Dual Channel Real-time 12-Bit Inductive Rotary Encoder IC

1. Features

- Non-contact coil induction sensing technology is adopted
- Customizable PCB inductor coil to meet the needs of different applications
- Dual-channel high-speed real-time output with 12bit resolution
- Angular linearity error less than ±0.1°
- Maximum Support Rev. up to 10k rpm
- Support through shaft or end closure installation
- Output interface
  - A, B, Z Orthogonal incremental output
  - U, V, W Differential output
  - SPI Absolute Angle serial output
- Programmable parameter
  - The resolution of A B can be reprogramed from 1000 to 10000(coil coordination required)
  - Programmable Zero-point
  - U, V, W can be programmed from 1 pole pair to 32 pole pairs
  - Zero position Pulse width Z programable
- Operating temperature from -40℃ to 125℃
- Package: SSOP28

2. Applications

- Servo motor control
- Angle encoder
- Industrial control
- Rev. speed feedback
- Optical encoder replacement

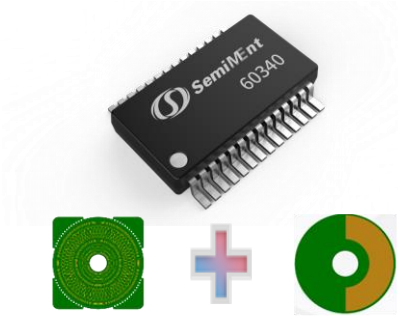
3. Description

SC60340 is a non-magnetic, non-contact coil inductive position sensor IC. The Device uses the physical principle of eddy current to detect the position of a simple metal target moving above the coil, so as to measure the signal output. The SC60340 can be used for high-speed absolute position detection in automotive, industrial, medical and consumer applications.

The sensor with SC60340 as the core consists of stator and rotor. The stator is usually made of three coils (including an exciting coil and two groups of receiving coils) on a copper wire printed circuit board (PCB). The reasonable arrangement of the coils makes the exciting coil induce secondary voltage in the four receiving coils, the induction of the secondary voltage depends on the position of the rotating object above the coil. The induced secondary voltage is demodulated and processed by SC60340 to get the position signal output.

The rotor is the rotating object, which can be any kind of metal, such as printed copper PCB, aluminum, steel or stamping metal.

SC60340 adopts a 28-pin SSOP28 package, matte tin plating, and halogen-free green material to meet environmental protection requirements.



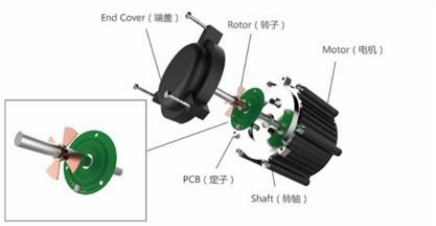


Fig.1 Schematic diagram of packaging and installation

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4. Terminal Configuration

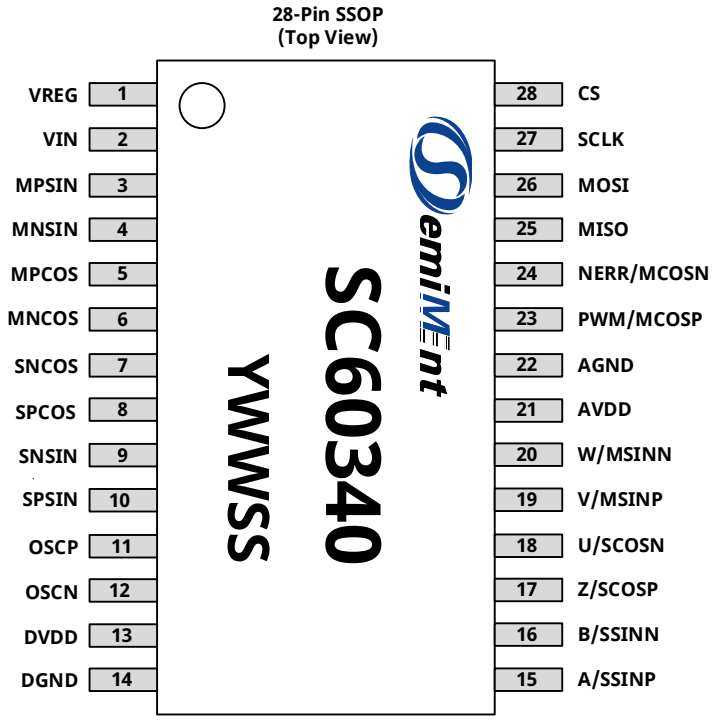


Fig.2 Pin description diagram

NO.	Pin Name	I/O	Type	Description
1	VREG	-	Power	Internal regulator module Output
2	VIN	-	Power	Internal regulator module Input
3	MPSIN	Input	Analog	Multi-period receiving coil PSIN signal input
4	MNSIN	Input	Analog	Multi-period receiving coil NSIN signal input
5	MPCOS	Input	Analog	Multi-period receiving coil PCOS signal input
6	MNCOS	Input	Analog	Multi-period receiving coil NCOS signal input
7	SNCOS	Input	Analog	Single-period receiving coil NCOS signal input
8	SPCOS	Input	Analog	Single-period receiving coil PCOS signal input
9	SNSIN	Input	Analog	Single-period receiving coil NSIN signal input
10	SPSIN	Input	Analog	Single-period receiving coil PSIN signal input
11	OSCP	Output	Analog	Exciting coil positive point output
12	OSCN	Output	Analog	Exciting coil negative point output
13	DVDD	-	Power	Digital Power
14	DGND	-	Power	Digital Ground
15	*A/SSINP	Output	Digital/Analog	A pulse signal/ Single-period analog sinusoidal signal

Terminal Configuration (Continued)

NO.	Pin Name	I/O	Type	Description
15	*A/SSINP	Output	Digital/Analog	A pulse signal/ Single-period analog sinusoidal signal
16	*B/SSINN	Output	Digital/Analog	B pulse signal/ Single-period analog sinusoidal signal
17	*Z/SCOSP	Output	Digital/Analog	Z pulse signal/ Single-period analog cosine signal
18	*U/SCOSN	Output	Digital/Analog	U pulse signal/ Single-period analog cosine signal
19	*V/MSINP	Output	Digital/Analog	V pulse signal/ Multi-period analog sinusoidal signal
20	*W/MSINN	Output	Digital/Analog	W pulse signal/ Multi-period analog sinusoidal signal
21	AVDD	-	GND	Analog Supply Voltage
22	AGND	-	GND	Analog Ground
23	*PWM/MCOSP	Output	Digital/Analog	PWM output / Multi-period analog cosine signal negative output
24	*NERR/MCOSN	Output	Digital/Analog	Error message output / Multi-period analog cosine signal negative output
25	MISO	Output	Digital	SPI/SSI data output signal
26	MOSI	Input	Digital	SPI/SSI data input signal
27	SCLK	Input	Digital	SPI/SSI clock signal
28	CS	Input	Digital	SPI Chip Select signal

Note:
** The port is a multiplexed port, default mode is digital output*

5. Ordering Information

Ordering Information	Mark	Ambient(℃)	Package	Pack	Quantity
SC60340ST-TB(1)	60340	-40-125	SSOP28	Tube	48Pcs
SC60340ST-TR	60340	-40-125	SSOP28	Reel	2000Pcs

Note:
(1) The Ordering Information Definition,SC60340=part number,ST=SSOP28,TB= Tube,TR=Reel.

6. Absolute Maximum Ratings

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
$V_{()}$	Voltage at VIN	-	-15	15	V
$V_{()}$	Voltage at VREG, DVDD, AVDD, A, B, Z, U, V, W, MISO, MOSI, CLK, CS, NERR, PWM	-	-0.3	6	V
$V_{()}$	Voltage at MPSIN, MNSIN, MPCOS, MNCOS, SPSIN, SNSIN, SPCOS, SNCOS	-	-0.3	6	V
$I_{()}$	Current at VIN, VREG, DVDD, AVDD	-	-10	50	mA
$I_{()}$	Current at A, B, Z, U, V, W, MISO, NERR, PWM	-	-100	100	mA
$I_{()}$	Current at CLK, CS, MOSI	-	-10	10	mA
-	EEPROM Write Cycles	-	-	100	cycle
T_A	Operating Ambient Tempreature	-	-40	125	℃
T_{STG}	Storage Temperature	-	-65	165	℃
$T_{J(max)}$	Maximum Junction Temperature	-	-	165	℃

Note:
Stresses above those listed here may cause permanent damage to the device. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

7. ESD Protection

Symbol	Parameter	Test Conditions	Min.	Max.	Unit
V_{ESD}	HBM	ANSI/ESDA/JEDEC-001	-4	4	kV
	CDM	ANSI/ESDA/JEDEC-002	-750	750	V

8. Operating Characteristics

Valid through the full operating temperature range, V_{IN}=12V or V_{REG}=5.0V; unless otherwise specified

Symbol	Characteristics	Test Conditions	Min.	Typ.	Max.	Unit
Power Parameter						
V_{IN}	Input Voltage	-	4.5	5.0	14.0	V
V_{REG}	Stabilivolt Output Voltage	V_{IN}=12V	4.3	4.4	4.5	V
C_{BP}	Stabilivolt capacitance	-	4.7	10.0	47.0	μF
I_{DD}	Operating Current	L=4.7μF, C=470pF, Rs=3Ω	40	50	60	mA
$V_{th(on)}$	Starting Voltage	V_{REG} voltage rising	3.5	3.8	4.1	V
$V_{th(off)}$	Low Voltage protection Voltage	V_{REG} voltage decreasing	3	3.3	3.6	V
$V_{th(Hys)}$	Hysteresis Voltage	-	0.3	-	-	V
LC Oscillator Parameter						
I_{osc}	Oscillator Drive Current	L=4.7μF, C=470pF, Rs=3Ω	2	-	10	mA
V_{osc}	Oscillator Turbulence	L=4.7μF, C=470pF, Rs=3Ω	3.2	4.0	4.8	V
F_{osc}	Oscillator Frequency	L=4.7μF, C=470pF, Rs=3Ω	-	2	-	MHz
L_{osc}	Oscillator Exciting Coil Inductance	-	2	-	15	μH
Q_{osc}	Oscillator quality Factor	$Q=(Losc/C)^{1/2}/Rs$	15	25	-	-
Angle Calculation Parameter						
$RES_{(sdc)}$	Angle Shift Resolution	-	-	12	-	bit
T_{delay}	Angle Output Delay	-	-	-	3.0	μs
$AA_{(abs)}$	Absolute Angle Accuracy	-	-0.3	-	0.3	Deg
$AA_{(rel)}$	Relative Angle Accuracy	AB pulse phase error	-	±10	-	%
PCB Coil and rotor-related Parameter						
D_{in}	Distance between Rotor and Stator	-	0.5	0.8	1.1	mm
VPP_{IN}	Coil Input Amplitude	-	1	-	40	mV
$f_{(rotator)}$	Rotor Rotational Frequency	-	-	-	1.67	kHz
rpm	Rotor Rotational Speed	-	-	-	200K	rpm
x_{dis}	Concentricity deviation allowance between Rotor and Stator	-	-0.2	-	0.2	mm
y_{diff}	Inclination deviation allowance between Rotor and Stator	-	-	-	0.3	°

Operating Characteristics (Continued)

Symbol	Characteristics	Test Conditions	Min.	Typ.	Max.	Unit
Digital Input: CS,SCLK,MOSI						
$V_{t()hi}$	High threshold voltage Input	-	-	-	2	V
$V_{t()lo}$	Low threshold voltage Input	-	0.8	-	-	V
$I_{pu()}$	CS,SCLK,MOSI Pull-up Current	$V_{()}$ = 0...V_{PD} − 1 V	-80	-140	-200	μA
Digital Output: A,B,Z,U,V,W,PWM,MISO,NERR						
$V_{s()hi}$	High Saturation Pressure Drop Output	Pull current 4mA, refer to DVDD voltage drop	-	-	200	mV
$V_{s()lo}$	Low Saturation Pressure Drop Output	The perfusion current was 4mA, and DGND uplift was referenced	-	-	200	mV
$I_{short()hi}$	GND Short Circuit Output	$V_{()}$ = GND;	4	-	20	mA
$I_{short()lo}$	Power Short Circuit Output	$V_{()}$ = VDD;	4	-	20	mA
$t_{Rise/Fall}$	Rise and Fall Time	Load R_L=100Ω	5	-	30	ns

9. Block Diagram

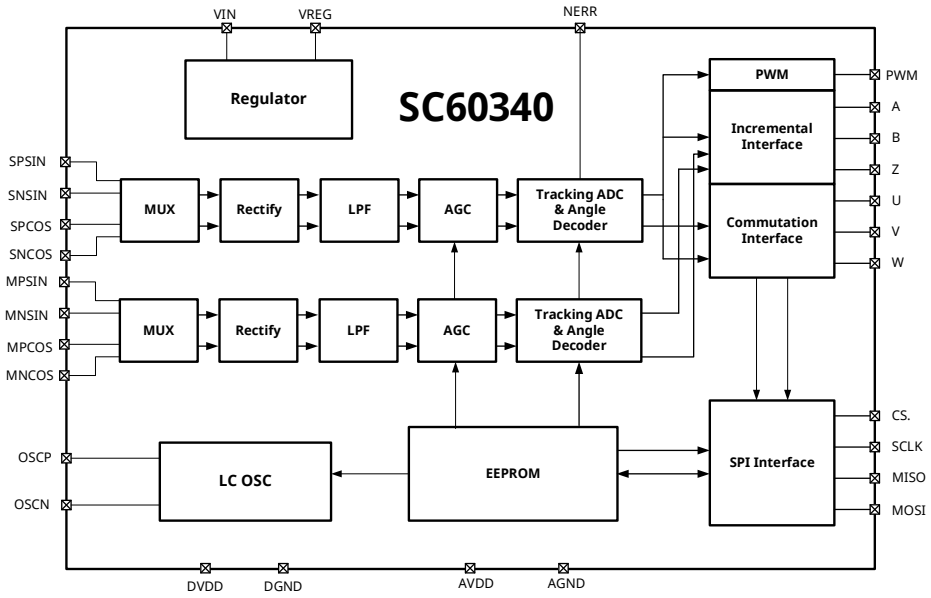


Fig.3 Block Diagram

The main modules are as follows:

Power management: power reset circuit, and linear regulator, etc. to power the internal digital processing circuit and driving circuit.

Oscillator: to Generate the exciting signal and drive the external exciting coil.

EEPROM: to store customer adjustment data.

Gain controller: to correct the input signal error of receiving coil within the reasonable range of digital circuit.

Signal decoder: to demodulate the input signal and convert it to the desired output signal.

Debugging interface: EEPROM data can be debugged through the common SPI interface.

Output signal: the signal required for programming.

10. Functional Description

10.1. SPI serial interface

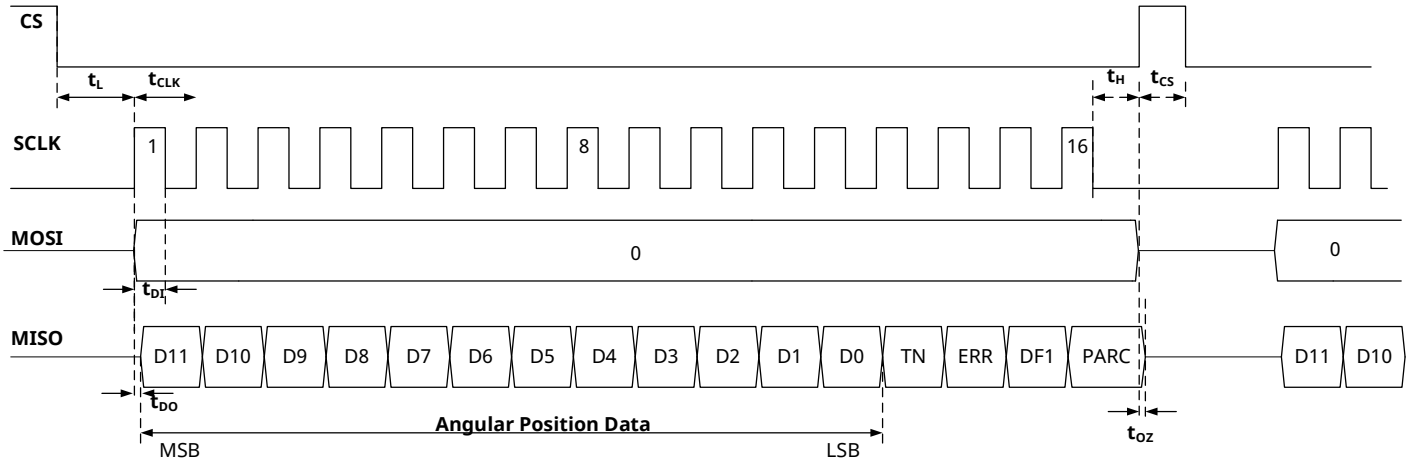


Fig.4 SPI Timing Definition

Parameter	Description	Min.	Max.	Unit
t_L	Time between CS falling edge and SCLK rising edge	250	--	ns
t_{CLK}	Serial clk period	100	--	ns
t_H	Time between last falling edge of SCLK and rising edge of CS	$t_{CLK/2}$	--	ns
t_{CS}	High time of CS between two transmissions	250	--	ns
t_{DO}	SCLK edge to data output valid	--	50	ns
t_{DI}	Data input valid to falling clock edge	20	--	ns
t_{OZ}	Release bus time after CS rising edge	--	10	ns

SPI Read Data Frame

Bit	Name	Description
15	PARC	Parity bit (odd) calculated on the lower 15 bits of data frame
14	DF2	Data fixed; logic High
13	DF1	Data fixed; logic High
12	ERR	Becomes logic High, when the fault occurs
11:0	DATA	Absolute angular position data (MSB is clocked out first)

10.2. Incremental A / B / Z Orthogonal Output

SC60340 output incremental orthogonal signal through A, B, Z pin. Under default setting, when the magnetic spin anticlockwise, pulse B is ahead of pulse A .

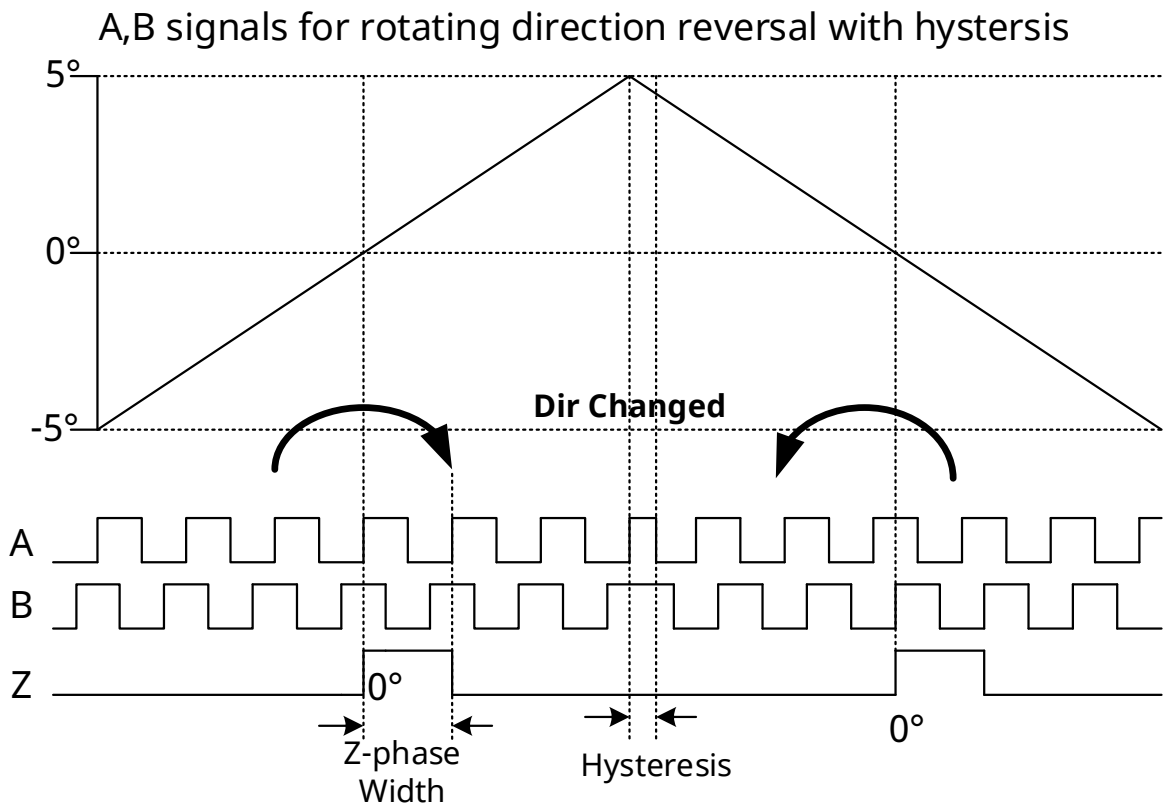


Fig.5 Pulse schematic

Note:
PPR of A and B can be programmed to from 1000 to 10000, default is at 1024.
Signal Z can be programmed to 1,2,4,8,16,32,64,128,256,512,1024,2048 LSB,default is at 1 LSB.
The hysteresis width of AB can be programmed to 1 LSB,2 LSB,4 LSB and 8 LSB,default is at 2 LSB.

10.3. Reversing signal of UVW motor

SC60340 output U ,V, W motor commutation position through. the Phase Difference is at 120°。Through programming it could generate a U ,V, W signal at 1 to 32 cycle corresponding to 1 to 32 pole-pair motor's commutation requirements.

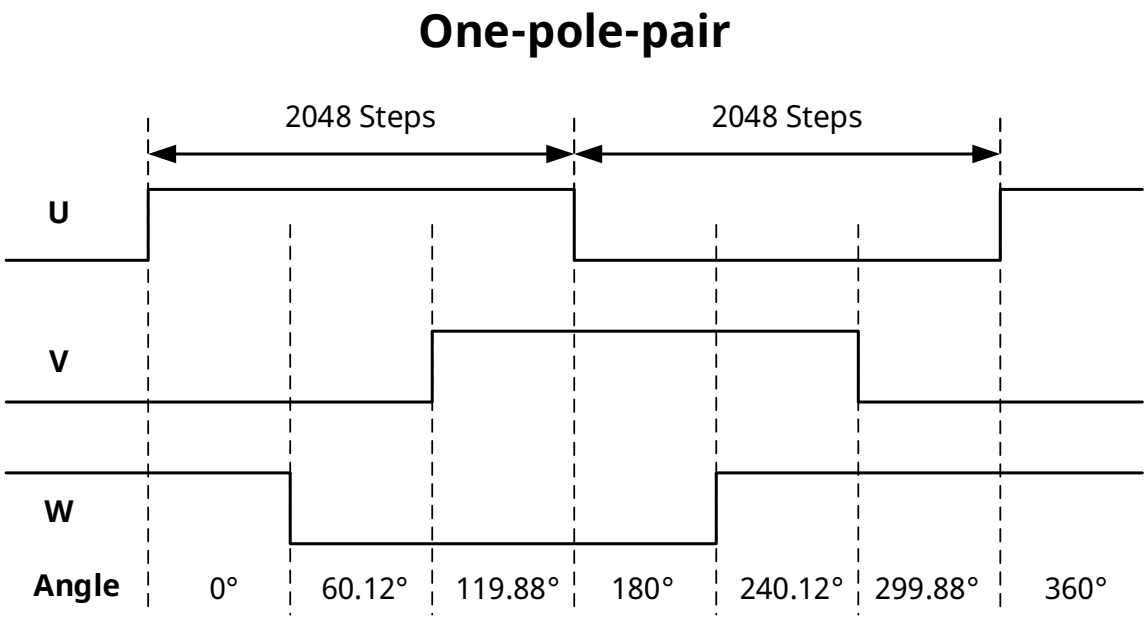


Fig.6 One pair of poles UVW

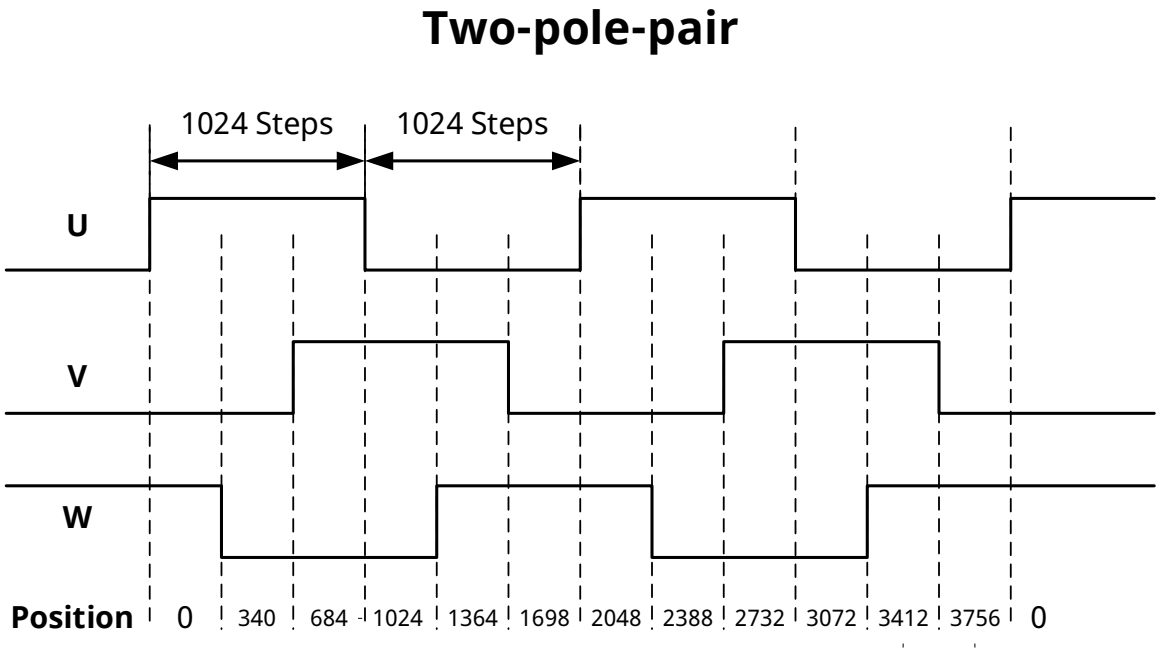


Fig.7 Two pair of poles UVW

10.4. Pulse width modulation output

SC60340 provides Pulse width modulation output mode , Duty ratio of waveform of PWM is related to the angle. Equation as follow:

Position = ton X 4098 / (ton + toff) - 1

The frequency of PWM is modulated in the circuit ,accuracy is at ±5%,Temperature range is at ±10%。Through testing the complete period of the PWM, the frequency error can be ignored.

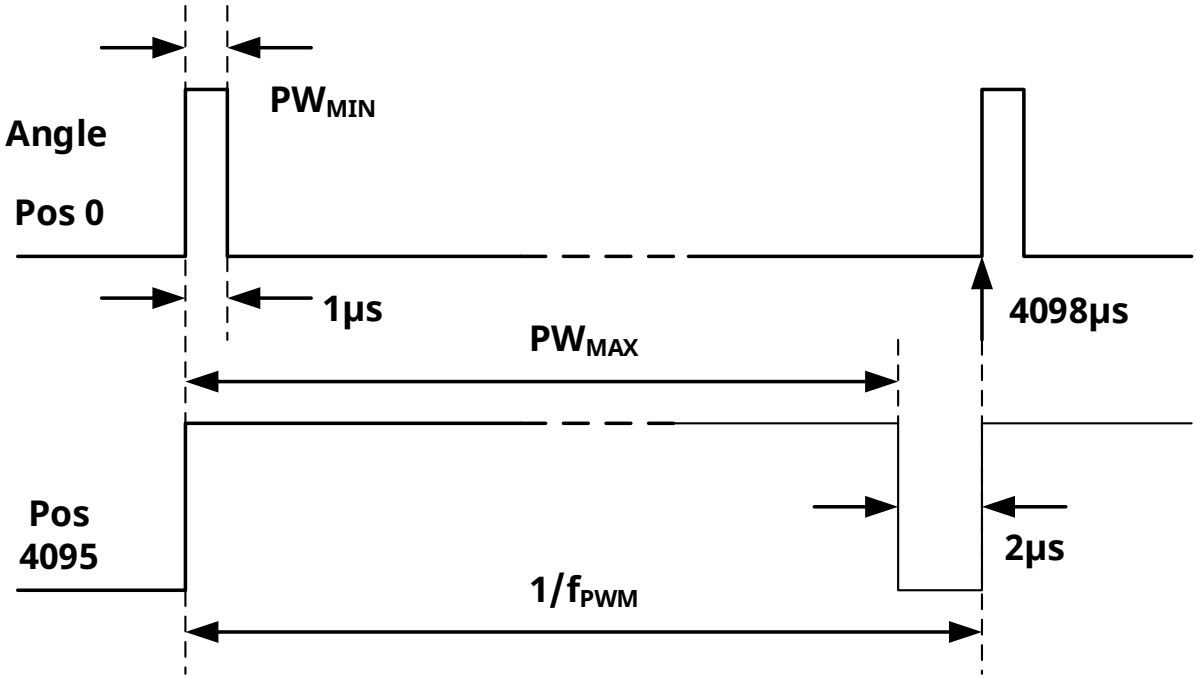


Fig.8 Schematic diagram of PWM waveform

Parameter	Symbol	Typical	Unit	Note
Frequent	f_{PWM}	0.244	kHz	Signal period: 4098µs
Minimal Pulse Width	PW_{MIN}	1	µs	Position 0deg
Maximum Pulse Width	PW_{MAX}	4096	µs	Position 4095deg

11. Typical Application

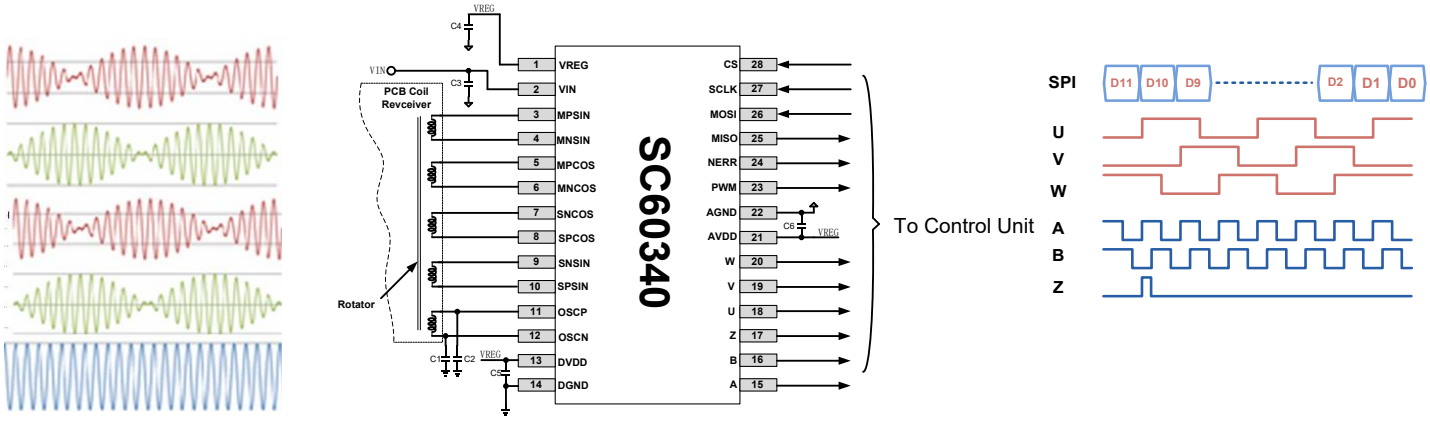


Fig.9 Enter the waveform\ Apply a circuit diagram\ Output waveform plots

1. C1,C2 selection:

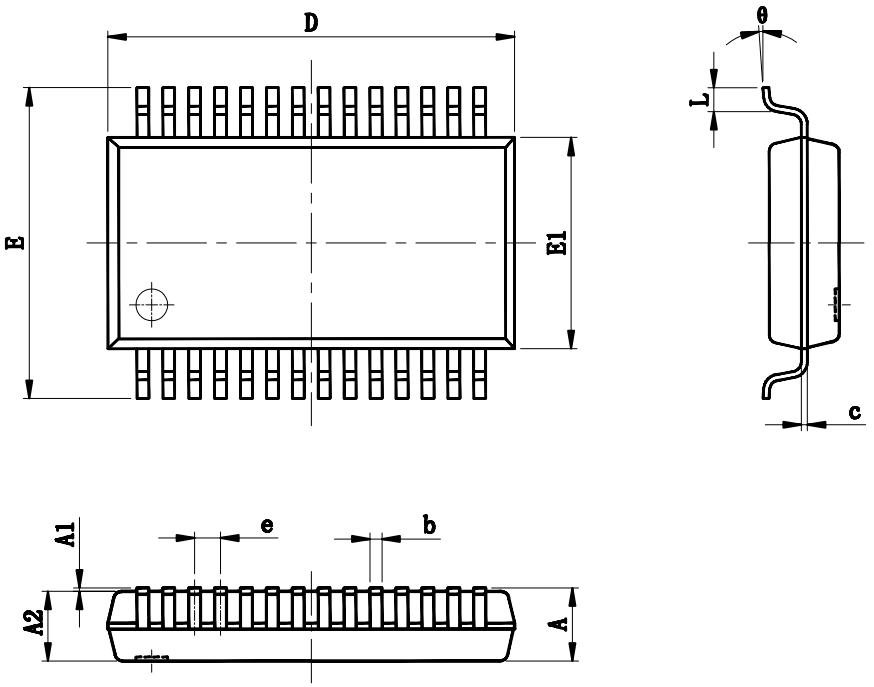
   LC oscillation frequency equation :

$$Fosc = \frac{1}{2\pi.\sqrt{\frac{C1.C2.Losc}{C1+C2}}}$$

2. Fosc range at 1.5MHz to 2.5MHz,The size of the capacitance is selected according to the PCB exciting coil's inductance Losc Conventional value at 300pF to 2nF.

3. C3=1μF/50V,C4=1μF/50V , C5,C6=10nF/50V.

12. Package Information ST



Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min.	**Max.**	**Min.**	**Max.**
A	--	2.000	--	0.079
A1	0.050	--	0.002	--
A2	1.650	1.850	0.065	0.073
b	0.220	0.380	0.009	0.015
c	0.090	0.250	0.004	0.010
D	9.900	10.500	0.390	0.413
E	7.400	8.200	0.291	0.323
E1	5.000	5.600	0.197	0.220
e	0.650(BSC)		0.026(BSC)	
L	0.550	0.950	0.022	0.037
θ	0°	8°	0°	8°

Fig.10 Package Dimension Drawing

13. Revision History

Revision	Date	Description
Rev.A1.0	2019-04-04	Preliminary Datasheet
Rev.A1.1	2019-07-16	Update typical application circuits
Rev.A1.2	2020-05-31	Add version history
Rev.A1.3	2020-11-17	Update the format
Rev.A1.4	2024-11-29	Modify order information