

# Basic parameter setting of sensorless motor

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## 1. Basic Parameters of Sensorless Motor

**Configuration file: Motor.h <Configuration Wizard>**

### Basic Motor Parameters

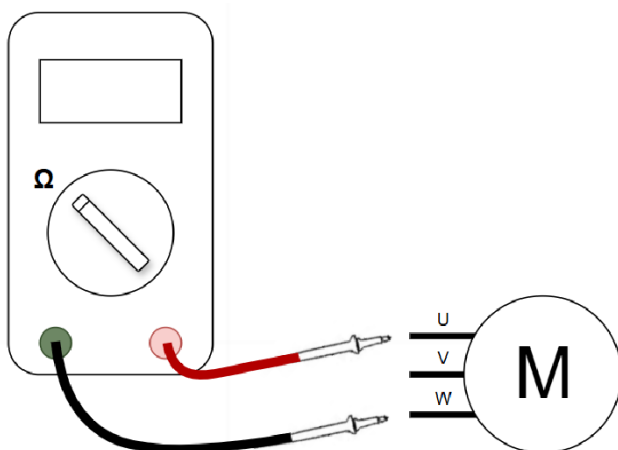
Parameters	Description	unit (of measure)
Stator Line-Line Resistance	Motor stator line impedance	mΩ
Stator Line-Line Inductance	Motor stator line inductance	uH
Motor Pole	Motor Poles	P
PWM Frequency	Output PWM Frequency	Hz
OPA GAIN	Setting the internal amplifier multiplier (sampling phase current)	gain
Rshunt	Sample Resistance of Phase Current	0.1 mΩ
Motor rated maximum speed	Rated Maximum Motor Speed	RPM
DC bus Voltage	Rated Input DC Voltage	V
Watt Maximum	Rated maximum output power	W

The following describes how to fill in the values for each of these basic parameters.

## 2. Measurement of motors

### 2.1 Three-Phase Line Resistance Measurement

A digital meter can be used to measure the line-to-line resistance of a three-phase motor. The measurement method is described below:



Measure any two phases separately:  $L(U-V)$ ,  $L(V-W)$ ,  $L(W-U)$   
 Reversing the order of the red and black rods does not affect the results, and the **inductance values of the three sets of data measured are added together and divided by "three" (averaged)**.

Confirm the unit of inductance, convert the unit to uH, and enter the value in the software parameter table (Stator Line-Line Inductance).

For example: any two-phase impedance is

0.17Ω/0.19Ω/0.144Ω respectively, then

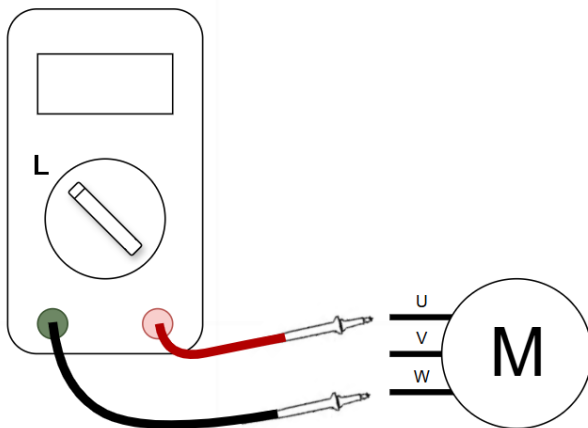
$$(0.17+0.19+0.144)/3 = 0.168\Omega,$$

$$0.168\Omega = 168m\Omega$$

Enter the value "168" into the software motor basic parameter table (**Stator Line-Line Resistance**).

## 2.2 Three-Phase Line Inductance Measurement

Three-phase line inductance can be measured using an LCR meter as shown below.



Measure any two phases separately:  $L(U-V)$ ,  $L(V-W)$ ,  $L(W-U)$   
 Reversing the order of the red and black rods does not affect the results, and the **inductance values of the three sets of data measured are added together and divided by "three" (averaged).**

Confirm the unit of inductance, convert the unit to  $\mu H$ , and enter the value in the software parameter table (Stator Line-Line Inductance)

LCR Meter Frequency Setting at 1KHz

For example, if the inductive reactance of any two phases is  $0.17mH/0.19mH/0.144mH$ , then  $(0.17+0.19+0.144)/3 = 0.168mH$ .

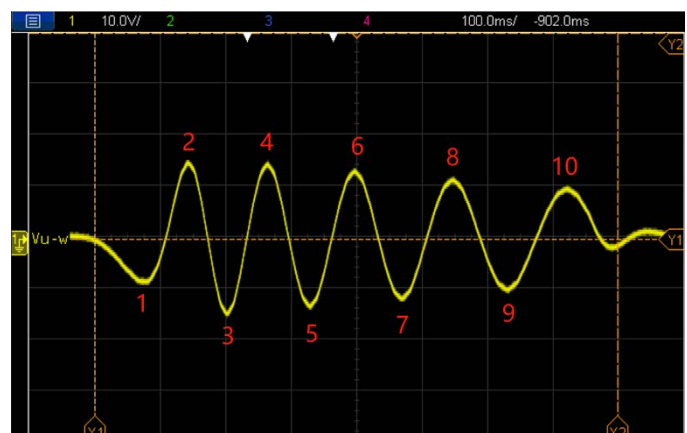
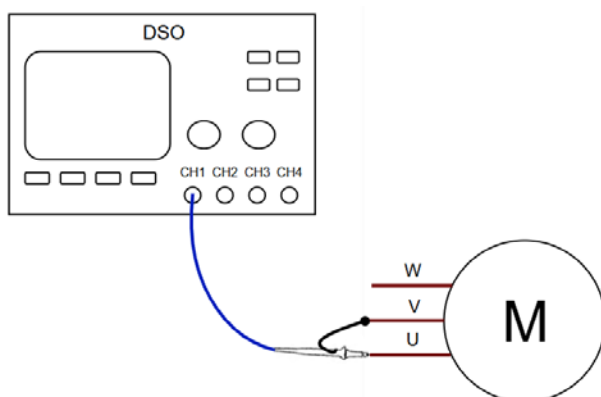
$$0.168mH = 168\mu H$$

Enter the value "168" into the software motor basic parameter table (Stator Line-Line Inductance).

## 2.3 Motor Pole Count Measurement

When the exact pole count of a motor is unknown, it can be determined by measuring the back electromotive force (BEMF). Connect an oscilloscope probe across any two phases of the motor (e.g., U to V or V to W...) and the motor does not need to be connected to the control board. At this time, the motor can be rotated once by hand or by external force. Then, count the total number of positive and negative half-cycles in the BEMF waveform, as shown in the figure below. This number corresponds to the motor's pole count (which is always a multiple of 2).

Enter this value into the software parameter table (Motor Pole).



Example of a 10-pole motor

## 3. Motor Rated Parameter Settings

### 3.1 PWM Output Frequency

The selection of PWM frequency should be based on the motor's application characteristics. While higher PWM frequencies increase MOSFET switching losses and motor heating—thereby reducing overall system efficiency—they are effective in suppressing current, power, and speed ripple, as well as vibration and noise during high-speed operation, which enhances overall system performance. Conversely, lower PWM frequencies (below 16 kHz) can be audible to the human ear. Therefore, it is recommended to use a higher carrier frequency for motors with lower inductance.

**The general recommendation is to increase the PWM frequency as much as possible for switching losses within the acceptable range of MOS temperature, unless there is a safety issue such as EMC and then adjust it appropriately.**

### 3.2 Rated parameters of the motor

Motor rated parameters include motor rated maximum speed, **motor rated input voltage** (DC bus Voltage), and **motor output maximum power** (Watt Maximum). These specifications can be found in the motor specifications or by asking the end customer.

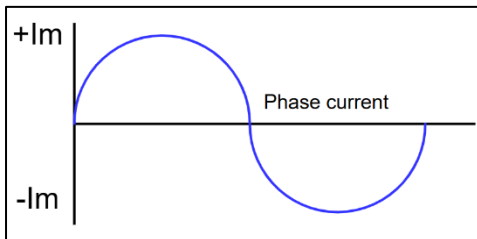
## 4. Sampling Resistance Related Settings

### 4.1 Phase Current Sampling Procedure

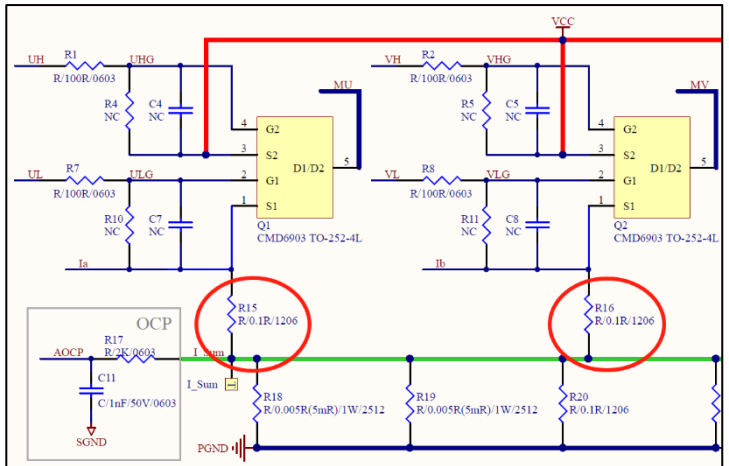
Sampling phase current resistor (hereinafter referred to as ShuntR) is the resistance in the red circle on the right, sampling  $I_a$  and  $I_b$  currents.

The OPA Gain selection and ShuntR selection can be found in the following equations.

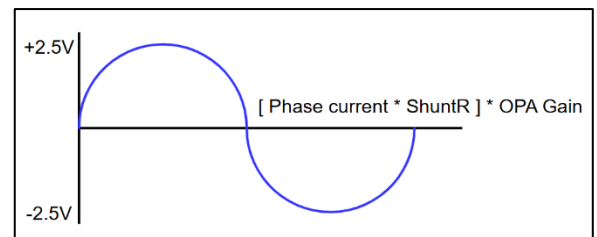
$$\text{OPA Gain} * \text{ShuntR} * \text{Sampled Maximum Phase Current} \leq 2.5\text{V}$$



Due to the motor's continuous operation, both positive and negative phase currents are generated. The left figure illustrates the actual current waveform flowing through ShuntR.



After multiplying the phase current by the ShuntR by the OPA Gain, the voltage range must be between  $\pm 2.5\text{V}$ , which is the reason why the previous formula limits the voltage to 2.5V. This is because the internal A/D reference voltage is 5V.



Because the internal A/D sampling can not effectively collect negative voltage, so it will go through an Offset 2.5V before A/D sampling, the Offset SFR setting is as follows :

**ADC1OS[H,L]:** Offset setting for the  $I_a$  sampling path, initially set to 0x200 (512)

**ADC2OS[H,L]:** Offset setting for the  $I_b$  sampling path, also initially set to 0x200 (512).

Both offsets are set to 512 to center the input signal around the 2.5 V midpoint.

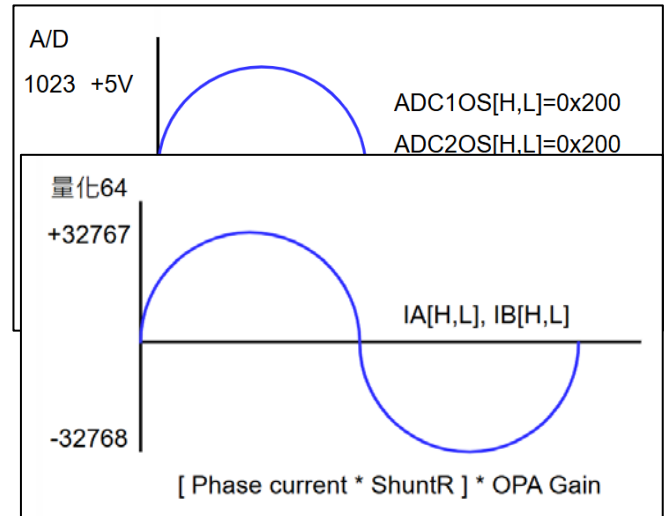
ADC10S_L		Address = C9H (SFR_PAGE = 0)		Reset Value = 0x00H				
ADC10Offset Value Register Low Byte								
ADC10S[7:0]								
Bit	7	6	5	4	3	2	1	0
Type	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W

ADC10S_H		Address = CAH (SFR_PAGE = 0)		Reset Value = 0x02H				
ADC10Offset Value Register High Byte								
ADC10S [9:8]								
Bit	7	6	5	4	3	2	1	0
Type	-----	-----	-----	-----	-----	-----	R/W	R/W

### 11. External Special Function Registers (XSFR)

#### XSFRs Memory Map

	8	9	A	B	C
1078	ZALPHA_L	ZALPHA_H	ES_IALPHA_L	ES_IALPHA_H	ES_EALPHA_L
1070	ZBETA_L	ZBETA_H	ES_IBETA_L	ES_IBETA_H	ES_EBETA_L
1068	IA_L	IB_H	IALPHA_L	IALPHA_H	VALPHA_L
1060	IB_L	IB_H	IBETA_L	IBETA_H	VBETA_L
1058					
1050					
1048					
1040	IR_DOUT0	IR_DOUT1	IR_DOUT2	IR_DOUT3	IR_DOUT4
1038	IR_DEC_SET	IR_DEC_CTRL	IR_HEADER_Z1_L	IR_HEADER_Z1_H	IR_HEADER_Z2_L
1030	MD_MODE	MD_CONT	MD0	MD1	MD2
1028	SOFT_RST_KEY	SOFT_RST_EN			
1020	IPWM_CYC_L	IPWM_CYC_H	IPWM_DUTY_L	IPWM_DUTY_H	IPWM_CTRL
1018	CRC_CTRL	CRC_DIN	CRC_DOUT_L	CRC_DOUT_H	CRC_STR_BANK
	0	1	2	3	4



Finally, IA[H,L] and IB[H,L] in the XSFR registers represent the sampled phase currents. Each of the 1,024 steps (ranging from -512 to +511) is internally scaled by a factor of 64, resulting in a final quantization range from -32,768 to +32,767. This relationship is illustrated in the figure below.

## 4.2 Sampling Resistance and OPA Gain Selection

Generally, the maximum phase current for A/D sampling is recommended to be **twice rated current of the motor.**

For example, if a motor has an input voltage of 310V and a maximum output power of 120W, its maximum output current is 0.38A, and it is 0.76A when it is doubled.

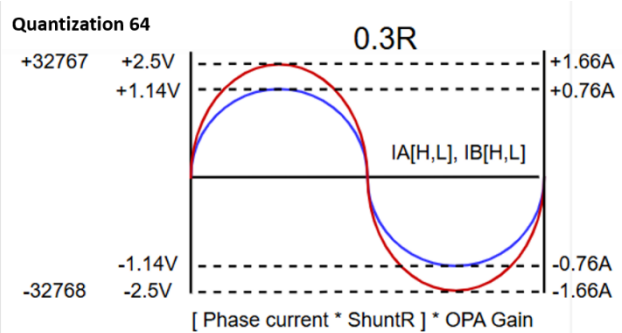
(Gain = 2.5) then  $ShuntR \leq 2.5V / 2.5 / 0.76A$ , then  $ShuntR \leq 1.31R$ , select a standard resistor close to this value: **1.3  $\Omega$**  (the larger the better within the limit), and this time the resistance power is  $(0.76^2) * 1.3 = 0.75W$ , selection of the recommended to catch more than two times, i.e.,  $0.75 * 2 = 1.5W$  (selection of the 2W resistor, or two 2.4R 1W resistors in parallel)

(Gain = 5) then  $ShuntR \leq 2.5V / 5 / 0.76A$ , then  $ShuntR \leq 0.65R$ , select a standard resistor close to this value: **0.5  $\Omega$**  (the larger the better within the limit), and this time the resistance power is  $(0.76^2) * 0.5 = 0.28W$ , the selection of the recommended to catch more than two times, i.e.,  $0.28 * 2 = 0.56W$  (selection of the 1W resistor).

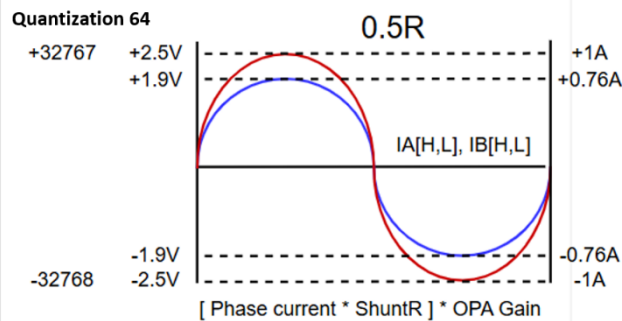
(Gain = 10) then  $ShuntR \leq 2.5V / 10 / 0.76A$ , then  $ShuntR \leq 0.32R$ , select a standard resistor close to this value: **0.3  $\Omega$**  (the larger the better within the limit), and this time the resistance power is  $(0.76^2) * 0.3 = 0.17W$ , the selection of the recommended to catch more than two times, i.e.,  $0.17 * 2 = 0.34W$  (selection of the 0.5W resistor).

**When heat dissipation is within acceptable limits and the OPA Gain setting remains the same, using a larger ShuntR value is preferable. This improves current sampling resolution and can contribute to better motor efficiency. Conversely, using a lower OPA Gain setting helps reduce noise interference in the sampling process.**

In the example above, with Gain = 5, the difference between using a 0.5 Ω and a 0.3 Ω ShuntR is illustrated in the figure below. The blue curve represents the actual applied current range, while the red curve shows the corresponding sampled current range. As shown, the 0.5 Ω configuration offers higher resolution than the 0.3 Ω configuration.



$$0.76 / 1.14 = 0.666(A/V)$$



$$0.76 / 1.9 = 0.4(A/V)$$