Dual Channel Inductive Rotary Encoder IC

1. Features

- Non-contact coil induction sensing technology is adopted
- Support through shaft or end closure installation
- Output interface
  - Sine and cosine signal output
  - SPI communication interface
- Internal EEPROM programmable
- Operating temperature from -40℃ to 125℃
- QFN6X6 packaging

2. Applications

- Servo motor control
- Permanent Magnet Synchronous Motor Control
- encoder
- industrial high-precision encoder
- optical encoder replacement

3. Description

SC60370 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 SC60370 can be used for high-speed absolute position detection in automotive, industrial, medical and consumer applications.

The sensor with SC60370 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 SC60370 to get the sine and cosine signal outputs.

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

SC60370 is available in 40-pin QFN6X6 package, and is lead (Pb) free, with 100% matte tin lead frame plating.

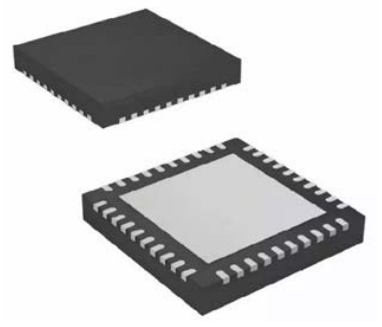

Fig1:Package outline drawing

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4. Terminal Configuration

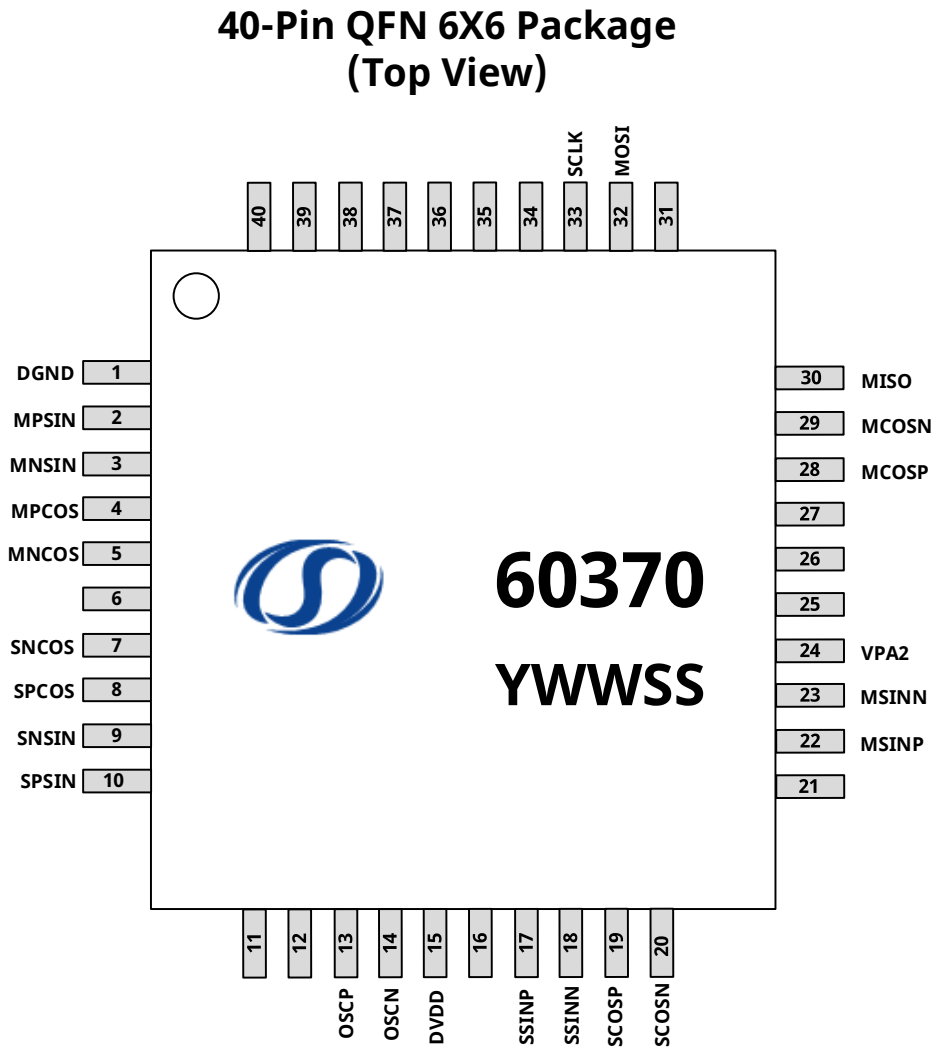


Fig2: Pin description diagram

NO.	Name	I/O	Type	Description
1	DGND	-	Power	Digital Ground
2	MPSIN	Input	Power	Multi-period receiving coil PSIN signal input
3	MNSIN	Input	Analog	Multi-period receiving coil NSIN signal input
4	MPCOS	Input	Analog	Multi-period receiving coil PCOS signal input
5	MNCOS	Input	Analog	Multi-period receiving coil NCOS signal input
6	DGND	-	Power	Digital Ground
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

(Continue)

NO.	Name	I/O	Type	Description
10	SPSIN	Input	Analog	Single-period receiving coil PSIN signal input
11/12	NC	-	-	NC
13	OSCP	Output	Analog	Exciting coil positive point output
14	OSCN	Output	Output	Exciting coil negative point output
15	DVDD	-	Power	Digital Power
16	DGND	-	Power	Digital Ground
17	SSINP	Output	Analog	Single-period analog sinusoidal positive signal
18	SSINN	Output	Analog	Single-period analog sinusoidal negative signal
19	SCOSP	Output	Analog	Single-period analog cosine positive signal
20	SCOSN	Output	Analog	Single-period analog cosine negative signal
21	NC	-	-	NC
22	MSINP	Output	Analog	Multi-period analog sinusoidal signal positive output
23	MSINN	Output	Analog	Multi-period analog sinusoidal signal negative output
24	VPA2	-	Power	Analog Power
25	VPA1	-	Power	Analog Power
26	VNA1	-	Power	Analog Ground
27	VNA2	-	Power	Analog Ground
28	MCOSP	Output	Analog	Multi-period analog cosine signal positive output
29	MCOSN	Output	Analog	Multi-period analog cosine signal negative output
30	MISO	Output	Digital	SPI/SSI data output signal
31	NC	-	-	NC
32	MOSI	Input	Digital	SPI/SSI data input signal
33	SCLK	Input	Digital	SPI/SSI clock signal
34	CSN	Input	Digital	SPI Chip Select signal
35	DGND	-	Power	Digital Ground
36	VREG	-	Power	Internal Regulator module Output
37	HVIN	-	Power	Internal Regulator module Input
38/39/40	NC	-	-	NC

5. Ordering Information

Ordering Information	Mark	Ambient, TA（℃）	Package	Packing	Quantity
SC60370QS-TY	60370	-40~125	QFN6X6-40	Tray	140Pcs

Note：

The Ordering Information Definition，SC60370=part number，QS=QFN6X6-40，TY= Tray

6. Absolute Maximum Ratings

Symbol	Characteristic	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 CLK, CS, MOSI		-10	10	mA
-	EEPROM Write Cycles		-	100	cycle
T_A	Operating Ambient Temperature		-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

Parameter	Symbol	Test Conditions	Min.	Max.	Units
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=4.7Fμ, 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	-	-
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 (Continue)

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

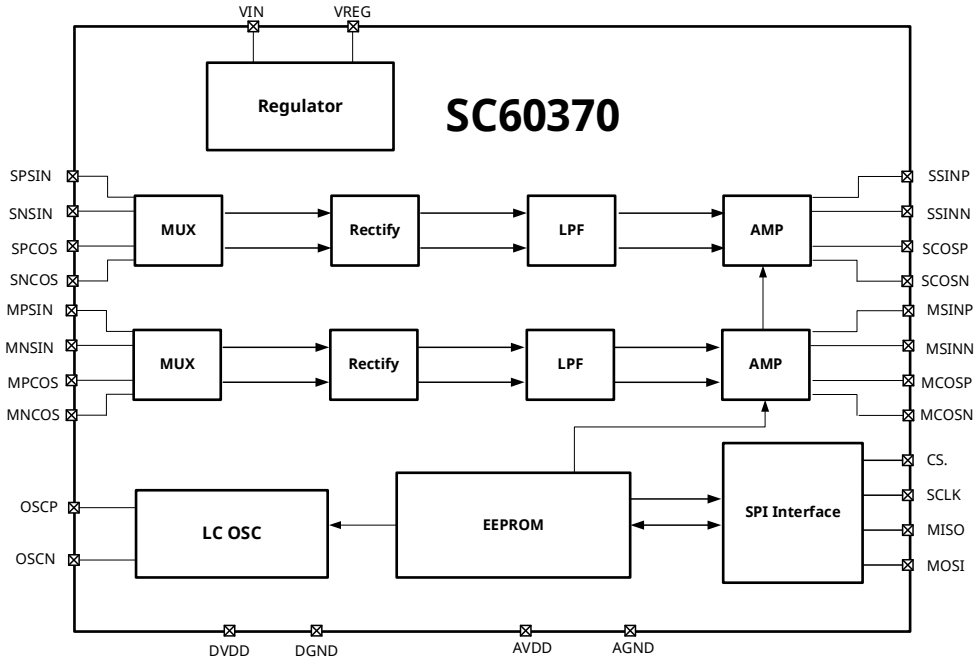


Fig3: Block Diagram

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.

Functional description

SC60370 is a non-contact high-speed and high-precision encoder chip with coil induction technology. The SC60370 drives LC resonant network composed of exciting coils. When rotor rotates, the alternating electric field of the exciting coil generates eddy current field in the rotor metal, and changes the induced electromotive force on the receiving coil, so as to get the signal curve related to the rotor position on the receiving coil. The signal related to rotor position is demodulated, filtered and amplified by SC60370, the final output corresponding to the rotating object is orthogonal cosine signal.

10. Typical Application

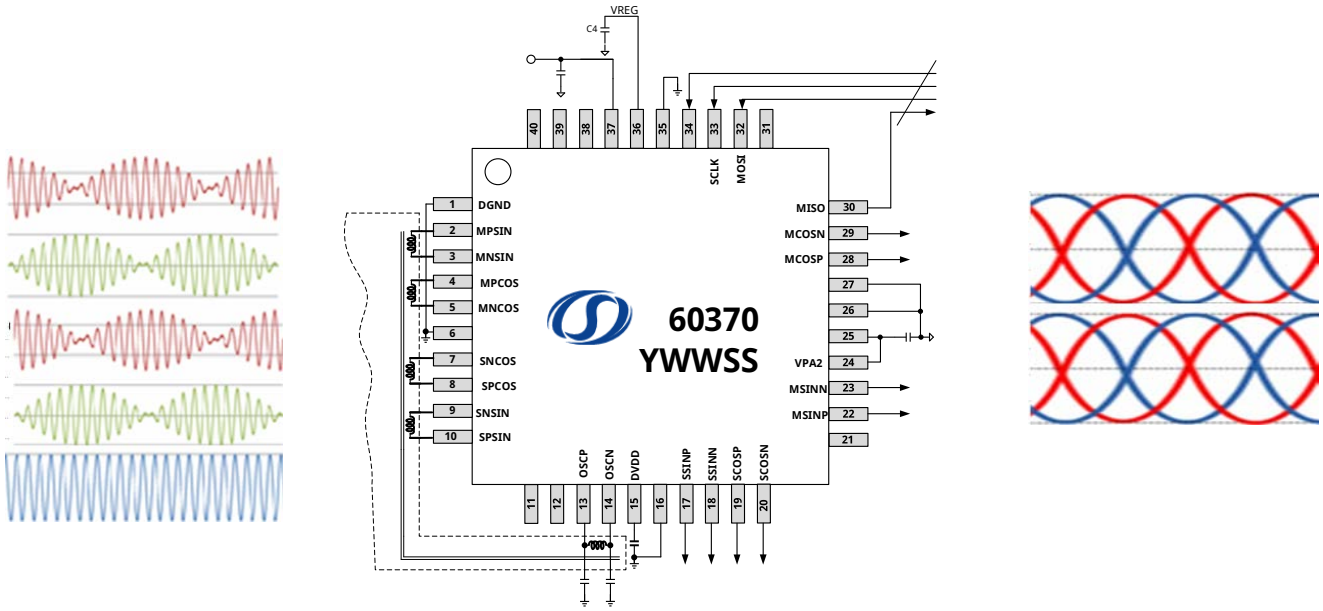


Fig4:Enter the waveform\ Apply a circuit diagram\ Output waveform plots

1. C1,C2 selection：

   LC oscillation frequency equation ：

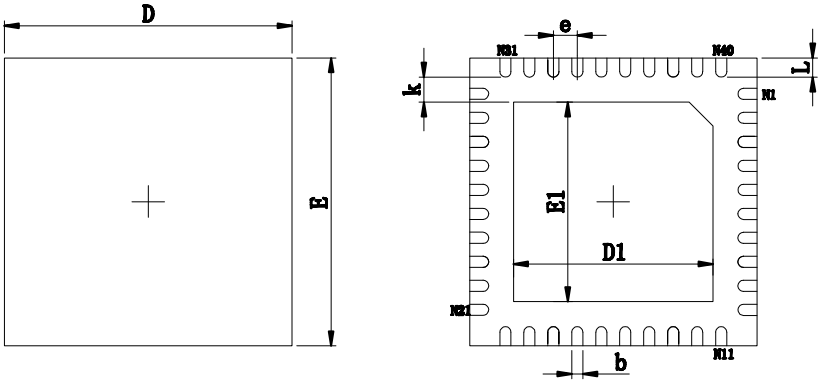
$$Fosc = \frac{1}{2\pi.\sqrt{\frac{C1.C2.Losc}{C1+C2}}}$$

   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

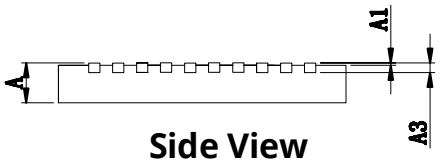
2. C3=1μF/50V，C4=1μF/50V , C5,C6=10nF/50V

3. Due to the use of external components (printed inductors and discrete capacitors), the Tx oscillation frequency will vary with temperature, mainly depending on the temperature coefficient of the discrete capacitor.
   Suggestion: to use low temperature coefficient capacitor or NPO material capacitor.

11. Package Information



Top View Bottom View



Side View

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	5.924	6.076	0.233	0.239
E	5.924	6.076	0.233	0.239
D1	4.100	4.300	0.161	0.169
E1	4.100	4.300	0.161	0.169
k	0.200MIN.		0.008MIN.	
b	0.180	0.280	0.007	0.011
e	0.500TYP.		0.020TYP.	
L	0.324	0.476	0.013	0.019

Fig5: Package Dimension Drawing

12. Revision History

Date	Revision	Description
2020.1.06	Rev0.10	Preliminary Datasheet
2020.3.20	Rev0.20	Modify typical application circuits
2020.6.21	Rev1.00	Add version history
2021.1.13	Rev A1.0	Uniform format publishing
2024-11-29	Rev A1.1	Modify order information