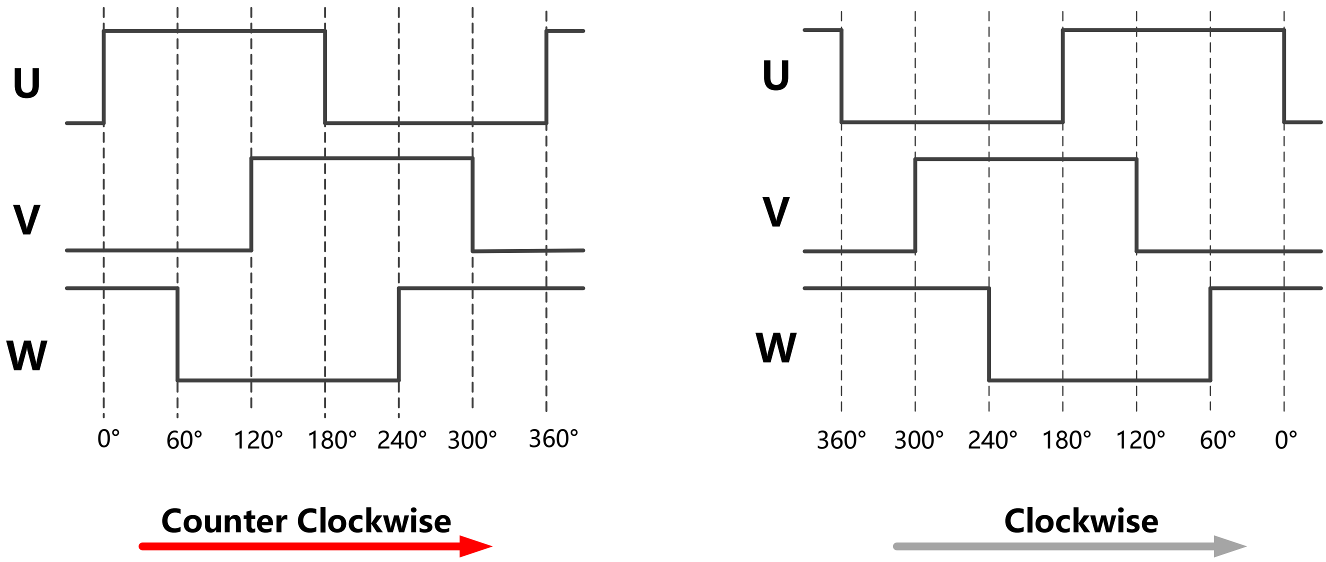


Figure 15: Typical Output Waveform for UVW Mode

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

8.5 Pulse Width Modulation (PWM) Output Mode

The MT6826S provides a digital Pulse Width Modulation (PWM) output, whose duty cycle is proportional to the measured angle as shown in Figure 16. 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. The MT6826S can output 12-bit speed data in addition to 12-bit absolute angle data via PWM.

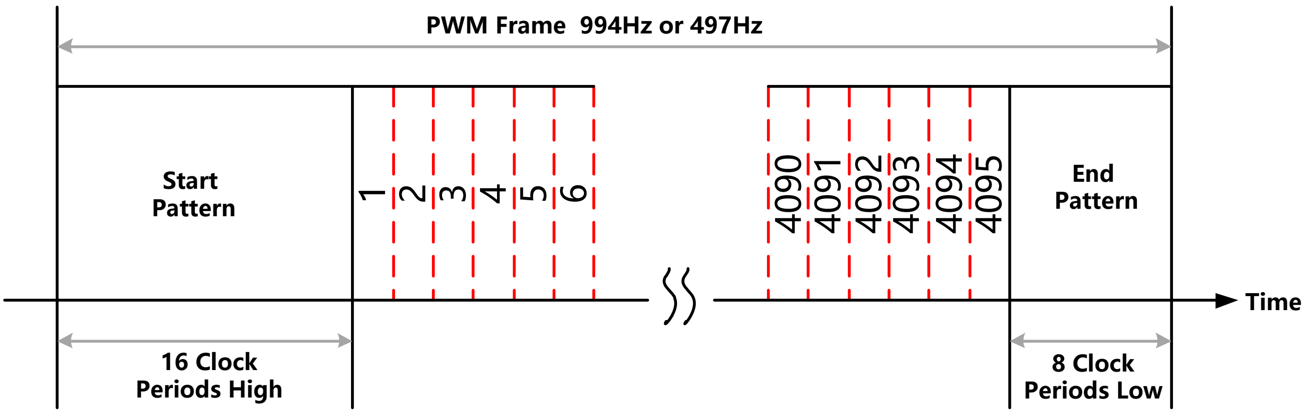


Figure 16: PWM Output Frame

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

8.6 SPI Interface

The MT6826S 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.

8.6.1 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 17.

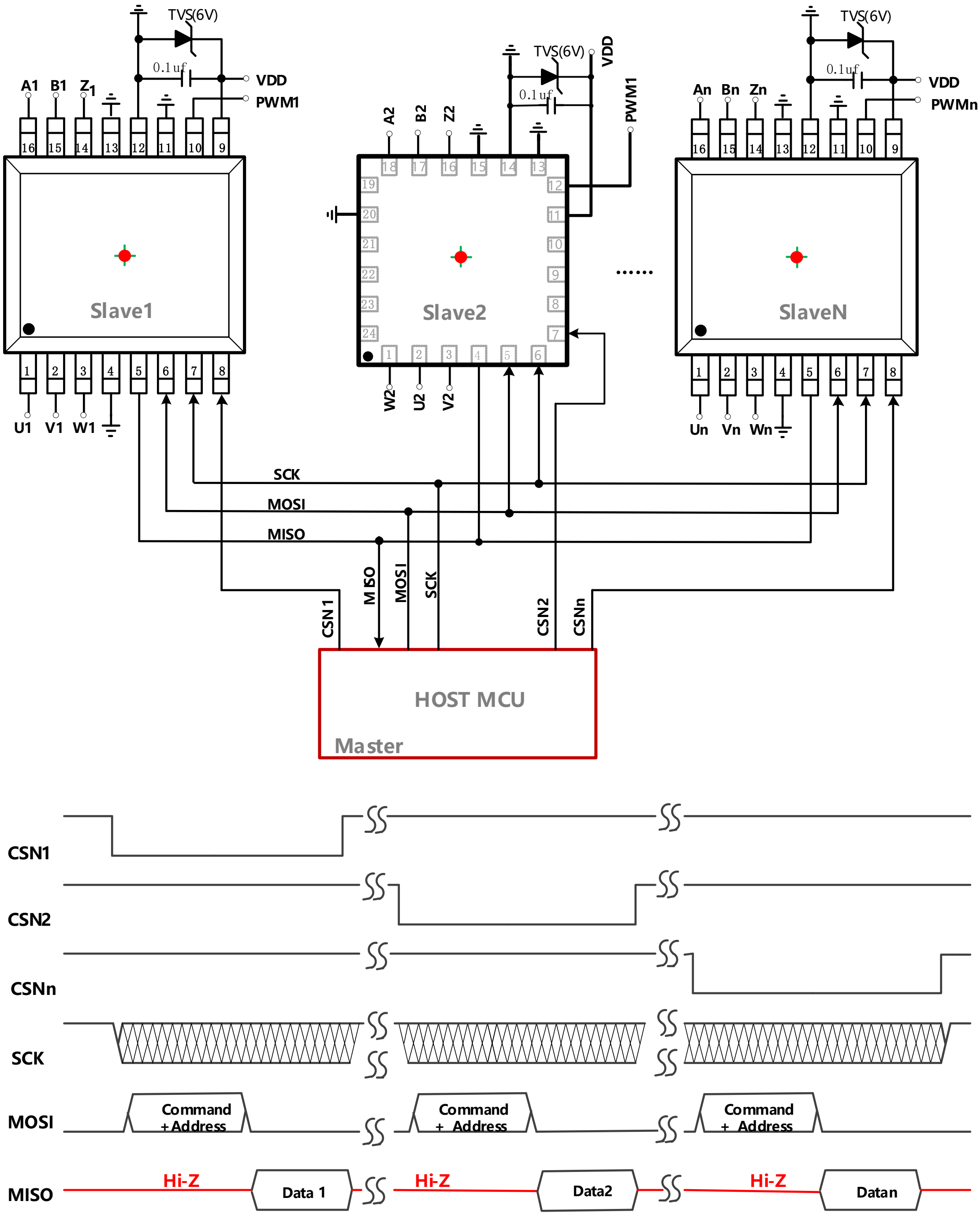


Figure 17: 4-Wire SPI Reference Circuit with multi-chips

8.6.2 SPI Timing Diagram

The MT6826S SPI uses mode3 (CPOL=1, CPHA=1) to exchange data. As shown in Figure 18, a data transfer starts with the falling edge of CSN. The MT6826S samples data on the rising edge of SCK, and the data transfer finally stops with the rising edge of CSN.

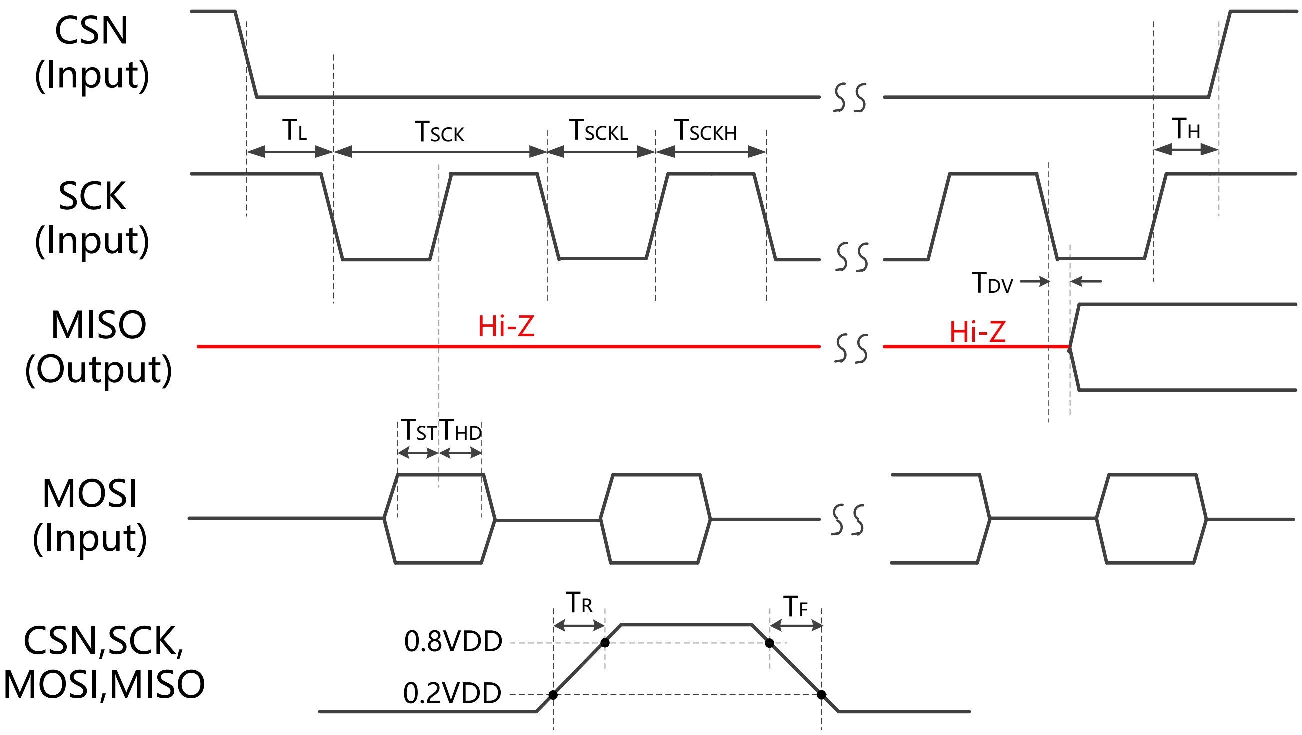


Figure 18: SPI Timing Diagram

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	64		-	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

8.6.3 SPI Protocol

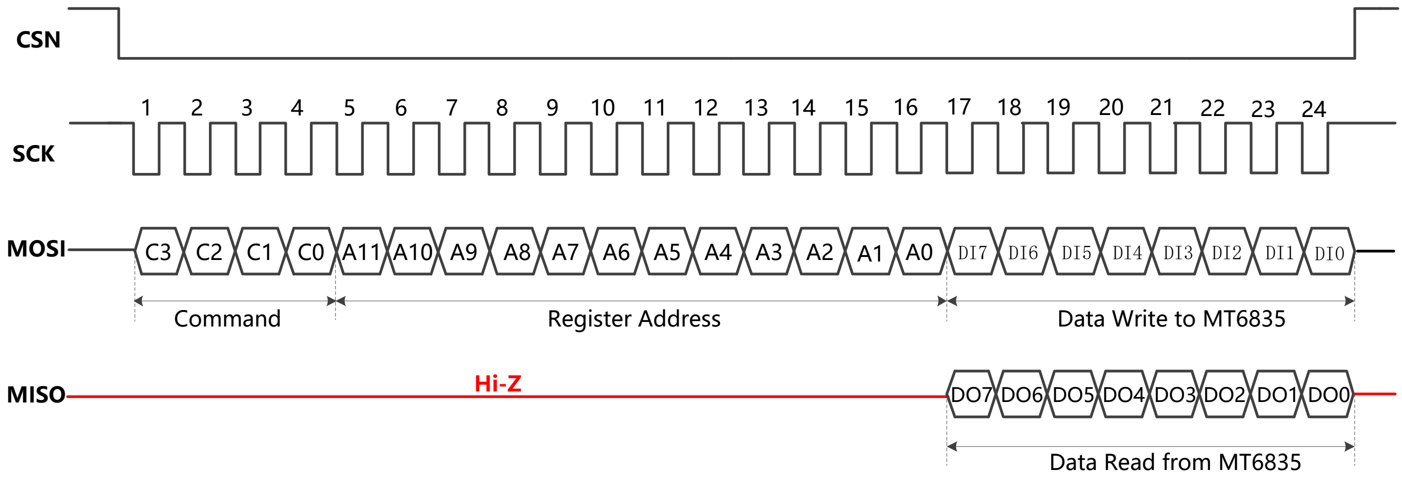


Figure 19: 4-Wire SPI Timing

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 19.

C3~C0	Operation	Notes
0011	Read	User Read Registers
0110	Write	User Write Registers
1100	Program EEPROM	User Erase and Program EEPROM
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.

8.6.4 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 11.

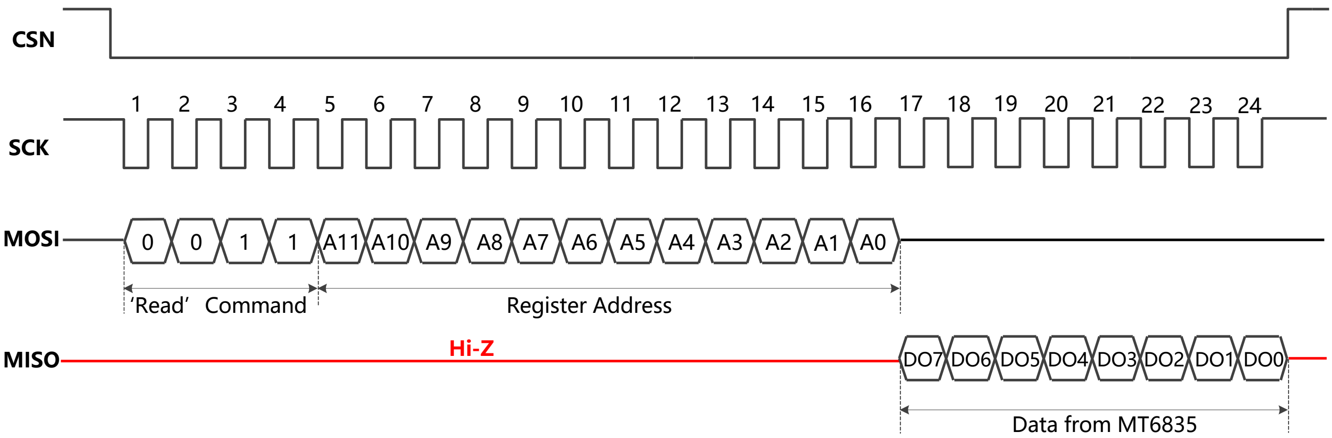


Figure 20: SPI Read One Byte Register

8.6.5 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 11.

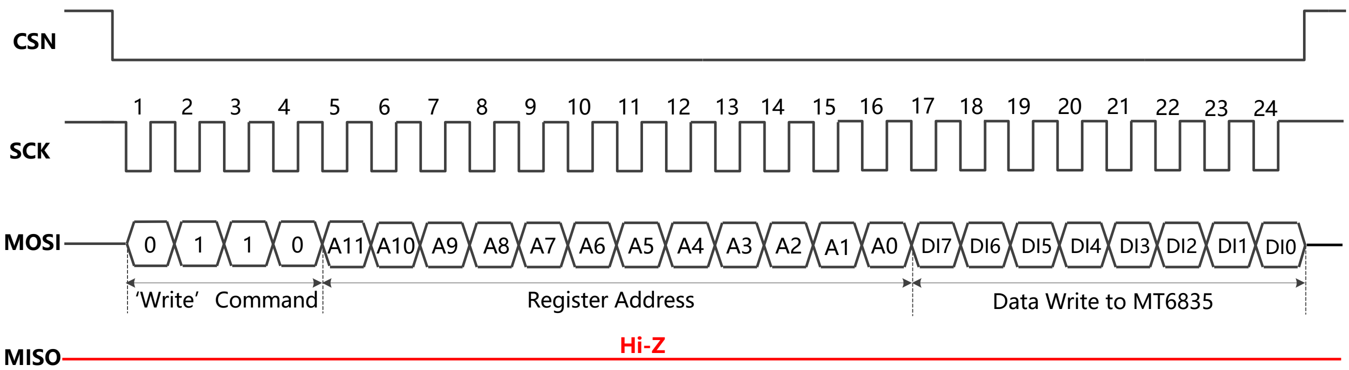


Figure 21: SPI Write One Byte Register

8.6.6 SPI Program EEPROM

As shown in Figure 22, 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. After EEPROM programming instruction is sent , users can query the programming status register to determine the success of the EEPROM programming. **Power off the chip only after the data of register EE_DONE is logic '1'**, otherwise the programming will fail. Address of EE_DONE is 0x112[5].

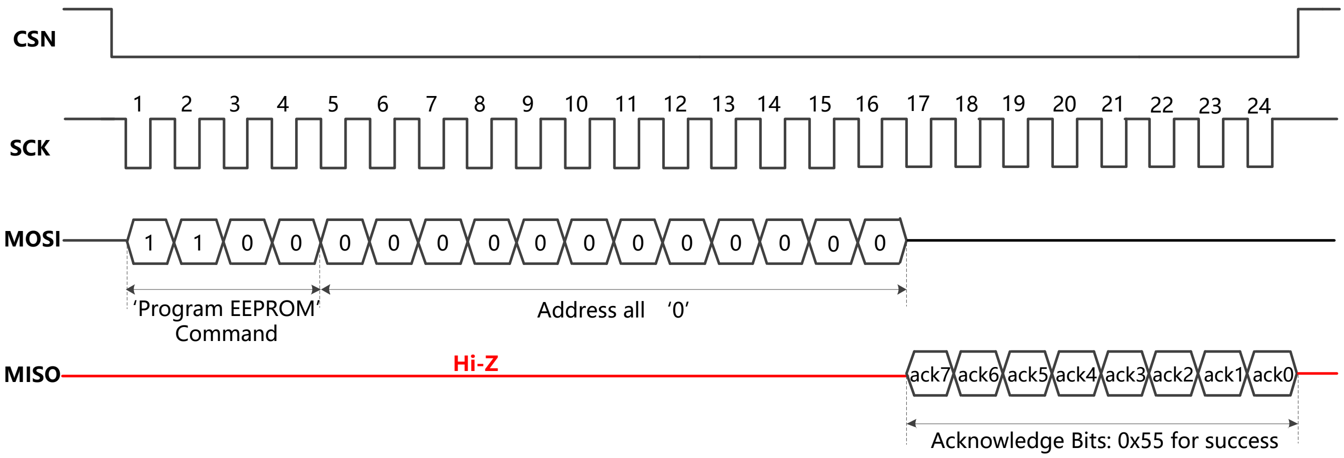


Figure 22: SPI Program EEPROM

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.

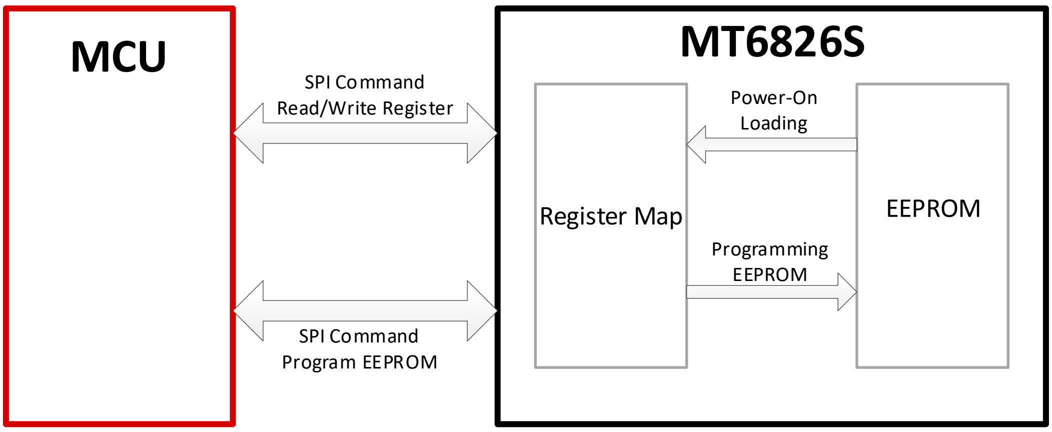


Figure 23: Register Map and EEPROM

8.6.7 SPI Single Byte Read Angle Registers

The 15-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, MT6826S internally latched the data of 0x003~0x006, which will not be refreshed until all 0x003~0x006 registers have been read out.

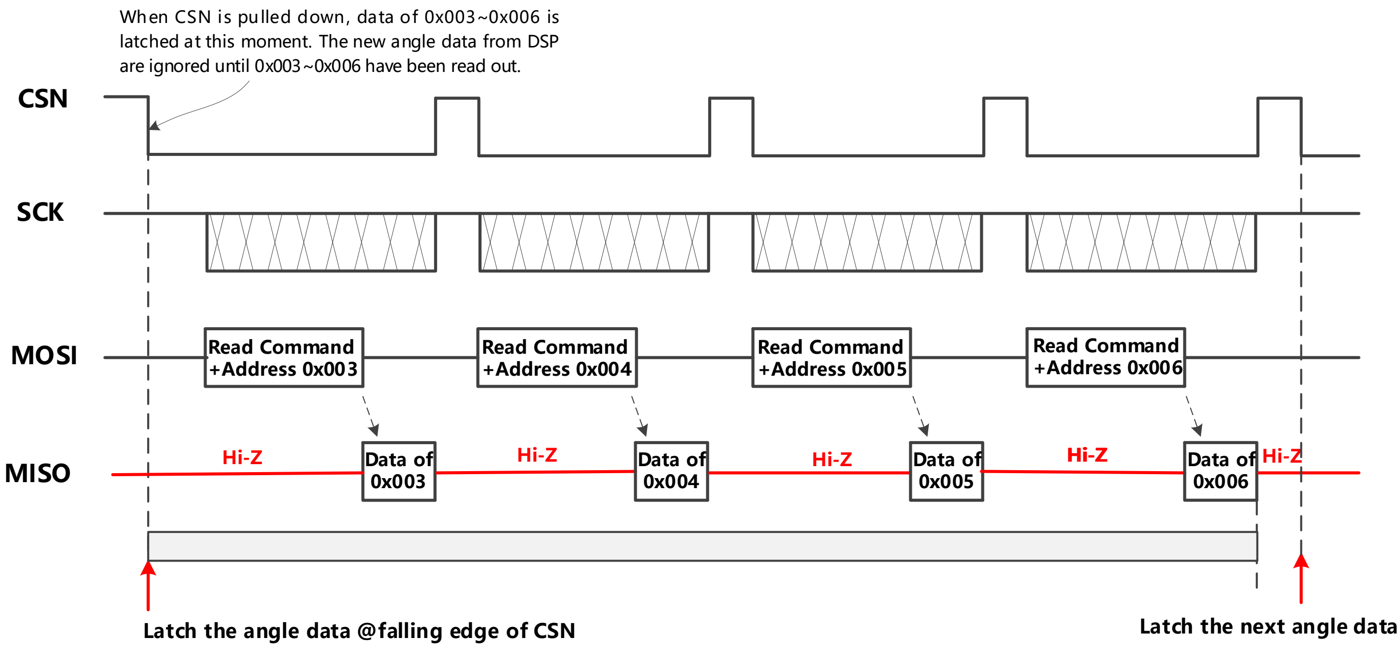


Figure -24: SPI Single Byte Read Angle Register

ANGLE[14:0]' Angle Data Register (Read Only)

Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x003	ANGLE[14:7]							
0x004	ANGLE[6:0]							Fixed Value：0
0x005	Fixed Value：00000					STATUS[2:0]		
0x006	CRC[7:0]							

0~360° absolute angle θ could be calculated by the below formula with ANGLE[14:0]:

$$\theta = \frac{\sum_{i=0}^{14} \text{ANGLE}[i] \bullet 2^i}{2^{15}} \bullet 360°$$

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: From register 0x003 to register 0x005, total 24bits

CRC polynomial: X^8+X^2+X+1, MSB (ANGLE[14]) shifts in first.

8.6.8 SPI Burst Read Angle Registers

The MT6826S 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, MT6826S 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, MT6826S internally latches the data of 0x003~0x006, which will not be refreshed until all 0x003~0x006 registers have been read out.

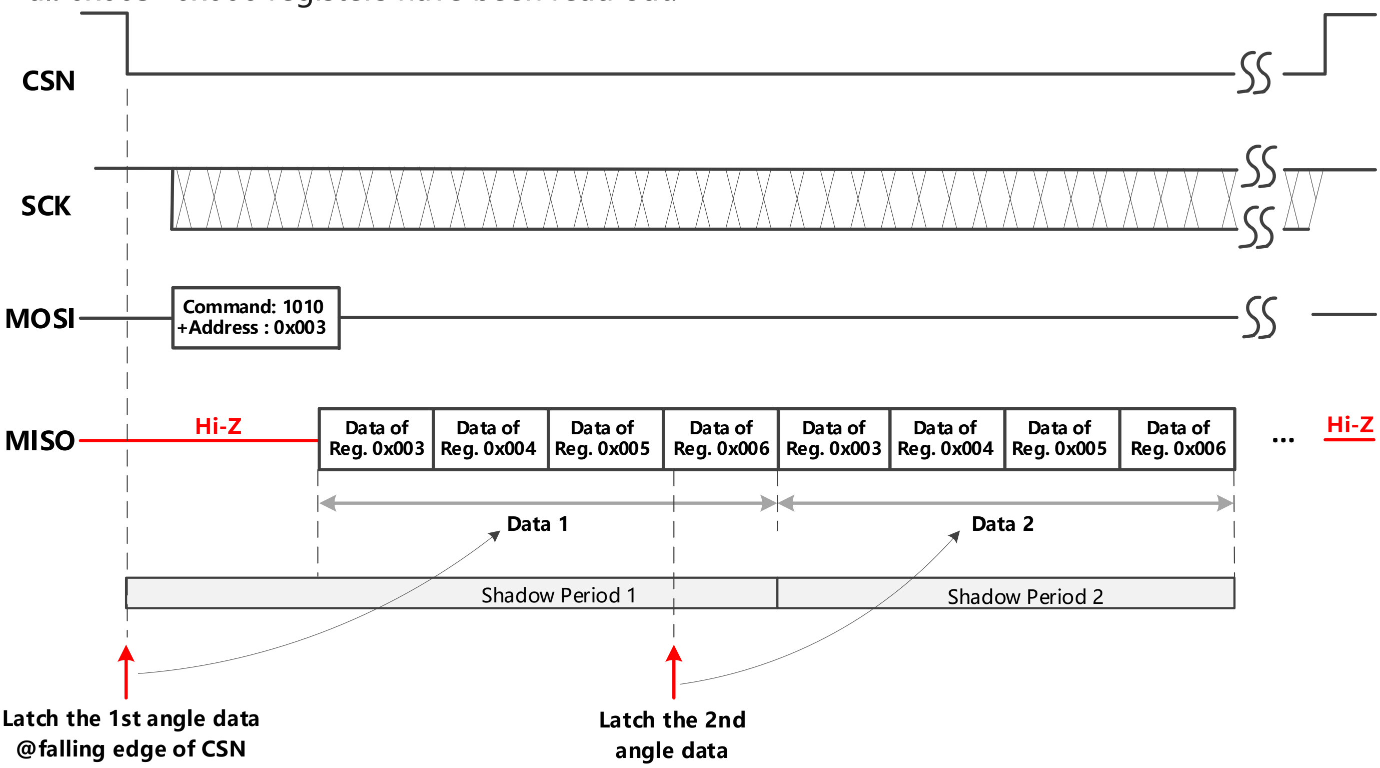


Figure 25: SPI Burst Read Angle Registers

9. Function and Setting of Zero-Position

9.1 Change & Program Zero-Position to EEPROM

The 'ZERO_POS[11:0]' register defines the zero degree of MT6826S, the default zero degree of MT6826S with a two-pole magnet is shown in Chapter 13. The method of changing the register 'ZERO_POS[11:0]' is 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_PUL_WID[3:0]				EEPROM

(1) (a) Write data 0x000 to register 'ZERO_POS[11:0]' by SPI; (Clear raw data to avoid interfering with calculations)

(2) **Wait for more than 100ms**, Read out the angle data of current position by SPI;

(3) Calculate the target Zero-Position value, write it to 'ZERO_POS[11:0]' by SPI;

(4) Program EEPROM, and more details of **programming EEPROM** please refer to **Chapter 8.8.6**

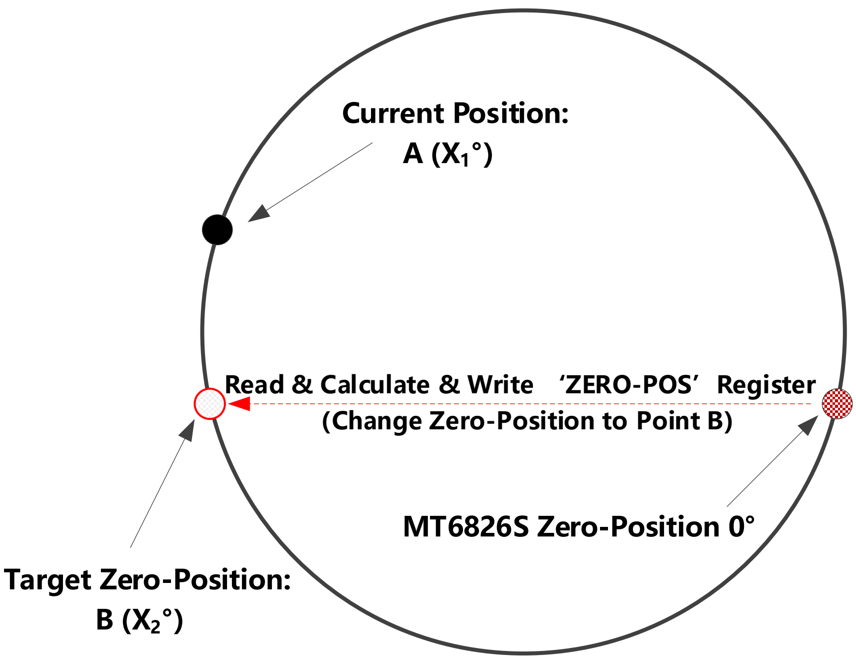


Figure 26: Manual Change Zero Position

9.2 AB Pulses Output the Absolute Angle During Power-on

After power-on, the ABZ output transmits several pulses which correspond to the actual absolute angle value, as shown in figure 27. This function can be enabled by register POS_INIT.

Out A leads out B indicates that the absolute angle is between 180° and 360° , Out B leads out A indicates that the absolute angle is between 0° and 180° . The out of this function is affected by the register ZERO_POS.

Output A leads output B :

The absolute position=360-360* (A steps+B steps) / (ABZ resolution *4) .

Output B leads output A :

The absolute position=360* (A steps+B steps) / (ABZ resolution *4) .

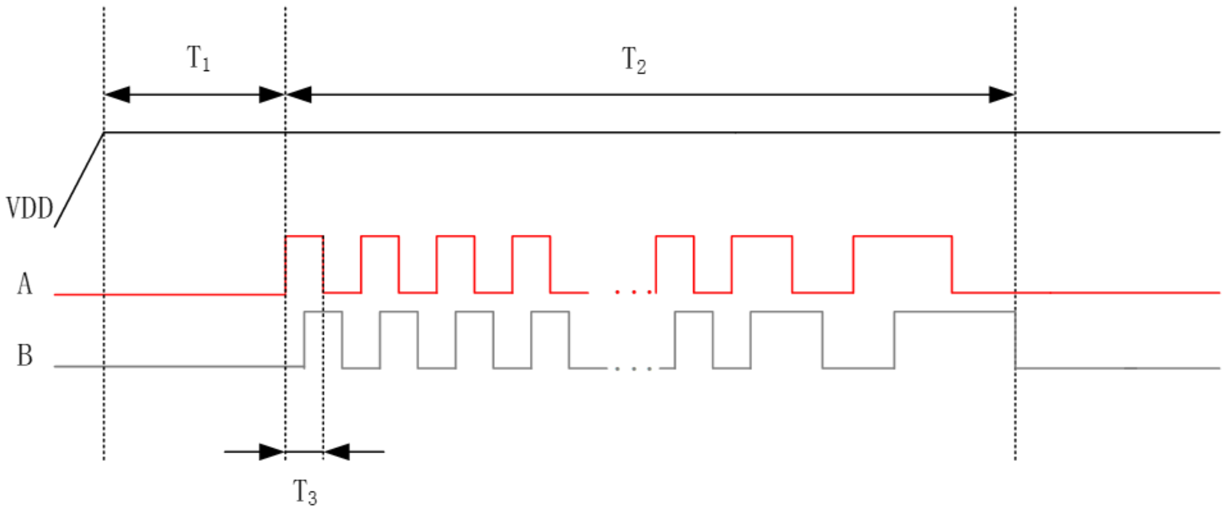


Figure 26: AB Pulses Output the Absolute Angle

AB Pulse Timing Parameter

Parameter	Notes	Min.	Typ.	Max.	Unit
T_1	Time Between Power-on and the First Rising Edge of A or B	450	500	550	us
T_2	Time the A & B Pulses Output Absolute Angle	-	-	30	ms
T_3	A or B Pulse Minimum width	0.9	-	-	us

'POS_INIT' Register (EEPROM)

Reg. POS_INIT	AB pulse represents the absolute Angle when power on
0x0	Disable
0x1	Enable

10. Calibration

Two calibration levels are designed in MT6826S: 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;

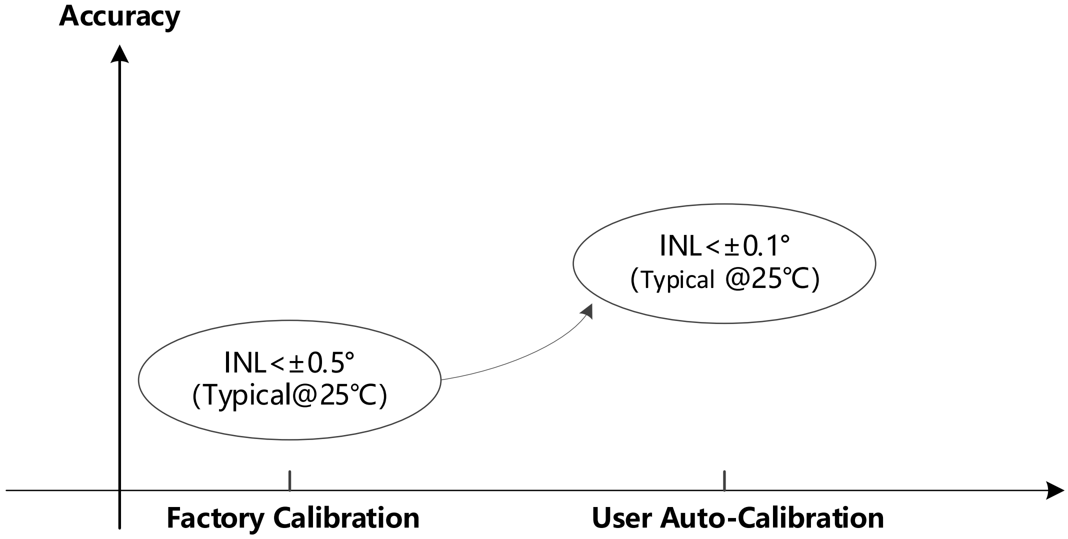


Figure 28: Two Calibration Levels

10.1 Factory Calibration

MT6826S 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 29, thus the INL could be reduced to less than ±0.5° (typical case).

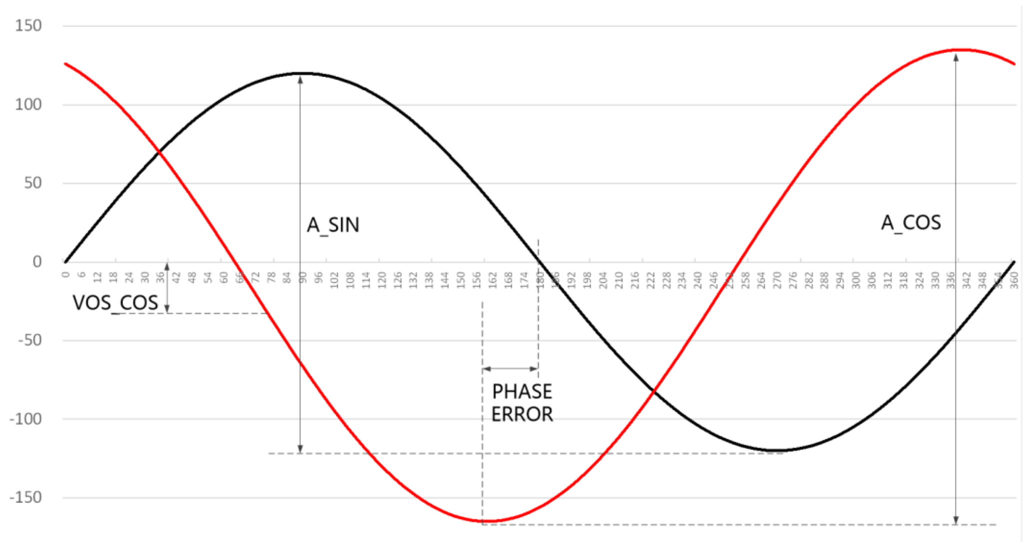


Figure 29: Offset, Gain-Mismatch and Phase-Error

10.2 User Auto-Calibration

User Auto-Calibration allows the user to configure MT6826S 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_CAL_EN to VDD （or write 0x5E to address 0x155） will enable this calibration, then the DSP of MT6826S will automatically calculate compensation coefficients compensate the calibration process. Both of the '0x155' register and CAL_EN exit self-calibration mode to disable the self-calibration. The operation steps:

(1) Setting the rotation speed register for User Auto-Calibration .User can choose different speed to run Auto-Calibration by writing data to Reg.AUTO_CAL_FREQ[2:0].

User Auto-Calibration Rotation Speed Register ‘AUTO_CAL_FREQ’ (EEPROM)

Reg. AUTOCAL_FREQ[2:0]	Description (Rotation Speed: RPM)
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

(2) Rotating the system at a constant speed with the present range ;

(3) Pull up CAL_EN to VDD（or write 0x5E to address 0x155） to start User Auto-Calibration. Keep the system rotating at the set speed for more than 18 rounds. Monitor PWM Output （Pin_PWM will indicate the self-calibration state in self-calibration mode）. **Without self-calibration, CAL_EN should be keep logic low**;

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, **power-down the chip**;

(6) **Other operations cannot be performed until the chip is powered on again.**

11. Register Map

<table>
<tr><th>Address</th><th>Bit7</th><th>Bit6</th><th>Bit5</th><th>Bit4</th><th>Bit3</th><th>Bit2</th><th>Bit1</th><th>Bit0</th><th>Type</th></tr>
<tr><td>0x001</td><td colspan="8">USER_ID[7:0]</td><td>EEPROM</td></tr>
<tr><td>0x002</td><td colspan="8">Not Used</td><td>NA</td></tr>
<tr><td>0x003</td><td colspan="8">ANGLE[14:7]</td><td>Read Only</td></tr>
<tr><td>0x004</td><td colspan="7">ANGLE[6:0]</td><td>Fixed：0</td><td>Read Only</td></tr>
<tr><td>0x005</td><td colspan="5">Fixed：00000</td><td colspan="3">STATUS[2:0]</td><td>Read Only</td></tr>
<tr><td>0x006</td><td colspan="8">CRC[7:0]</td><td>Read Only</td></tr>
<tr><td>0x007</td><td colspan="8">ABZ_RES[11:4]</td><td>EEPROM</td></tr>
<tr><td>0x008</td><td colspan="4">ABZ_RES[3:0]</td><td colspan="2">MagnTek Use Only</td><td>ABZ_OFF</td><td>AB_SWAP</td><td>EEPROM</td></tr>
<tr><td>0x009</td><td colspan="8">ZERO_POS[11:4]</td><td>EEPROM</td></tr>
<tr><td>0x00A</td><td colspan="4">ZERO_POS[3:0]</td><td colspan="4">Z_PUL_WID[3:0]</td><td>EEPROM</td></tr>
<tr><td>0x00B</td><td colspan="2">Z_PHASE[1:0]</td><td>UVW_MUX</td><td>UVW_OFF</td><td colspan="4">UVW_RES[3:0]</td><td>EEPROM</td></tr>
<tr><td>0x00C</td><td colspan="3">MagnTek Use Only</td><td>PWM_FQ</td><td>PWM_POL</td><td colspan="3">PWM_SEL[2:0]</td><td>EEPROM</td></tr>
<tr><td>0x00D</td><td colspan="4">MagnTek Use Only</td><td>ROT_DIR</td><td colspan="3">HYST[2:0]</td><td>EEPROM</td></tr>
<tr><td>0x00E</td><td>GPIO_DS</td><td colspan="3">AUTOCAL_FREQ[2:0]</td><td colspan="4">MagnTek Use Only</td><td>EEPROM</td></tr>
<tr><td>0x011</td><td>Z_EDGE</td><td colspan="4">MagnTek Use Only</td><td colspan="3">BW[2:0]</td><td>EEPROM</td></tr>
<tr><td>0x0D8</td><td colspan="6">MagnTek Use Only</td><td>POS_INIT</td><td>MagnTek</td><td>EEPROM</td></tr>
<tr><td>0x155</td><td colspan="8">Self-Calibration Software Control Key</td><td>R/W</td></tr>
</table>

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

(1) 0x001 *User_ID (EEPROM)*

<table>
<tr><th>Address</th><th>Bit7</th><th>Bit6</th><th>Bit5</th><th>Bit4</th><th>Bit3</th><th>Bit2</th><th>Bit1</th><th>Bit0</th><th>Type</th></tr>
<tr><td>0x001</td><td colspan="8">USER_ID[7:0]</td><td>EEPROM</td></tr>
</table>

- 'USER_ID[7:0]' is a free byte for the user.

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

Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0	Type
0x003	ANGLE[14:7]								Read Only
0x004	ANGLE[6:0]							Fixed：0	Read Only
0x005	Fixed：00000					STATUS[2:0]			Read Only
0x006	CRC[7:0]								Read Only

- 0~360° absolute angle θ could be calculated by the below formula with ANGLE[14:0]:

$$\theta = \frac{\sum_{i=0}^{14} \mathrm{ANGLE}[i] \bullet 2^{i}}{2^{15}} \bullet 360°$$

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

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

- 'CRC[7:0]' : From register 0x003 to register 0x005，total 24bits ,
- CRC polynomial : X^8+X^2+X+1, MSB (ANGLE[14]) shifts in first.

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

Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x007	ABZ_RES[11:4]							
0x008	ABZ_RES[3:0]				MagnTek Use Only		ABZ_OFF	AB_SWAP

- 'ABZ_RES[11:0]' configures the resolution of AB output， please refer to Chapter 8.3;

Reg. ABZ_RES[11:0]	AB Resolution (Pulse per. Round)	Factory Default Setting
0x000	1	√
0x001	2	
… …	… …	
0xFFE	4,095	
0xFFF	4,096	

- '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_PUL_WID[3:0]			

- 'ZERO_POS[11:0]' configures the Zero-Position of MT6826S, 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_PUL_WID[3:0]' configures the width of Z pulse.

Reg. Z_PUL_WID[3:0]	Width (LSBs/°)	Reg. Z_PUL_WID[3:0]	Width (LSBs/°)
0x0	1 (Default)	0x8	32
0x1	2	0x9	64
0x2	4	0xA	128
0x3	8	0xB	45°
0x4	16	0xC	90°
0x5	60°	0xD	135°
0x6	120°	0xE	240°
0x7	180°	0xF	1

(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 and Figure 13.
- '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	

(6) 0x00C PWM Related Registers (EEPROM)

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

- ‘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	

- '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	

(8) 0x011 System Bandwidth (EEPROM)

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

- 'Z_EDGE' configures the relationship of 0° and Z pulse edge ;

Reg. Z_EDGE	Description	Factory Default Setting
0x0	Z Pulse Rising Edge Aligned with Zero-Degree	√
0x1	Z Pulse Falling Edge Aligned with Zero-Degree	

- 'BW[2:0]' configures the MT6826S' 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)	

(9) 0x155 Auto-Calibration software control

Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x155	Auto-Calibration software control KEY							

Write 0x5E to address 0x155 (or pull up CAL_EN to VDD) to start User Auto-Calibration. And write 0x00 to address 0x155 to exit User Auto-Calibration. Both of the '0x155' register and CAL_EN exit self-calibration mode to disable the self-calibration state.

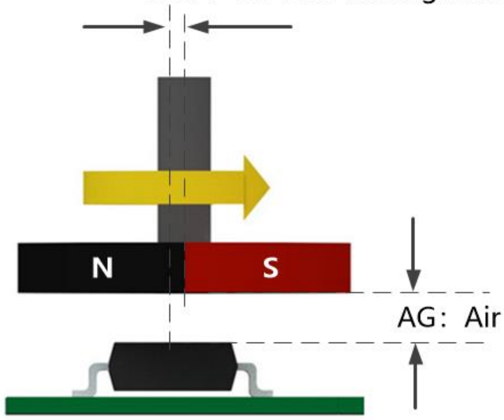
(10) 0x0D8 AB pulse represents the absolute Angle enable

Address	Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
0x0D8	**MagnTek Use Only**						POS_INIT	**MagnTek**

Write 0x1 to 0x0D8[1] to enable this function, and write 0 to 0x0D8[1] to disable this function.

12. Magnet Placement

It is required that the magnet' s center axis be aligned with the sensing element center of MT6826S 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. Without Auto-Calibration, more tolerant to DISP (off-axis misalignment) and bigger AG (air-gap between Magnet and device) will cause larger angle error, shown in Figure30.



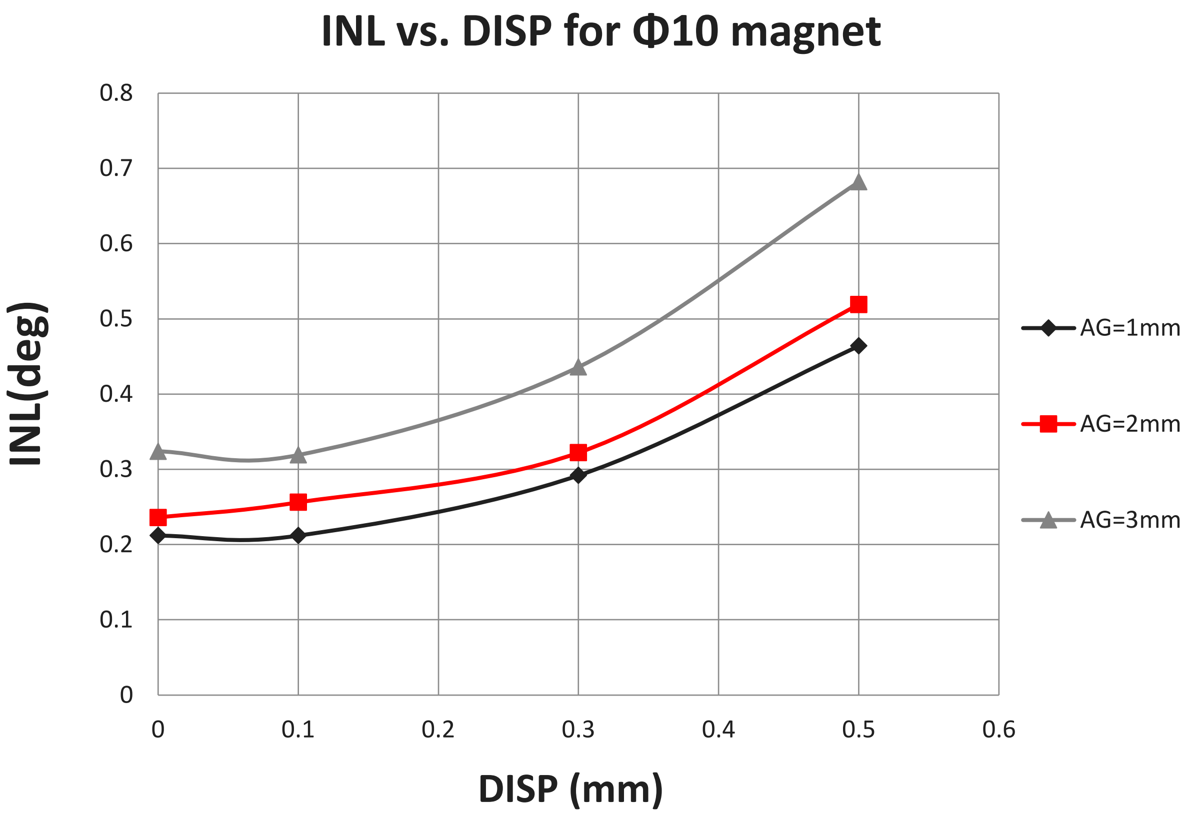
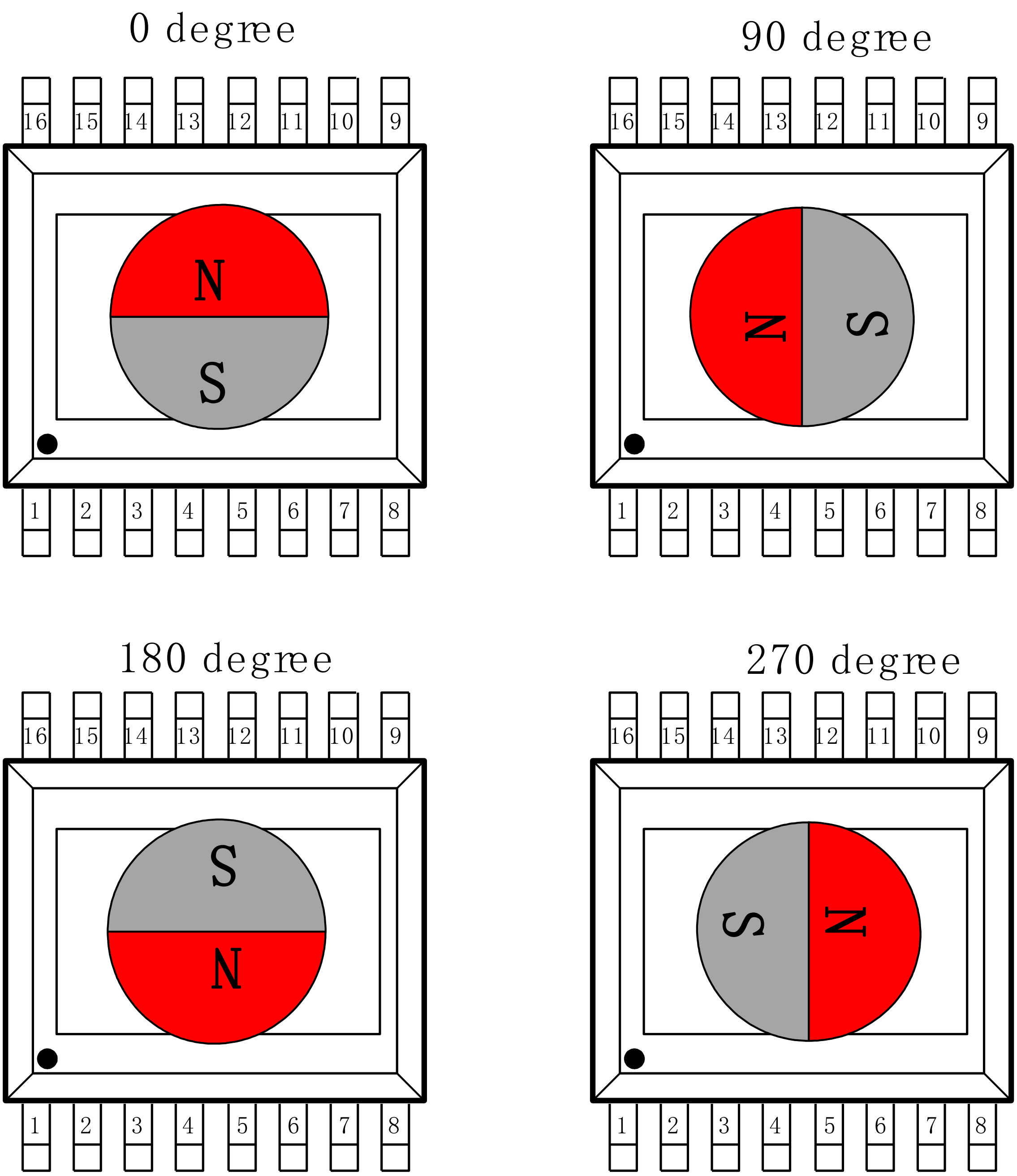


Figure 30: INL vs DISP and AG with Factory Calibration Only

13. Mechanical Angle Direction

Top View

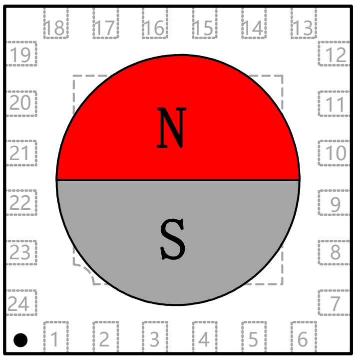


Counter-Clockwise Rotation (CCW)

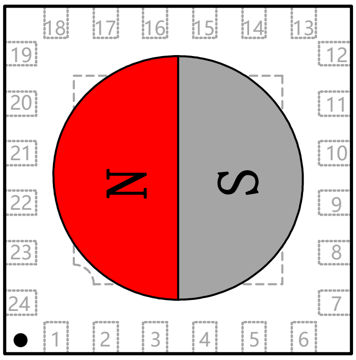
(with Register ‘ROT-DIR’ =0)

Top View

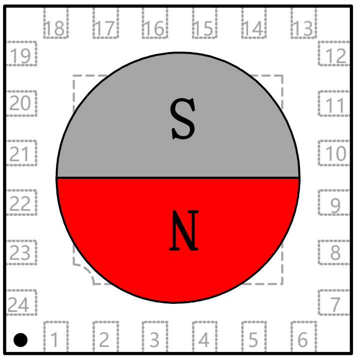
0 degree



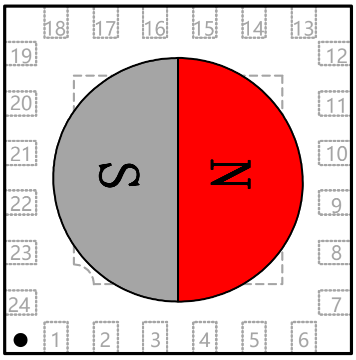
90 degree



180 degree



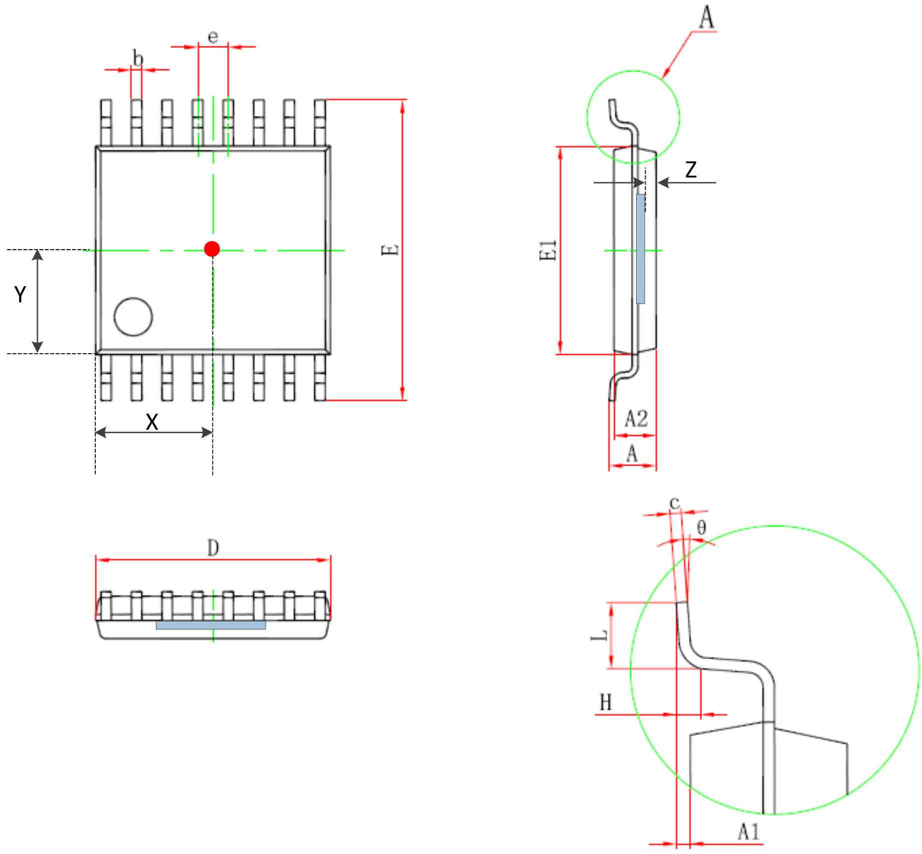
360 degree



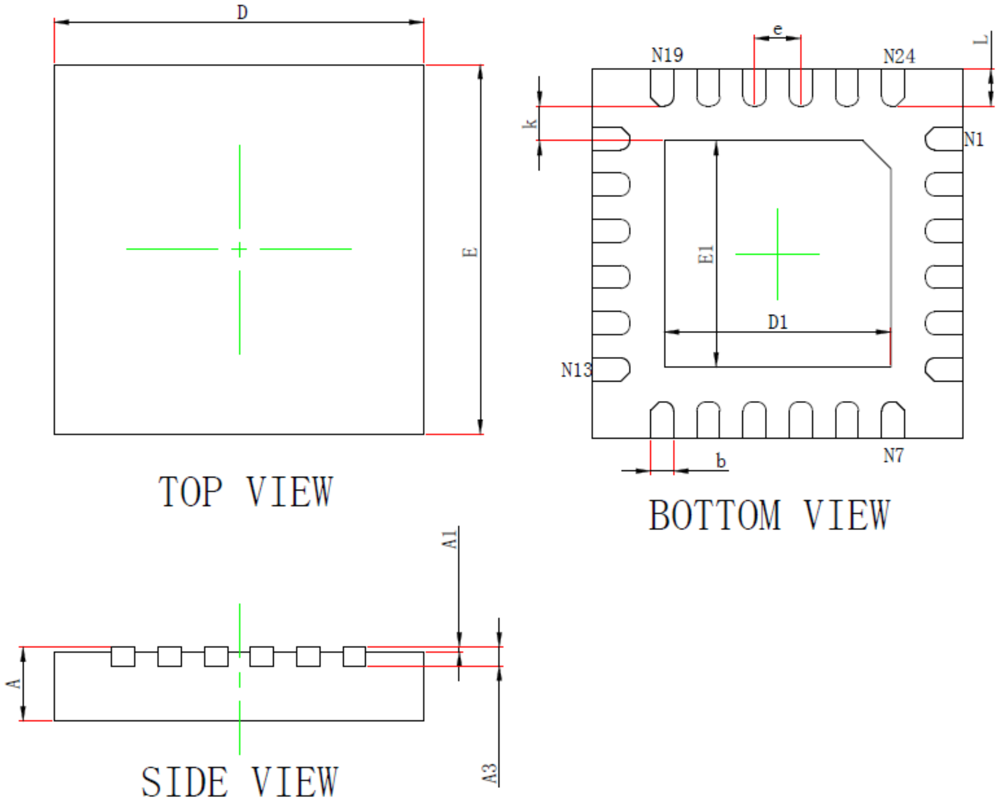
Counter-Clockwise Rotation (CCW)

(with Register ‘ROT-DIR’ =0)

14. Package Information



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



Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min.	Max.	Min.	Max.
A	0.700/0.800	0.800/0.900	0.028/0.031	0.031/0.035
A1	0.000	0.050	0.000	0.002
A3	0.203REF.		0.008REF.	
D	3.950	4.050	0.156	0.159
E	3.950	4.050	0.156	0.159
E1	2.400	2.500	0.094	0.098
D1	2.400	2.500	0.094	0.098
k	0.200MIN		0.008MIN	
b	0.200	0.300	0.008	0.012
e	0.500TYP.		0.020TYP.	
L	0.350	0.450	0.014	0.018

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16. Revision History

Revision	Date	Comments
1.0	2023.10	Formal Release
1.1	2024.01	(1) Update Chapter.1.2: QFN4x4 Pin Configuration (2) Update Chapter.9.2: AB Pulses Output the Absolute Angle During Power-on

单击下面可查看定价，库存，交付和生命周期等信息

>>Magntek(麦歌恩)