

14-Bit High Speed Magnetic Encoder IC Series

1. Features

- AEC-Q100 Grade0 automotive grade qualified
- 14-bit resolution rotary encoder
- Support maximum speed of 200K rpm
- Angular linear error $<\pm 0.35^\circ$
- Power output withstand voltage $\geq 24V$, $< -18V$
- Support multiple interface options:
 - Sin/Cos analog signals
 - ABZ+PWM
 - SPI protocol output
- Supports 3.3V and 5.0V operating voltage applications
- SC60214 supports 3 times of zero adjustment
- Diagnostic functions: wire breakage, overcurrent, undervoltage/overvoltage, overtemperature
- Operating temperature range: -40°C to 150°C
- Package type: SOP-8

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 2048 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.

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

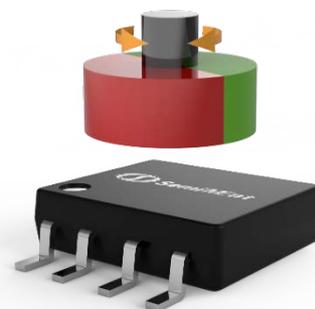


Fig.1 Schematic diagram of the work

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4. Pin Description

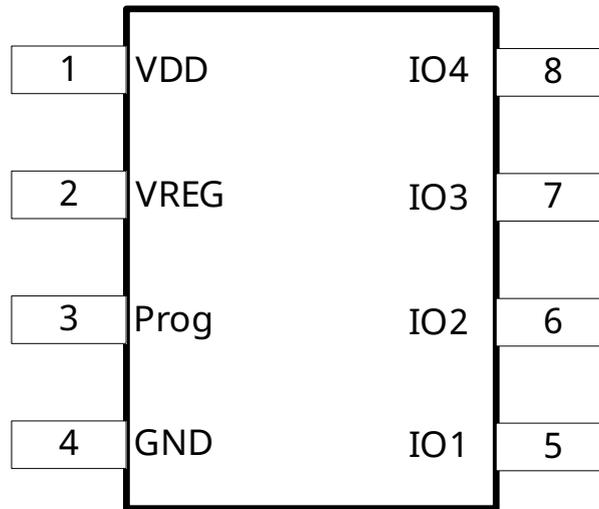


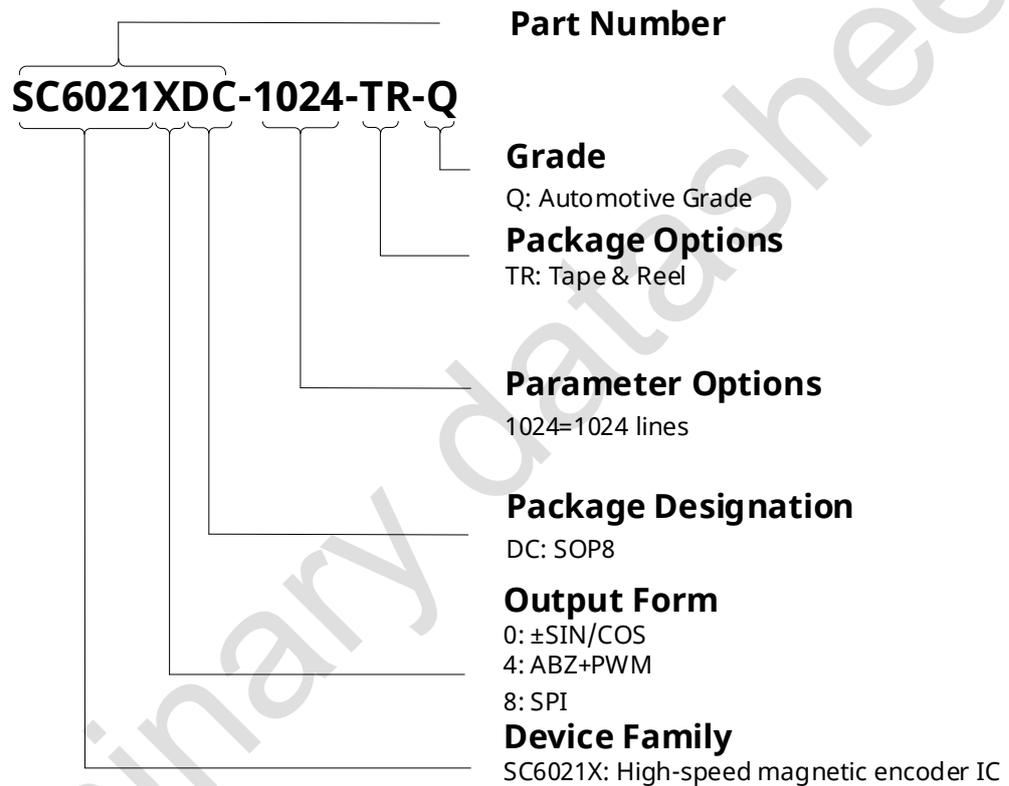
Fig.2 SC6021X Pin Description

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(°C)	Package	Pack	Amount
SC60210DC-TR-Q	60210	-	± SIN/COS	-40~150	SOP8	Tape&Reel	4000Pcs/Reel
SC60214DC-1024-TR-Q	60214	1024	ABZ+PWM	-40~150	SOP8	Tape&Reel	4000 Pcs/Reel
SC60218DC-TR-Q	60218	-	SPI	-40~150	SOP8	Tape&Reel	4000 Pcs/Reel

Ordering Information Format



6. Absolute Maximum Ratings

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
VDD	Power supply end withstand voltage		-18	24	V
VREG	Voltage rating of the voltage stabilizing terminal		-0.5	6.5	V
Prog	Programming feet		-0.5	6.5	V
IO1/2/3/4	Output withstand voltage		-0.5	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		-20	0.0	20	mV
R_{LOAD}	Sine and Cosine output pull up resistor		4.7	-	470	k Ω
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: $R \geq 4.7k\Omega$	-	0.5	1	$\%V_{DD}$
		Pull up Resistor: $R \geq 4.7k\Omega$	-	98	100	$\%V_{DD}$
BV _{SS} PD	Passive Diagnostic Output Level (Open)	V _{SS} open circuit, pull-down resistor, 4.7 k $\Omega \leq R \leq 47k\Omega$	-	0	3	$\%V_{DD}$
BV _{SS} PU		V _{SS} open circuit, pull-up resistor, 4.7 k $\Omega \leq R \leq 47k\Omega$	97	98	-	$\%V_{DD}$
BV _{DD} PD		V _{DD} open circuit, pull-down resistor, 4.7 k $\Omega \leq R \leq 47k\Omega$	-	0	1	$\%V_{DD}$
BV _{DD} PU		V _{DD} open circuit, pull-up resistor, 4.7 k $\Omega \leq R \leq 47k\Omega$	96.5	98	-	$\%V_{DD}$
°C	Over-temperature protection		-	170	-	°C
I _{LOCP}	Overcurrent protection		-		30	mA
A/D conversion characteristics						
R _{ES(SD)}	Sigma/Delta 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*V _{DD}	-	-	V
V _{OL}	Input low level		-	-	0.2*V _{DD}	V
V _{OH}	Output high level		0.8*V _{DD}	-	-	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

Operating Characteristics (Continued)

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

EPROM Parameter Analysis Table

Page	Row	bit7	bit6	bit5	bit4	bit3	bit2	bit1	bit0	
0	0	DP1EN<1:0>		DP1<13:8>						
	1	DP1<7:0>								
	2	DP2EN<1:0>		DP2<13:8>						
	3	DP2<7:0>								
	4	DP3EN<1:0>		DP3<13:8>						
	5	DP3<7:0>								
	6	TRIMBG<2:0>			TRIMOSC<4:0>					
	7	DIR	CLK_SLOW	OUTMOD1<0>		V3P3EN	VOSEN	OTPEN	OVPEN	
	8	UVLOEN	VOSX2	G2<2:0>			G1<2:0>			
	9	ABZEDG<1:0>		ABZ_HYS<1:0>		ABZWID<1:0>		ABZLINE<2:1>		
	A	ABZLINE<0>	PWMCTRL	PWMPOL	PWMT	PWMMS	-	PID_FILTER_SEL		
	B	VOS_SIN<7:0>								
	C	VOS_COS<7:0>								
	D	-	-	-	-	-	-	-	-	
	E	-	-	-	-	-	-	-	-	
	F	-	-	-	-	-	-	-	-	

EPROM Parameter Information

Symbol	BITS	ADDR	Type	Description
DP1EN<1:0>	2	0x00[7:6]	r/w	第一次零点校准标志位
DP1	14	0x00[5:0]+0x01[7:0]	r/w	零点位置信息, 将当前位置设置为零点
DP2EN<1:0>	2	0x00[7:6]	r/w	
DP2	14	0x00[5:0]+0x03[7:0]	r/w	零点位置信息, 将当前位置设置为零点
DP3EN<1:0>	2	0x04[7:6]	r/w	第三次零点校准标志位
DP3	14	0x04[5:0]+0x05[7:0]	r/w	零点位置信息, 将当前位置设置为零点
TRIMBG	3	0x06[7:5]	r/w	芯片内部基准电压 trim
TRIMOSC	5	0x06[4:0]	r/w	芯片内部 OSC 频率 trim
DIR	1	0x07[7]	r/w	旋转方向配置: 0: 顺时针: A 先 B 后、逆时针: B 先 A 后; 1: 顺时针: B 先 A 后、逆时针: A 先 B 后;
CLK_SLOW	1	0x07[6]	r/w	ADC 采样频率: 0: 8MHz; 1: 16MHz;
OUTMOD	2	0x07[5:4]	r/w	输出模式配置: 0: SPI 模式; 1: ABZ+PWM 模式; 2: 模拟正余弦输出模式; 3: SPI 模式;
V3P3EN	1	0x07[3]	r/w	3.3V 应用标志位
VOSEN	1	0x07[2]	r/w	内部 offset 消除使能信号
OTPEN	1	0x07[1]	r/w	过温检测: 0: 过温检测; 1: 无过温检测;
OVPEN	1	0x07[0]	r/w	过压检测: 0: 过压检测; 1: 无过压检测;
UVLOEN	1	0x08[7]	r/w	欠压检测: 0: 欠压检测; 1: 无欠压检测;
VOSX2	1	0x08[6]	r/w	vos 补偿范围: 0: $\pm 5.2\text{mV}$; 1: $\pm 2.6\text{mV}$;
G2<2:0>	3	0x08[5:3]	r/w	第二级增益调节: 6.06~21.93 $\times 1.2$
G3<2:0>	3	0x08[2:0]	r/w	第三级增益调节: 0.81~1.51 $\times 1.1$

Continued

ABZEDG<1:0>	2	0x09[7:6]	r/w	Z 脉冲与 AB 脉冲波形边沿调整： 0: Z 上升沿与 B 上升沿对齐； 1: Z 上升沿与 B 下降沿对齐； 2: Z 上升沿与 A 下降沿对齐； 3: Z 上升沿与 A 上升沿对齐；
ABZHYS	2	0x09[5:4]	r/w	ABZ 信号的迟滞设置： 0: 0.25*T 1: 0.5*T 2: 0.75*T 3: 1*T
ABZWID	2	0x09[3:2]	r/w	ABZ 信号中 Z 的脉宽设置： 0: 0.25*T 1: 0.5*T 2: 180° 3: 1*T
ABZLINE	3	0x09[2:0]+ 0x0A[7]	r/w	ABZ 每圈线数配置： 0: 12 线 1: 24 线 2: 50 线 3: 128 线 4: 256 线 5: 512 线 6: 2048 线 7: 1024 线
PWMCTRL	1	0x0A[6]	r/w	0: PWM 标志位输出； 1: 正常 PWM 输出；
PWMPOL	1	0x0A[5]	r/w	0: PWM 标志位输出； 1: 正常 PWM 输出；
PWMT	1	0x0A[4]	r/w	PWM 输出频率 0: 250Hz 1: 1000Hz
VOS_SIN	8	0x0B[7:0]	r/w	SIN 支路 offset 调节
VOS_COS	8	0x0C[7:0]	r/w	COS 支路 offset 调节

10. Block Diagram

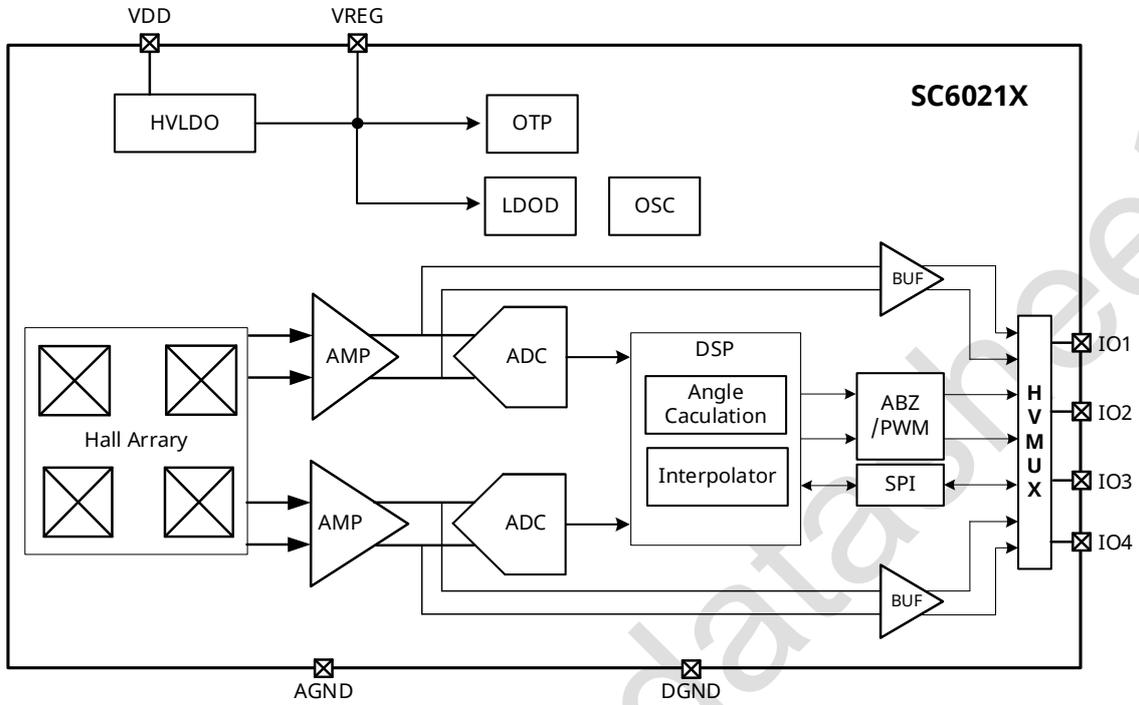


Fig.3 Block Diagram

11. Output Format

11.1. SIN/COS analog output

Typical application diagram

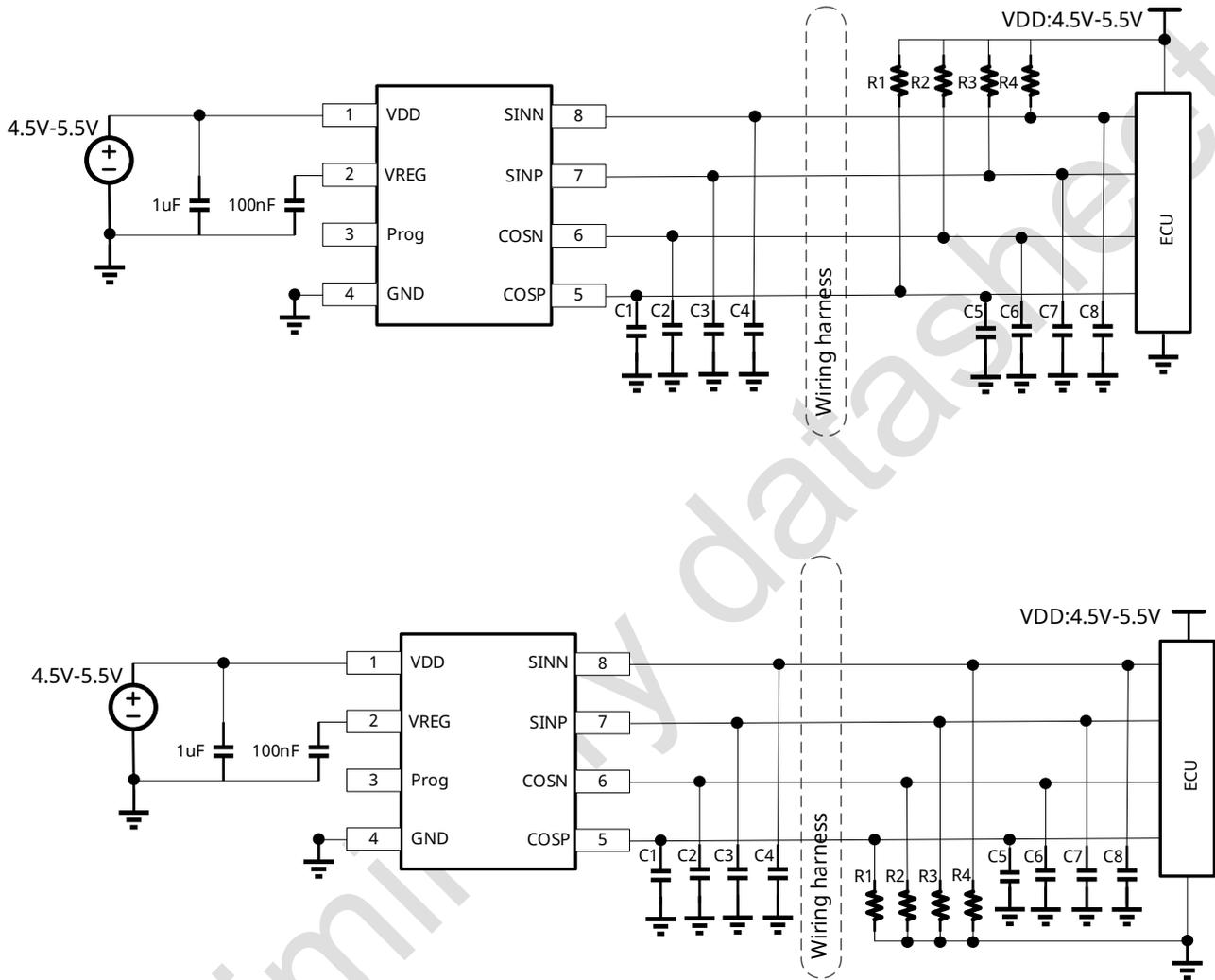


Fig.4 Analog output application diagram

SIN/COS output waveform diagram

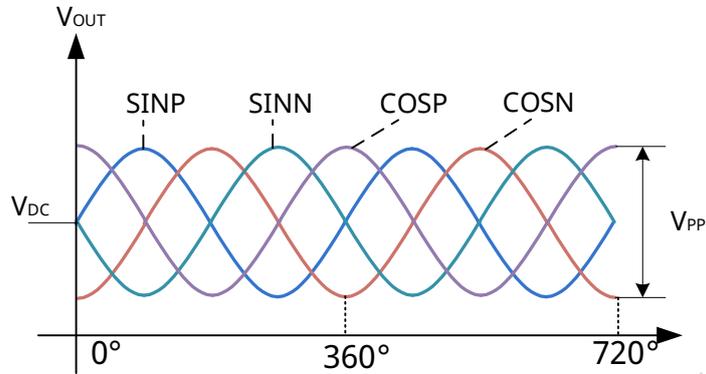


Fig.5 Analog output waveform diagram

11.2. ABZ/PWM output

Typical application diagram

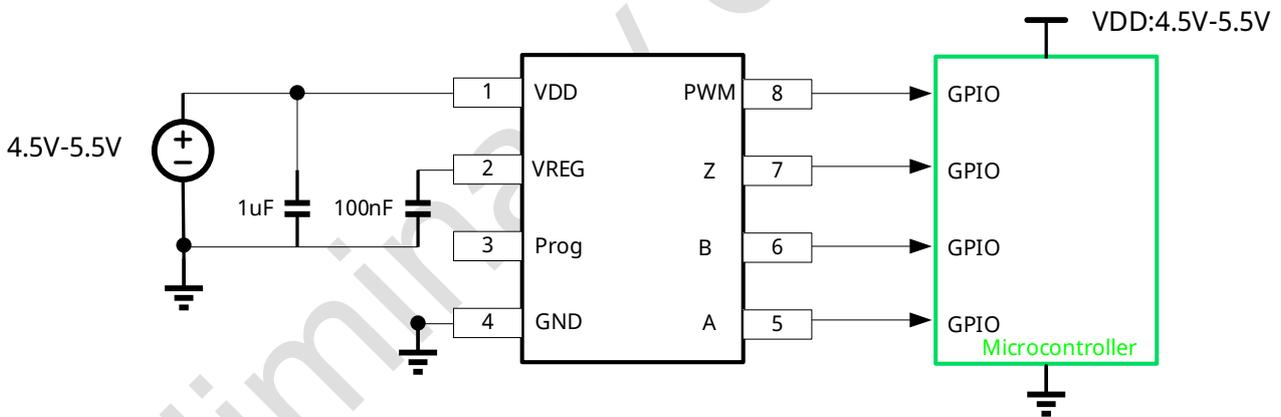


Fig.6 Incremental output application diagram

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

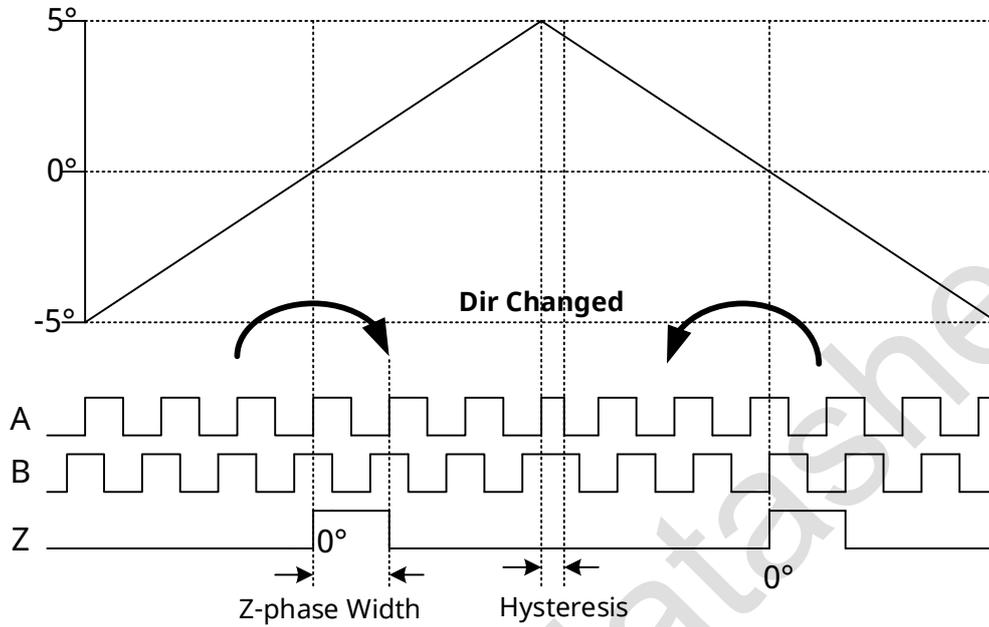


Fig.7 Incremental output waveform diagram

PWM output waveform diagram

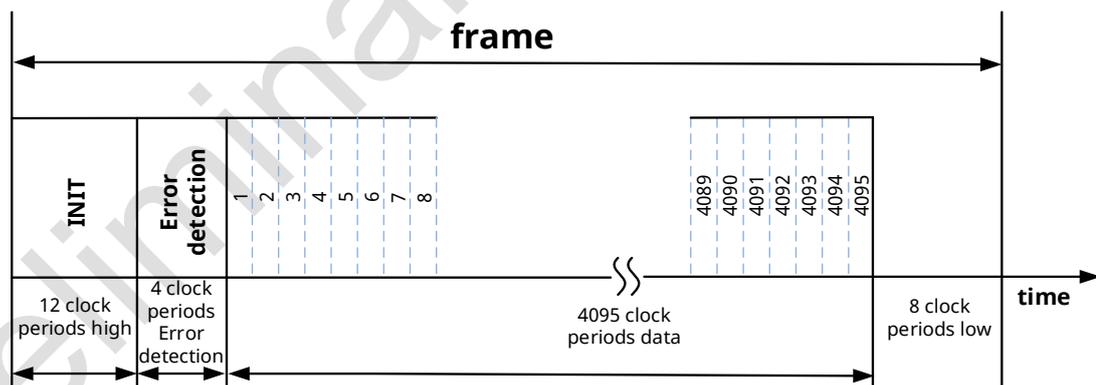


Fig.8 PWM output waveform diagram

11.3. SPI output

Typical application diagram

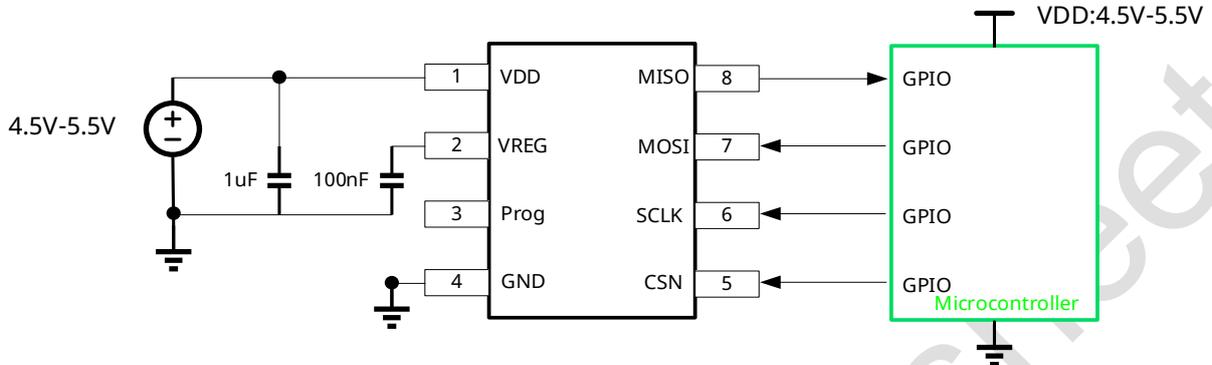


Fig.9 SPI application diagram

SPI output waveform diagram

Register read-write mode

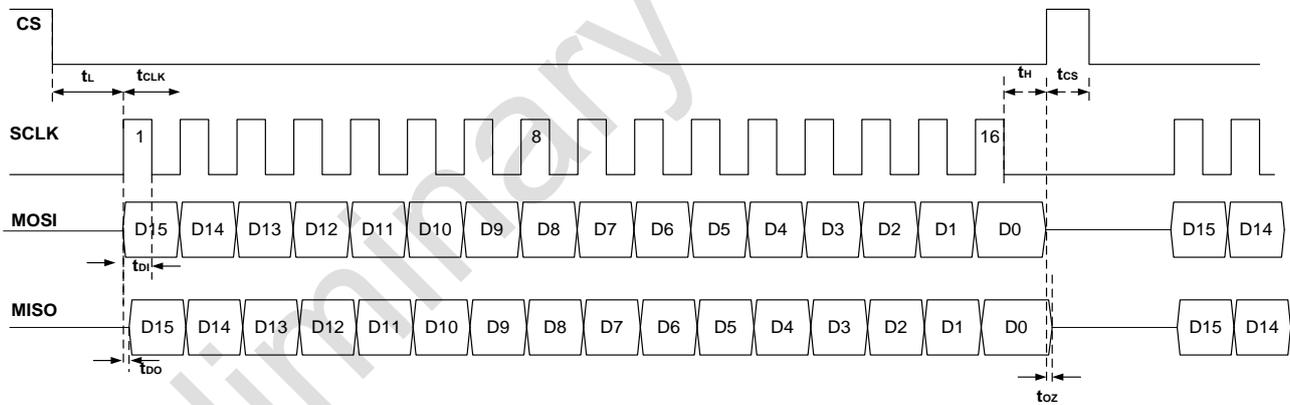


Fig.10 SPI register read-write mode diagram

Angle reading mode

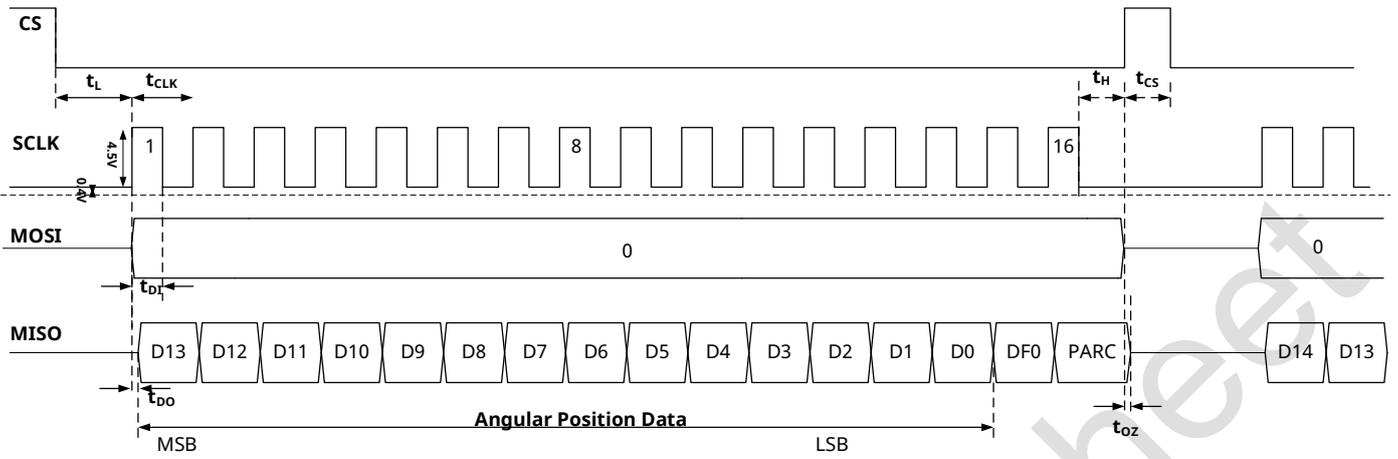


Fig.11 SPI angle reading mode diagram

12. Power supply connection method

12.1. Application circuit connection(5V)

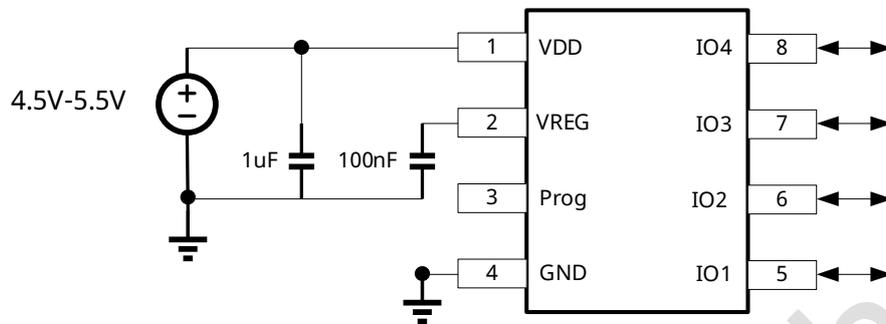


Fig.12 5V power supply circuit diagram

12.2. Application circuit connection(3.3V)

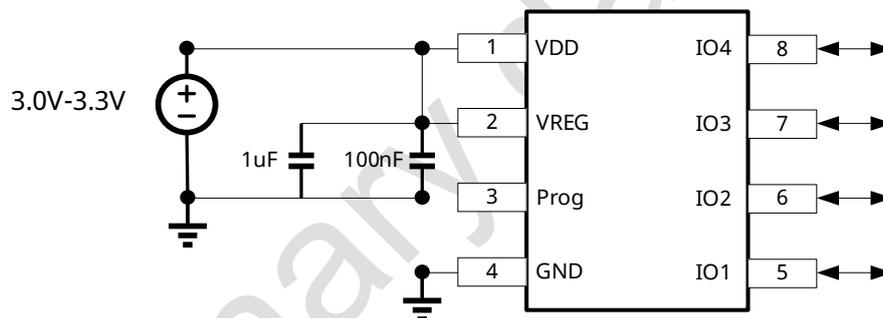
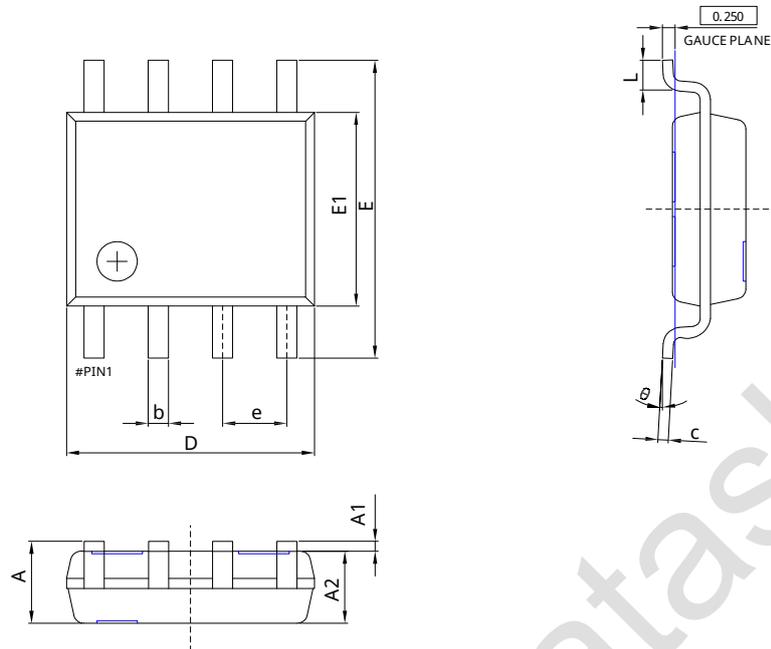


Fig.13 3.3V power supply circuit diagram

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

Revision	Date	Description
Rev. V0.1	2025-07-31	Preliminary datasheet

Preliminary datasheet