1. Features

- 14-bit resolution rotary encoder
- Support maximum speed of 200K rpm
- Angular linear error <±0.35°
- Power output withstand voltage ≥24V, < -18V
- Support multiple interface options:
  - Sin/Cos analog signals
  - ABZ+PWM
  - 4-wire/3-wire SPI protocol output
- Supports 3.3V and 5.0V operating voltage applications
- SC60214 supports 3 times of zero adjustment and features a wire-saving mode
- Diagnostic functions: wire breakage, overcurrent, undervoltage/overvoltage, overtemperature
- Operating temperature range: -40℃ to 125℃
- SOP8 package type

2. Applications

- Absolute angular position sensor
- Robotic joint control
- Contactless knobs/Potentiometers
- Mouse scroll wheel encoding
- Stage lighting pan/Tilt position feedback

3. Description

SC6021X is a non-contact, high-speed, high-precision magnetic encoder chip series with a built-in Hall induction point matrix in the center of the chip, which generates sine and cosine position signals by sensing a pair of pole magnets above the chip. The analog-to-digital conversion circuit inside the chip samples the amplified sine and cosine signals, the DSP circuit performs angle calculations, and finally outputs various position signals. The SC6021X has a resolution of 14-bit and supports up to 200K rpm.

SC60210 supports differential sine and cosine output, and can program magnification and offset according to the user's actual application environment.

SC60214 the chip is calibrated to zero point through an external programmer, which needs to be phased in at the zero position of the motor, and then the encoder chip is calibrated. The incremental output interface outputs up to 1024 lines through the A, B, and Z pins, providing products with different resolutions according to actual usage needs.

SC60218 provides 14-bit SPI protocol output and supports four-wire/three-wire mode.

SC6021X is available in an 8-pin SOP-8 package, matt tin plated, and halogen-free green material to meet environmental protection requirements.
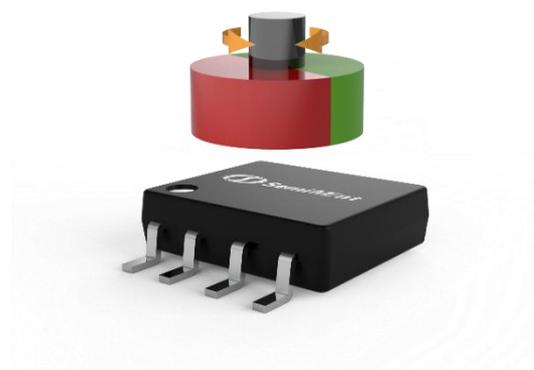

Fig.1 Schematic diagram of the work

CONTENTS

4. Pin Description

Fig.2 SC6021X Pin Description

Pin		Type	Pin function description
Name	No.		
VDD	1	PWR	Chip power supply port
VREG	2	PWR	The high-voltage LDO output inside the chip is connected to an external 100nF decoupling capacitor
Prog	3	Program	Program debug pin Program debug pin
GND	4	Ground	Chip Ground
IO1	5	In/Out	SPI mode: CSN, SPI communication enables input signal
			ABZ/PWM mode: A-channel incremental signal output/line-saving mode PWM output
			SIN/COS mode: COSP, cosine signal positive output
IO2	6	In/Out	SPI mode: SCK, SPI communication clock input signal
			ABZ/PWM mode: B-channel incremental signal output
			SIN/COS mode: COSN, negative output of cosine signal
IO3	7	In/Out	SPI mode: MOSI, SPI communication data slave signal input
			ABZ/PWM mode: Z-channel incremental signal output
			SIN/COS mode: SINP, positive output of sine signal
IO4	8	In/Out	SPI mode: MISO, SPI communication data slave signal output
			ABZ/PWM mode: PWM absolute angular output
			SIN/COS mode: SINN, negative output of sinusoidal signal

5. Ordering Information

Ordering Information	Mark	Option	Output	Ambient(℃)	Package	Pack	Amount
SC60210DC-TR-	60210	-	±SIN/COS	-40~125	SOP8	Tape&Reel	4000Pcs/Reel
SC60214DC-1024-TR	60214	1024	ABZ+PWM	-40~125	SOP8	Tape&Reel	4000 Pcs/Reel
SC60214DC-256-TR	60214	256	ABZ+PWM	-40~125	SOP8	Tape&Reel	4000 Pcs/Reel
SC60214DC-50-TR	60214	50	ABZ+PWM	-40~125	SOP8	Tape&Reel	4000 Pcs/Reel
SC60214DC-24-TR	60214	24	ABZ+PWM	-40~125	SOP8	Tape&Reel	4000 Pcs/Reel
SC60218DC-TR	60218	-	SPI	-40~125	SOP8	Tape&Reel	4000 Pcs/Reel

Ordering Information Format

Part Number

SC6021XDC-1024-TR

Package Options
TR: Tape & Reel

Parameter Options
1024=1024 lines
256=256 lines
50=50 lines
24=24 lines

Package Designation
DC: SOP8

Output Form
0: ±SIN/COS
4: ABZ+PWM
8: SPI

Device Family
SC6021X: High-speed magnetic encoder IC
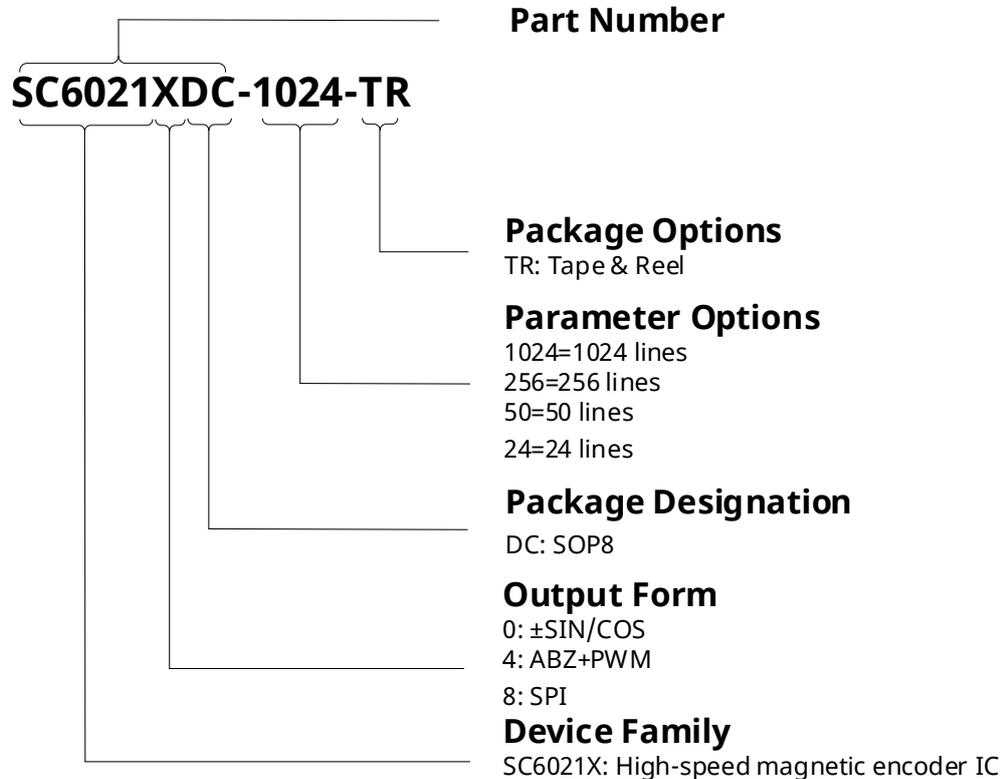
6. Absolute Maximum Ratings

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
VDD	Power supply end withstand voltage		-24	24	V
VREG	Voltage rating of the voltage stabilizing terminal		-0.3	6.5	V
Prog	Programming feet		-0.3	6.5	V
IO1/2/3/4	Output withstand voltage		-24	24	V
T_A	Operating temperature		-40	160	°C
T_{STG}	Storage temperature		-65	175	°C
$T_{J(max)}$	Maximum junction temperature		-55	165	°C

Note:
Stresses above those listed here may cause permanent damage to the device. Prolonged exposure to absolute maximum ratings may affect the reliability of the device.

7. ESD Protection

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
V_{ESD}	HBM	Human failure model, refer to ANSI/ESDA/JEDEC-001 standard	-4	4	kV
	CDM	Device failure model, refer to ANSI/ESDA/JEDEC-002 standard	-750	750	V

8. Operating Characteristics

Operating temperature range (V_{DD}=5.0V, unless otherwise noted) [1]

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Electrical Characteristics						
V_{DD_5v}	5V application operating voltage	Refer to the 5V application circuit connection	4.5	5.0	5.5	V
$V_{DD\_3.3v}$	3.3V application operating voltage	Refer to the 3.3V application circuit connection	3.0	3.3	3.6	V
I_{DD_5V}	5V application current	V_{DD}=5.0V	-	8.0	12	mA
$I_{DD\_3.3V}$	3.3V application current	V_{DD}=3.3V	-	7.0	11	mA
V_{REG}	5V operation, V_{REG} pin voltage	C_{REG}=100nF	3.7	4.0	4.3	V
C_{REG}	VREG pin decoupling capacitors		47	100	470	nF
$PSRR\_{VREG}$	Power supply rejection ratio	1K-1M?				dB
V_{OVP}	Overvoltage diagnoses the on-voltage voltage	V_{DD}>8V	6.5	7.0	7.5	V
V_{OVP_HYS}	Overvoltage diagnoses hysteresis voltage		0.2	0.5	0.8	V
V_{UVR}	Undervoltage diagnostic on-voltage		3.4	3.7	4.3	V
V_{UVR_HYS}	Undervoltage diagnostics hysteresis voltage		0.1	0.3	0.5	V
Magnetic field input characteristics						
D_{MAG}	Radial magnetized magnet diameter		4.0	6.0	8.0	mm
T_{MAG}	Radial magnetizing magnet thickness			2.5		mm
A_{DIS}	Magnet and chip surface distance		1.0	1.5	2.0	mm
H_{EXT}	Magnetic field strength range		20	30	60	mT
Rpm	Magnet speed				200,000	rpm
X_{DIS}	Magnet and chip center deviation				0.2	mm
SIN/COS analog output						
V_{PP5V}	5V applies sine and cosine output amplitude	V_{DD}=5.0V, H_{EXT}=27mT	1.0	2.0	3.8	Vpp
$V_{PP3.3V}$	3.3V applies sine and cosine output amplitude	V_{DD}=3.3V, H_{EXT}=27mT	1.0	1.8	2.6	Vpp
V_{DC}	Sine and Cosine DC level		40	50	60	%V_{DD}
OFF_{VPP}	Sine and Cosine output amplitude deviation		-10	0.0	10	mV
OFF_{VDC}	Sine Cosine DC level deviation		-5	0.0	5	mV
R_{LOAD}	Sine and Cosine output pull up resistor		4.7	-	470	kΩ
C_{LOAD}	Sine and Cosine output load capacitors	Directly connected to the output port	-	-	100	pF
T_{DELAY}	Sine and Cosine output signal is delayed		-	7	-	µs

Operating Characteristics (Continued)

Symbol	Parameter	Test Conditions	Min.	Typ.	Max.	Unit
Diagnostic function						
Dsat_lo	Proactive diagnostic output levels	Pull down Resistor: R≥4.7k	-	0.5	1	%V$_{DD}$
		Pull up Resistor: R≥4.7k	-	98	100	%V$_{DD}$
BV$_{SS}$PD	Passive Diagnostic Output Level (Open)	V$_{SS}$ open circuit, pull-down resistor, 4.7K≤R≤47k	-	0	3	%V$_{DD}$
BV$_{SS}$PU		V$_{SS}$ open circuit, pull-up resistor, 4.7K≤R≤47k	97	98	-	%V$_{DD}$
BV$_{DD}$PD		V$_{DD}$ open circuit, pull-down resistor, 4.7K≤R≤47k	-	0	1	%V$_{DD}$
BV$_{DD}$PU		V$_{DD}$ open circuit, pull-up resistor, 4.7K≤R≤47k	96.5	98	-	%V$_{DD}$
℃	Over-temperature protection		-	170	-	℃
I$_{\_OCP}$	Overcurrent protection		-		30	mA
A/D conversion characteristics						
R$_{ES(SD)}$	Sigma/Detal modulation resolution		-	14	-	Bit
T$_{(ON)}$	Startup time		-	-	5	ms
ABZ/PWM output characteristics						
F$_{PWM}$	PWM frequency (default)		976	1000	1024	Hz
F$_{PWM(OPT)}$	PWM frequency (optional)		232	244	256	Hz
R$_{ES(AB)}$	AB output line count	24, 50, 256, 1024 lines	24	-	1024	lines
Z$_{WIDTH}$	Z zero width	1/4T, 1T	1	4	-	LSB
Rpm	Rotate speed	REG_rpm=0	-	50000	-	rpm
	Rotate speed	REG_rpm=1	-	200000	-	rpm
IO digital port electrical characteristics						
V$_{THI}$	Enter a high level threshold		-	-	2.0	V
V$_{TLO}$	Enter a low level threshold		0.8	-	-	V
V$_{SHI}$	Output high voltage	4mA pull-down current	V$_{DD}$-0.5	-	-	V
V$_{SLO}$	Output low voltage	4mA pull-up current	-	-	0.5	V
V$_{IH}$	Input high level		0.5*D$_{VDD}$	-	-	V
V$_{OL}$	Input low level		-	-	0.2*D$_{VDD}$	V
V$_{OH}$	Output high level		0.8*D$_{VDD}$	-	-	V
I$_{SHI}$	Outputs high-level short-to-ground current	V$_{DD}$=3.3V	-	-	30	mA
I$_{SLO}$	Outputs a low-level short-circuit to the supply current	V$_{DD}$=3.3V	-	-	30	mA
SPI communication time parameters						
T$_{CSN}$	CSN signal setup time		100	-	-	ns
T$_{SCKH}$	SCK high level time		80	-	-	ns
T$_{SCKL}$	SCK low level time		80	-	-	ns
T$_{SCK}$	SCK time period		160	-	-	ns

9. Register Description

Volatile register table

Address	Symbol	Default	Description
0x01	GENECNFG	0x00	Common configuration of encoders
0x02	DIGI_CNFG0	0x00	The digital output of the encoder is configured with register 0
0x03	DIGI_CNFG1	0x06	Encoder digital output configuration register 1
0x04	ZPOSM	0x00	The middle 6 bits of the zero corner value
0x05	ZPOSL	0x00	6 bits lower than the zero angle value
0x06	PWMSET	0x00	PWM output configuration
0x07	GAINOUTSEL	0x00	Gain output final value
0x08	VQSINPSEL	0x00	VQ(SIN+) outputs the final value
0x09	VQSINNSEL	0x00	VQ(SIN-) outputs the final value
0x0A	VQCOSPSEL	0x00	VQ(COS+) outputs the final value
0x0B	VQCOSNSEL	0x00	VQ(COS-) outputs the final value
0x0C	OSCTRIM	0x00	Control the internal oscillator frequency
0x20	PROG	0x00	Programming registers
0x21	OUTEN	0x00	Output switch registers
0x2F	ERRFL	0x00	Error registers
0x3E	ANGL	0x00	The measurement angle output register is 7 bits lower
0x3F	ANGLE	0x00	The measurement angle output register is 7 bits high

Symbol	Read/Write	Address	Description
GENECNFG 0x01			
Reserve	R/W	5:4	retain
PWM	R/W	4	Wire-saving Mode 0: 4096 Normal PWM; 1: 4119 PWM with clamping
PWM	R/W	3	Wire-saving Mode 0: Turn off the provincial mode; 1: Turn on the provincial mode
DIR	R/W	2	Rotation direction setting 0: Clockwise - A leads, B follows/counterclockwise - B leads, A follows 1: Clockwise - B leads, A follows/counterclockwise - A leads and B follows
OUTMOD	R/W	1:0	Output mode selection 00: SPI mode; 01: ABI PWM； 10: Analog output (SIN /SIN-, COS /COS-)
DIGI_CNFG0 0x02			
ZALGN	R/W	5:4	Z pulse aligned with A-B waveform: 00: The rising edge of Z is aligned with the rising edge of A; 01: The rising edge of Z is aligned with the rising edge of B. 10: The rising edge of Z is aligned with the falling edge of A; 11: The rising edge of Z is aligned with the falling edge of B.
HYS	R/W	3:2	Lag setting for ABI signals 00: 1/4 T; 01: 1/2 T; 10: 3/4 T; 11: 1 T
ZWID	R/W	1:0	Z pulse width 00: 1/4 T; 01: 1/2 T 10: 3/4 T; 11: 1T
DIGI_CNFG1 0x03			
ZPEN	R/W	5	Enable or disable the zero point feature
ZPOSH	R/W	4:3	2 digits higher than the zero angle value 4:3 : Bit 13: Bit 12
ABIRES	R/W	2:0	ABI resolution 000: 12 lines per turn; 001: 24 lines per turn; 010: 50 lines per turn; 011: 128 lines per turn; 100: 256 lines per turn; 101: 512 lines per turn; 110: 1024 lines per lap; 111: Default.
ZPOSM 0x04			
ZPOSM	R/W	5:0	The middle 6 bits of the zero corner value 5:0: Bit 11 to Bit 6
ZPOSL 0x05			
ZPOSL	R/W	5:0	6 bits lower than the zero angle value 5:0: Bit 5 to Bit 0
PWMSET 0x06			
PWMPOL	R/W	2	PWM polarity 0：0-0%, 360-100%; 1：0-100%, 360-0%
PWMFREQ	R/W	1:0	PWM signal frequency 00: 250Hz; 01: 500Hz 10: 1000Hz; 11: 2000Hz

Symbol	Read/Write	Address	Description
GAINOUTSEL 0x07			
GAINADCSEL	R/W	4:2	Gain of analog input: 000: 2.34 001: 2.74 010: 3.21 011: 3.75 100: 1.25 101: 1.46 110: 1.71 111: 2.00
GAINOUTSEL	R/W	1:0	Gain settings for sine (SIN /-) and cosine (COS /-) outputs 00: 1x the original analog output 01: 1.33 times the original analog output 10: 2x the original analog output 11: 4x the original analog output
VQSINPSEL 0x08			
VQSINPSEL	R/W	3:0	0000: 50% VDD 0001: 50% VDD + 4mV 0010: 50% VDD + 8mV 0011: 50% VDD + 12mV 0100: 50% VDD + 16mV 0101: 50% VDD + 20mV 0101: 50% VDD + 24mV 0111: 50% VDD + 28mV 1000: 50% VDD - 4mV 1001: 50% VDD - 8mV 1010: 50% VDD - 12mV 1011: 50% VDD - 16mV 1100: 50% VDD - 20mV 1101: 50% VDD - 24mV 1110: 50% VDD - 28mV 1111: 50% VDD - 32mV
VQSINNSEL 0x09			
VQSINPSEL	R/W	3:0	0000: 50% VDD 0001: 50% VDD + 4mV 0010: 50% VDD + 8mV 0011: 50% VDD + 12mV 0100: 50% VDD + 16mV 0101: 50% VDD + 20mV 0101: 50% VDD + 24mV 0111: 50% VDD + 28mV 1000: 50% VDD - 4mV 1001: 50% VDD - 8mV 1010: 50% VDD - 12mV 1011: 50% VDD - 16mV 1100: 50% VDD - 20mV 1101: 50% VDD - 24mV 1110: 50% VDD - 28mV 1111: 50% VDD - 32mV
VQCOSPSEL 0x0A			
VQSINPSEL	R/W	3:0	0000: 50% VDD 0001: 50% VDD + 4mV 0010: 50% VDD + 8mV 0011: 50% VDD + 12mV 0100: 50% VDD + 16mV 0101: 50% VDD + 20mV 0101: 50% VDD + 24mV 0111: 50% VDD + 28mV 1000: 50% VDD - 4mV 1001: 50% VDD - 8mV 1010: 50% VDD - 12mV 1011: 50% VDD - 16mV 1100: 50% VDD - 20mV 1101: 50% VDD - 24mV 1110: 50% VDD - 28mV 1111: 50% VDD - 32mV
VQCOSPSEL 0x0B			
VQSINPSEL	R/W	3:0	0000: 50% VDD 0001: 50% VDD + 4mV 0010: 50% VDD + 8mV 0011: 50% VDD + 12mV 0100: 50% VDD + 16mV 0101: 50% VDD + 20mV 0101: 50% VDD + 24mV 0111: 50% VDD + 28mV 1000: 50% VDD - 4mV 1001: 50% VDD - 8mV 1010: 50% VDD - 12mV 1011: 50% VDD - 16mV 1100: 50% VDD - 20mV 1101: 50% VDD - 24mV 1110: 50% VDD - 28mV 1111: 50% VDD - 32mV

Symbol	Read/Write	Address	Description
OSCTRIM 0x0C			
OSCTRIM	R/W	5:0	000000: Default 16MHz 000001 ~ 011111: Frequency increases; 100000 ~ 111111: Frequency decreased.
PROG 0x20			
PROGOTP	R/W	3	Start the OTP programming cycle
OTPREF	R/W	2	Refresh non-volatile memory content to match OTP programming content
PROGFIN	R/W	0	0: OTP not completed 1: The program OTP is complete
OUTEN 0x21			
OUTEN	R/W	0	1 needs to be reset after each configuration modification 0: Automatically set 0 1: Update the output waveform according to the output-related settings
ERRFL 0x2F			
PARERR	R	2	Parity error
INVCOMM	R	1	Invalid command error: Set to 1 when trying to read or write an invalid register address
FRERR	R	0	Frame error: Set to 1 when a frame that does not meet the SPI frame specification is detected
ANGL 0x3E			
ANGL	R	6:0	Low 7-bit angular value output
ANGL 0x3F			
ANGL	R	6:0	High 7-bit angular value output

10. Block Diagram
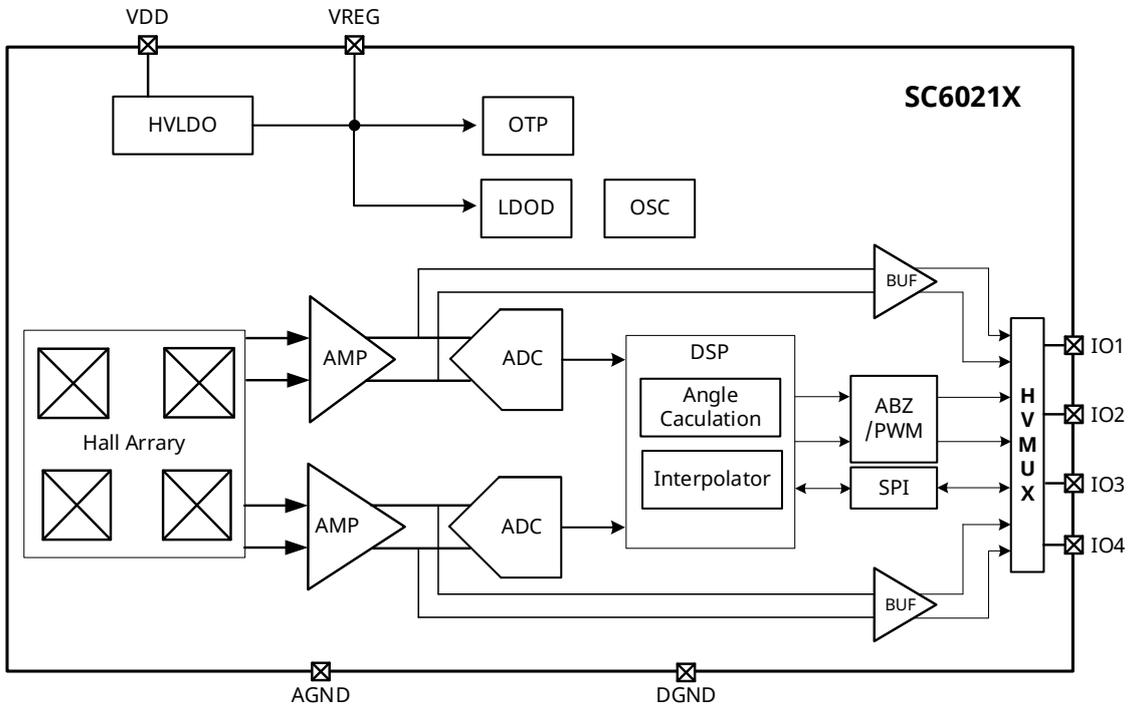
Fig.3 Block Diagram

11. Output Format

11.1. SIN/COS analog output

Typical application diagram
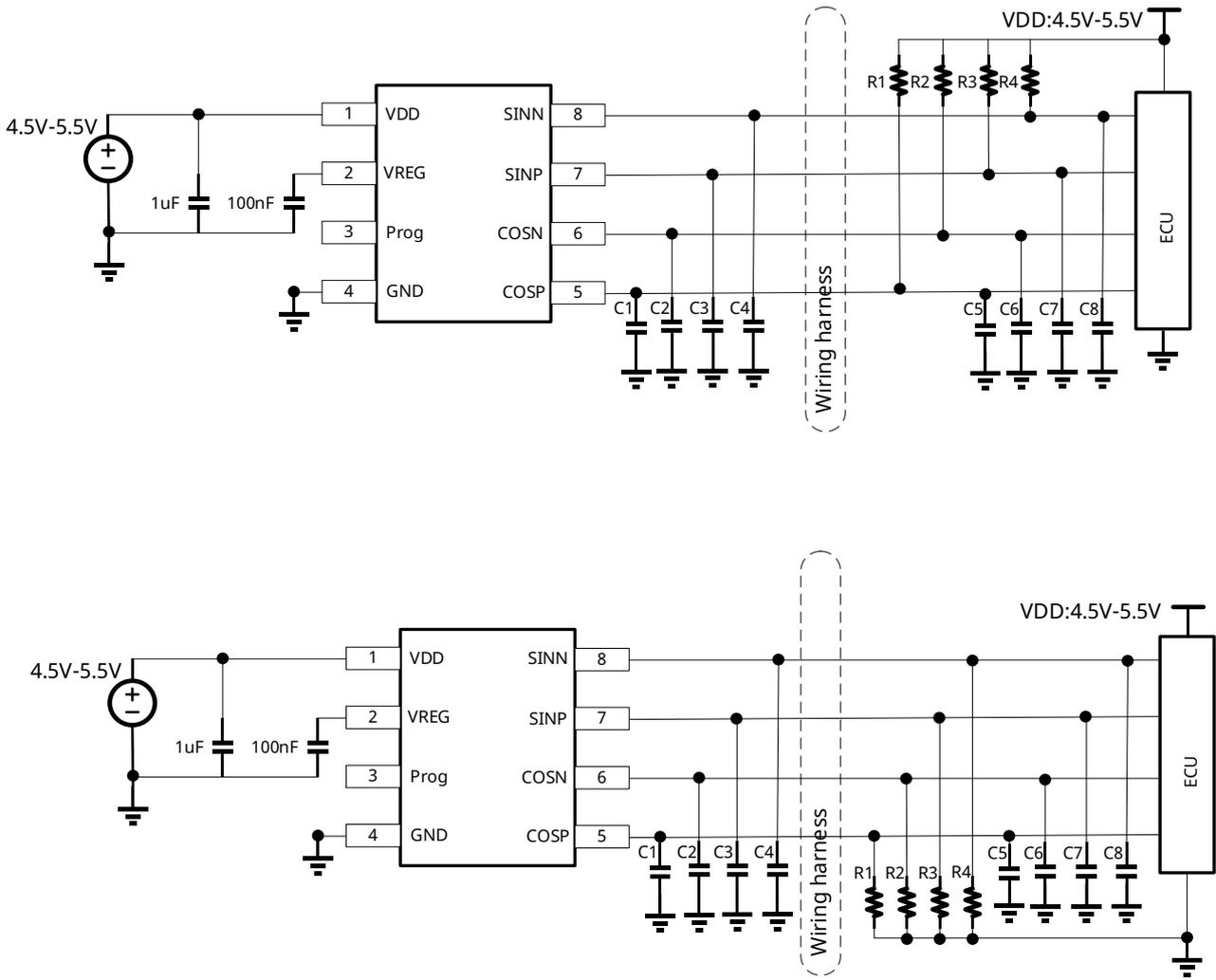
Fig.4 Analog output application diagram

SIN/COS output waveform diagram
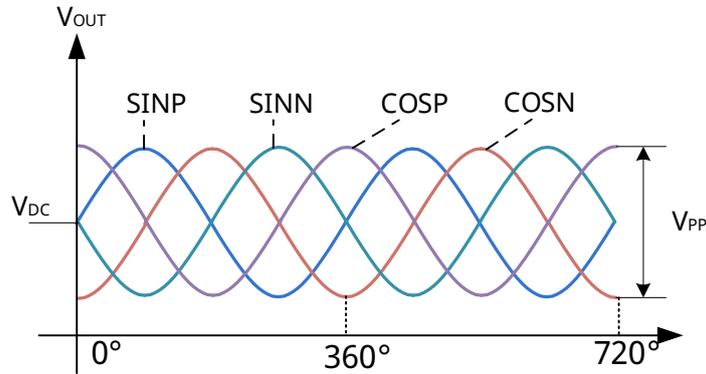
Fig.5 Analog output waveform diagram

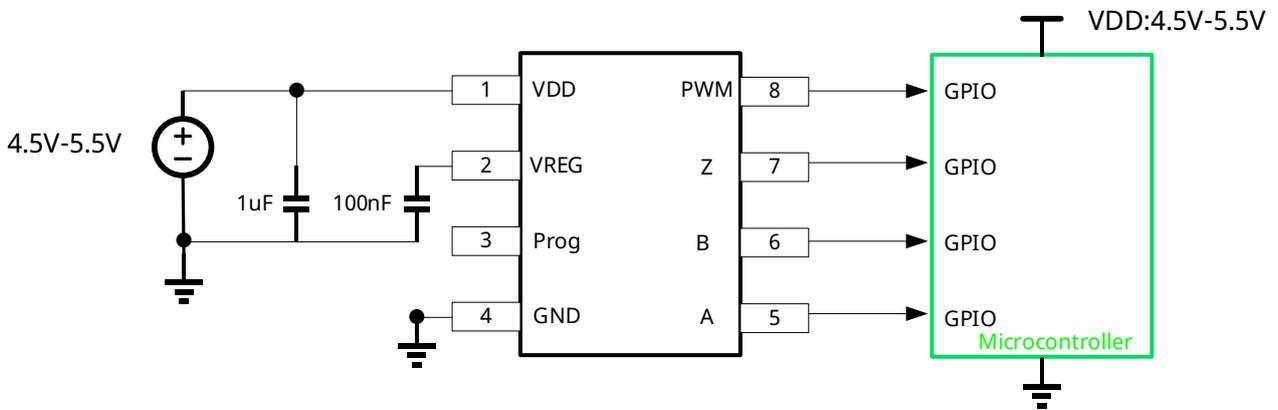## 11.2. ABZ/PWM output

Typical application diagram

Fig.6 Incremental output application diagram

Description of Prog function:

When the motor is phase-locked at the zero position, short-circuit the Prog pin to the power supply for 2 seconds to achieve zero adjustment of the encoder chip, and program the current position as the encoder zero position.

ABZ output waveform diagram
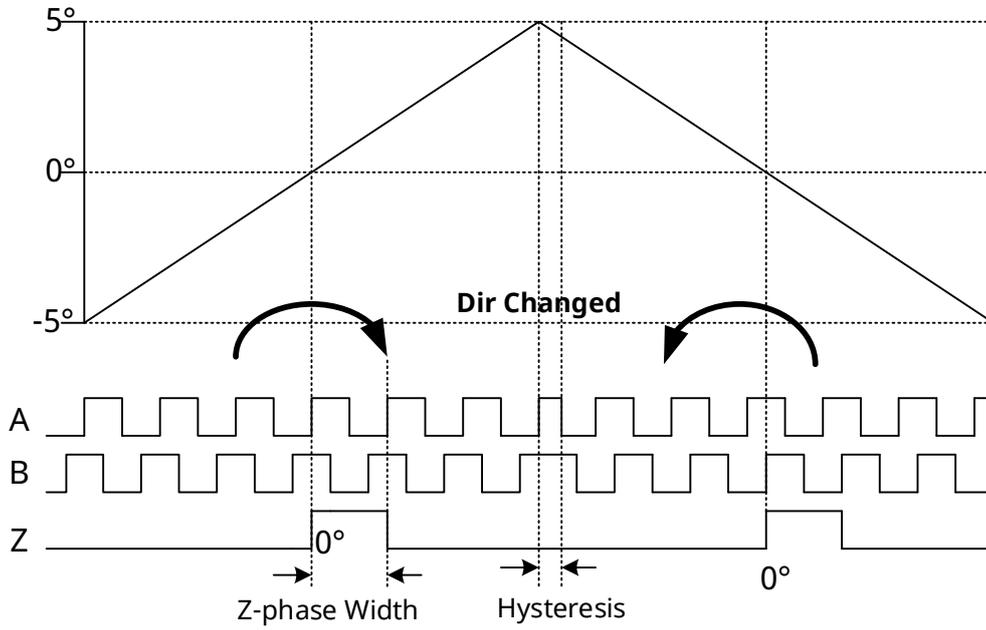
Fig.7 Incremental output waveform diagram

PWM output waveform diagram
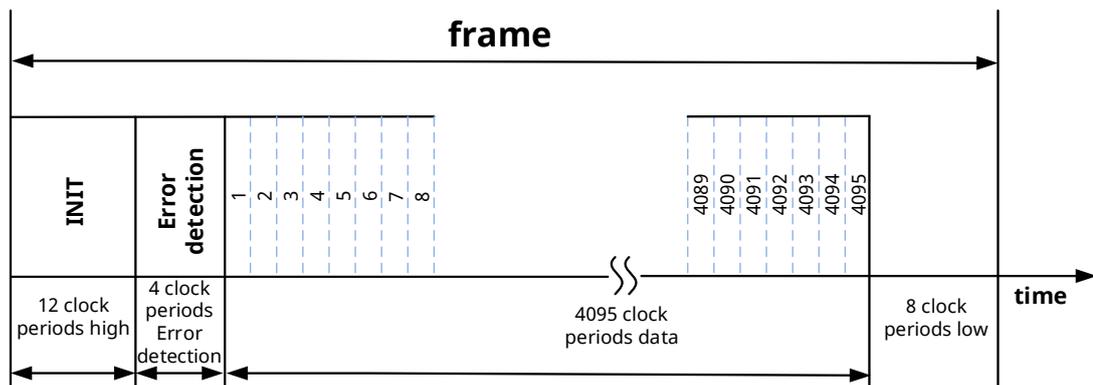
Fig.8 PWM output waveform diagram

11.3. SPI output

Typical application diagram
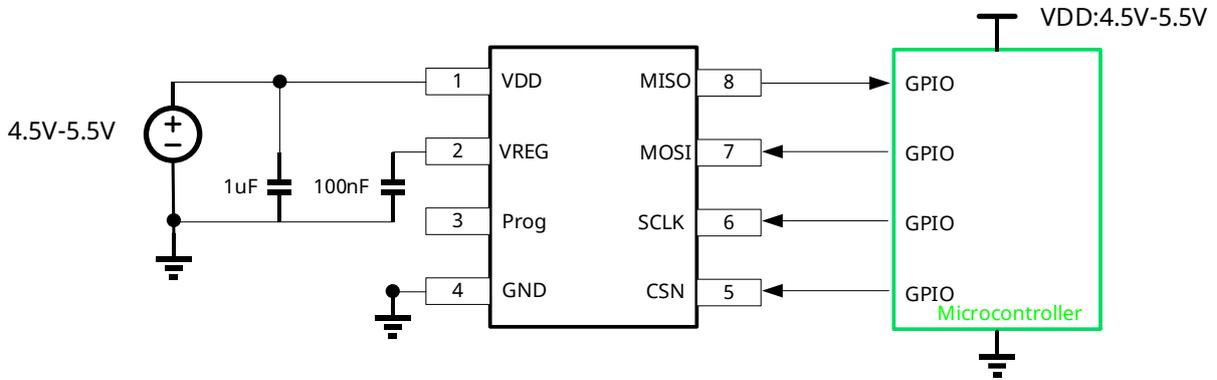
Fig.9 SPI application diagram

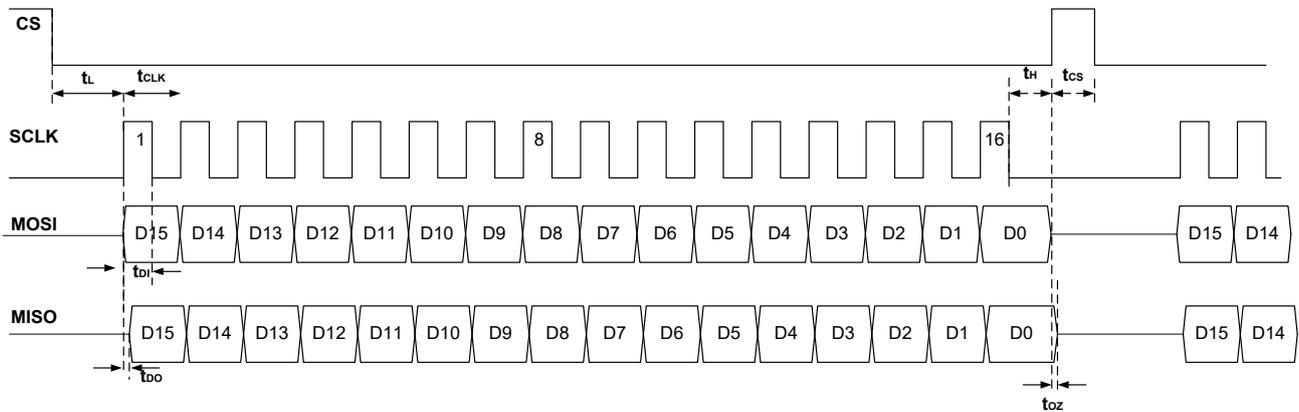### SPI output waveform diagram

Register read-write mode

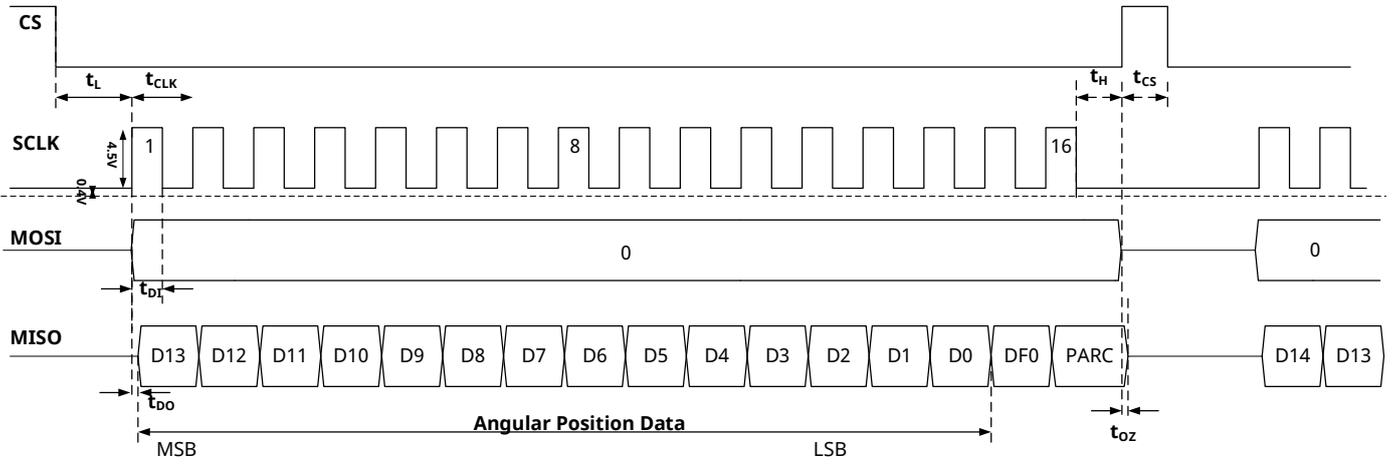Fig.10 SPI register read-write mode diagram

Angle reading mode

Fig.11 SPI angle reading mode diagram

12. Power supply connection method
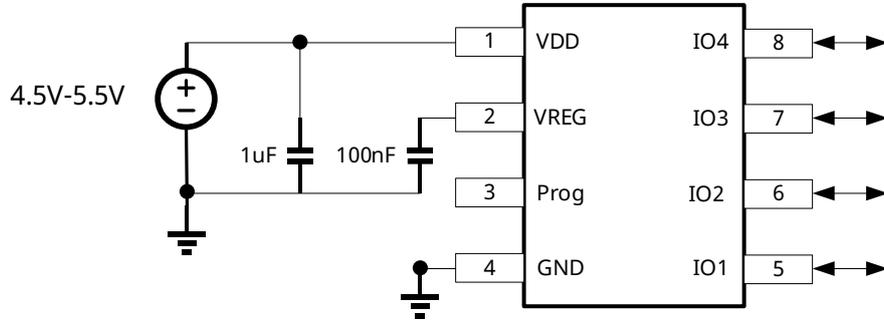
12.1. Application circuit connection(5V)

Fig.12 5V power supply circuit diagram
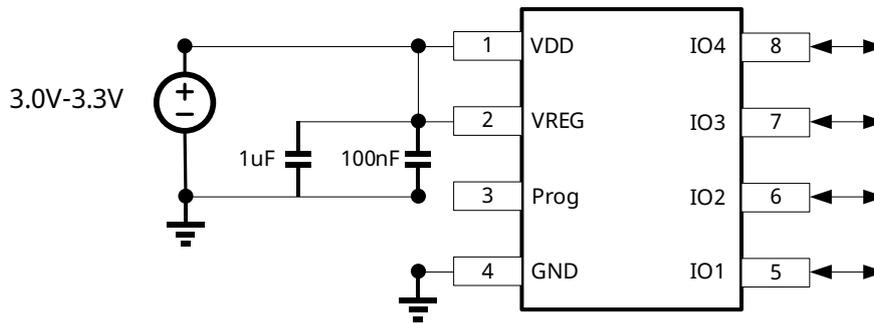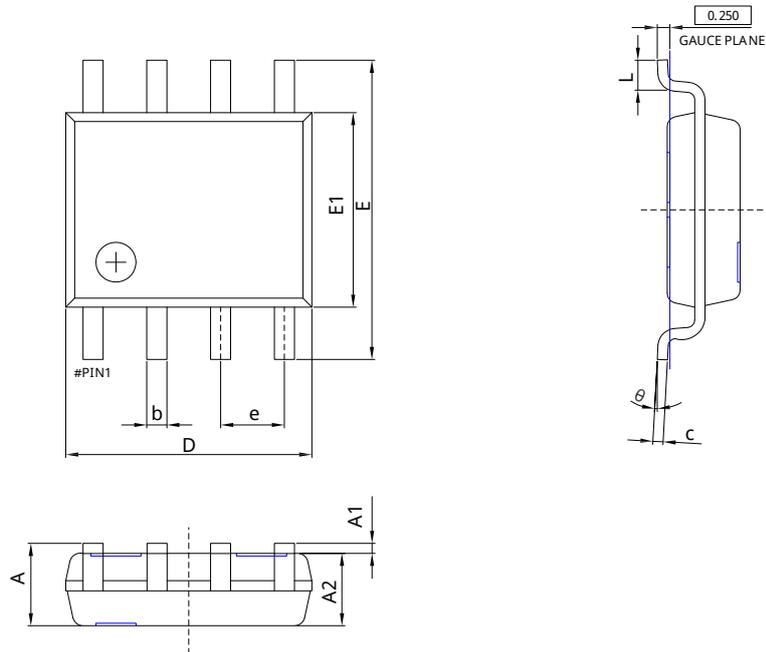
12.2. Application circuit connection(3.3V)

Fig.13 3.3V power supply circuit diagram

13. Package Information DC

Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	Max.	Min.	Max.
A	1.450	1.750	0.057	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D	4.700	5.100	0.185	0.201
E	5.800	6.200	0.228	0.244
E1	3.800	4.000	0.150	0.157
e	1.270(BSC)		0.050(BSC)	
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

Fig.14 SOP8 Package Dimension Drawing

14. Revision History

Date	Reviser	Modified items	Modification suggestions	Whether to confirm the modification
2025-07-28	Harry	functionality	Add Z-item press signal, home appliance knob application	否
2025-07-31	Harry	EPROM	GTA has never done EEPROM, so I still do EPROM first	否
2025-07-31	HLX	wire-saving mode	As soon as the chip is powered on, the A signal pin first spits out the number of pulses corresponding to the angle value at a frequency of 1MHz	否