

SX68200M Series: Motor Drivers with Sensorless Vector Control

# A Guide to Demo Board Evaluation and Parameter Adjustment

# **Precautions for High Voltage**



Dangerously high voltages exist inside the demonstration board.

Mishandling the demonstration board may cause the death or serious injury of a person.

Before using the demonstration board, read the following cautions carefully, and then use the demonstration board correctly.

# DO NOT touch the demonstration board being energized.

Dangerously high voltages that can cause death or serious injury exist inside the demonstration board being energized.

# Electrical shock may be caused even by accidental short-time contact or by putting hands close to the demonstration board.

Electrical shock can result in death or serious injury.

Before touching the demonstration board, make sure that the capacitors have been discharged.

# For safety purpose, an operator familiar with electrical knowledge must handle the demonstration board.

The demonstration board is for evaluation of all the features of the SX68200M series.

The demonstration board shall not be included or used in your mass-produced products.

Before using the demonstration board, see this document and refer to the SX68200M series data sheet.

Be sure to use the demonstration board within the ranges of the ratings for input voltage, frequency, output voltage, and output current.

Be sure to strictly maintain the specified ambient environmental conditions, such as ambient temperature and humidity.

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#### Introduction

The SX68200M series are 3-phase brushless motor drivers in which output transistors, pre-drive circuits, bootstrap diodes with current-limiting resistors are highly integrated. Employing a sinusoidal driving strategy with a sensorless vector control, the SX68200M series brings a small-sized, high-efficient, and low-noise motor controlling into your application.

The SX68200M series incorporates a microcontroller, allowing users to set individual parameters with a dedicated GUI. This application note describes how to evaluate a demo board equipped with an SX68200M series device and how to adjust parameters with the GUI. For more details, refer to the SX68200M series data sheet.

# **SX68200M Series Features**

- Pb-free (RoHS Compliant)
- Sinusoidal Current Waveform (Low Noise, High Efficiency) Sensorless Vector Control (High Efficiency at Load Variation, Small Size)
- Built-in Bootstrap Diodes with Current-limiting Resistors
- EEPROM as a Control Parameter Storage
- Two Speed Control (PI Control) Modes:
  - Analog Voltage Control (VSP Pin)
  - Serial Communications Control (I<sup>2</sup>C Compatible)
- 3-shunt Current Detection
- DIAG Pin Fault Signal to Be Output
- Protections Include:
  - V3 Pin Undervoltage Protection
  - Watchdog Timeout Detection
  - Memory Error Detection
  - Overvoltage Protection and Undervoltage Lockout for Main Power Supply (VM Pin)
  - Soft Overcurrent Protection
  - Hard Overcurrent Protection
  - Thermal Warning
  - Thermal Shutdown
  - Undervoltage Lockout for Logic Supply
  - Loss-of-Synchronization Protection

#### Applications

- Fan Motor for Air Conditioner
- Fan Motor for Air Purifier and Electric Fan

#### SX68200M Series Package





Not to scale

#### SX68200M Series Demo Board



#### SX68200M Series GUI



# 1. Demo Board Overview

Table 1-1 provides the specifications of the demo boards for evaluating the SX68200M series devices. Select a demo board based on your applications and power supply specifications. The demo boards are available from the URL below.

URL: https://www.semicon.sanken-ele.co.jp/support/evalboard/hvmd.html

			-			
No.	On-board IC (V <sub>DSS</sub> , I <sub>O</sub> )	Motor Type	Input Supply Voltage	Rectified Voltage	VCCx Pin Voltage	VSP Pin Voltage
Demo Board 1	SX68201M (250 V, 2.0 A)	100 V system	100 VAC	141 VDC	, on age	- · · · · · · · · · · · · · · · · · · ·
Demo Board 2	SX68203M (600 V, 1.5 A)	100 V system / 200 V system	100 VAC / 200 VAC	141 VDC / 282 VDC	15 V	1.50 V to 5.06 V*
Demo Board 3	SX68205M (600 V, 2.0 A)	100 V system / 200 V system	100 VAC / 200 VAC	141 VDC / 282 VDC		

Table 1-1. Demo Board Specifications

\* Refers to when adjusting by the VSP pin voltage-adjusting resistor, VSP\_VR; when using an external power supply, apply a 1.40 to 5.88 voltage to the VSP pin of the CN3 (see Figure 1-1).



Figure 1-1 is the circuit diagram of a demo board populated with an SX68200M series device.

Figure 1-1. Circuit Diagram of Demo Board

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# • Bill of Materials

l of Materia		<u> </u>			
Symbol	Part Type	Ratings	Symbol	Part Type	Ratings
C3	Electrolytic	120 µF, 400 V	R109*	General	Open
C4	Electrolytic	100 μF, 25 V	R110	General	10 kΩ, 0.25 W
C5	Electrolytic	10 μF, 50 V	R111	General	100 Ω, 0.25 W
C6	Ceramic	0.22 μF, 50 V	R112	General	100 Ω, 0.25 W
C100	Film	0.047 µF, 400 V	R113	General	100 Ω, 0.25 W
C101	Ceramic	1 μF, 50 V	R114	General	10 kΩ, 0.25 W
C102	Ceramic	1 μF, 50 V	R115	General	10 kΩ, 0.25 W
C103	Ceramic	1 μF, 50 V	R116	General	2.2 kΩ, 0.25 W
C104	Electrolytic	100 μF, 25 V	R117	General	Open
C105	Ceramic	1 μF, 50 V	R119	General	3.3 kΩ, 0.25 W
C106	Ceramic	1 μF, 50 V	R120	General	10 kΩ, 0.25 W
C107	Ceramic	100 pF, 50 V	R121	General	10 kΩ, 0.25 W
C108*	Ceramic	Open	R201	General	1 kΩ, 0.25 W
C109	Ceramic	0.1 μF, 50 V	R202	General	100 Ω, 0.25 W
C110	Ceramic	1 μF, 50 V	R203	General	Open
C111	Ceramic	0.1 μF, 50 V	R204	General	100 Ω, 0.25 W
C112	Ceramic	0.1 μF, 50 V	R205	General	1 kΩ, 0.25 W
C113	Ceramic	1000 pF, 50 V	RS1*	Metal plate	0.36 Ω, 1 W
C114	Ceramic	1000 pF, 50 V	RS2*	Metal plate	0.36 Ω, 1 W
C115	Ceramic	1000 pF, 50 V	RS3*	Metal plate	0.36 Ω, 1 W
C116	Ceramic	100 pF, 50 V	RD0	Metal plate	1 MΩ, 1 W
C117	Ceramic	100 pF, 50 V	TH0	Thermistor	10 Ω, 1800 mW
C201*	Ceramic	Open	VSP_VR	Trimmer	20 kΩ, 0.5 W
C202*	Ceramic	Open	D1	Fast recovery	200 V, 1 A
C203	Ceramic	0.1 µF, 50 V	D2	Fast recovery	500 V, 1 A
C204	Ceramic	Open	D3	Fast recovery	500 V, 1 A
C205	Ceramic	1 μF, 50 V	D4	Zener diode	1  W, Vz = 18.8  V  (min.)
C206	Ceramic	0.1 µF, 50 V	L1	Filter	74.5 mH
C207	Ceramic	Open	L2	Inductor	1 mH
CX0	Film	22 nF, 275 VAC	F1	Fuse	250 VAC, 1 A
CY1	Ceramic	4.7 nF, 250 VAC	LED1	LED	5 V, 30 mA
CY2	Ceramic	4.7 nF, 250 VAC	LED2	LED	5 V, 30 mA
R1	General	10 kΩ, 0.25 W	LED3	LED	5 V, 30 mA
R2	General	47 kΩ, 0.25 W	LED4	LED	5 V, 30 mA
R3	General	4.7 kΩ, 0.25 W	RESET	Switch	TS-AGGNH-G
R4	General	4.7 kΩ, 0.25 W	DIR SW	Switch	1MS1-T2-B1-M1-Q-N-S
				Micro USB	
R5	General	33 kΩ, 0.25 W	USB_Micro	Type-b	ZX62-B-5PA
		,	_	connector	
R6	General	33 kΩ, 0.25 W	CN1	Connector	Equiv. to B2P3-VH
R7	General	33 kΩ, 0.25 W	CN2	Connector	Equiv. to B3P5-VH
R8	General	33 kΩ, 0.25 W	CN3	Pin header	2.54 mm pitch
R9	General	33 kΩ, 0.25 W	CN4	Pin header	2.54 mm pitch
R101	Metal plate	1 MΩ, 0.25 W	DC-Link	Connector	Equiv. to B2P3-VH
R102	Metal plate	1 MΩ, 0.25 W	RC1	Bridge diode	D3SBA60
R102	Metal plate	1 MΩ, 0.25 W	Q1	NPN transistor	Open
R105	Metal plate	$10 \text{ k}\Omega, 0.25 \text{ W}$	IPM1	IC	SX68200M series
R104	General	$47 \text{ k}\Omega, 0.25 \text{ W}$	IC1	IC	STR5A464D
R105	General	$47 \text{ k}\Omega_2, 0.25 \text{ W}$ 5.6 k $\Omega$ , 0.25 W	IC1 IC2	IC	FT232RL
R100	General	$10 \text{ k}\Omega, 0.25 \text{ W}$	JP1		Short
				Jumper	
R108	General	$10 \text{ k}\Omega, 0.25 \text{ W}$	JP2	Jumper	Short

\* Refers to a part that requires adjustment based on operation performance in an actual application.

#### 2. Evaluating the Demo Board

This section explains the procedure until the motor starts to rotate in Int SR mode. For more details on the parameter adjustment, see Section 3.

# 2.1. Calculating Winding Ls

This section describes how to calculate a value to be selected from the **Winding Ls** list in the GUI, which is required when rotating a testing motor with your demo board. Note that the motor does not start to rotate unless a proper value is selected from the **Winding Ls** list.

Firstly, measure the average line inductance,  $L_{AVG}$ , of the testing motor. As Figure 2-1 shows, measure line inductances across any two phases,  $L_{IJ}$ , by an LCR meter. Measure the line inductances for multiple times since a line inductance varies according to the position of a rotor. In addition, measure the line inductances of multiple motors. After measuring the line inductances, calculate an average line inductance,  $L_{AVG}$  (see Table 2-1). The  $L_{AVG}$  is an average value from all the individual phase-to-phase inductances you measured.



Figure 2-1. Line Inductance Measurement

Motor	Number of		Line Inductance, L <sub>IJ</sub> (mH	I)
Motor	Measurements	$L_{UV}$	L <sub>VW</sub>	$L_{UW}$
	First	81	80	79
No. 1	Second	82	82	81
Third		80	82	81
	First	81	80	81
No. 2	Second	82	82	82
	Third	81	80	82
Average (LAVG)			81.1	

Table 2-1. Example Results of Line Inductance Measurement

Secondly, calculate a value of the Winding L<sub>S</sub>. The equations below define the Winding L<sub>S</sub>:

Winding 
$$L_S = \frac{L_{AVG}}{2} \times \frac{I_{FS} \times 20 \times 10^6}{V_{DC} \times f_C \times 8.29 \times 10^{-3}}$$
 (1)

$$I_{FS} = \frac{CS \text{ Range}}{R_{Sx}}.$$
(2)

$$f_{\rm C} = \frac{1}{T_{\rm PR}}.$$
(3)

Where:

L<sub>AVG</sub> is the average line inductance (H),

 $V_{DC}$  is the main power supply voltage (V),

I<sub>FS</sub> is the maximum current range of the current-sensing operational amplifiers (A),

CS Range is the maximum input voltage range of the current-sensing operational amplifiers (V),

 $R_{Sx}$  is the shunt resistance ( $\Omega$ ),

 $f_C$  is the PWM carrier frequency (Hz), and

 $T_{PR}$  is the PWM period (s).

When you operate the testing motor with your demo board for the very first time, the following parameters must be calculated with their default values shown in the GUI: CS Range = 0.5 V,  $T_{PR}$  (i.e., PWM period) = 58.9 µs. When  $L_{AVG}$  = 0.0811 H,  $V_{DC}$  = 282 V, CS Range = 0.5 V,  $R_{Sx}$  = 0.36  $\Omega$ , and  $T_{PR}$  = 58.9 µs, for instance, we will find the Winding  $L_S$  as follows:

Winding 
$$L_{s} = \frac{0.0811}{2} \times \frac{\frac{0.5}{0.36} \times 20 \times 10^{6}}{282 \times \frac{1}{58.9 \times 10^{-6}} \times 8.29 \times 10^{-3}} = 28 \text{ Lu}$$

We also offer you Winding  $L_s$  Calculation Tool that helps you perform quick and easy calculations. Please visit the URL below to find out more:

URL: https://www.semicon.sanken-ele.co.jp/en/calc-tool/windingls\_caltool\_en.html

#### Winding L<sub>c</sub> Calculation Tool



and click **Calculate**.





Section 2.4 describes how to enter a calculated value into the GUI. Note that any calculation results are reference only. When you adjust parameters, be sure to fine-tune the calculated value based on an actual motor rotation speed. For more details, see Section 3.4.1.

# 2.2. Preparing the Devices and Tools for Evaluations

#### • Required Devices

Make sure that the following devices have been prepared before starting your demo board evaluation.

Device	Description	Remarks
AC Power Supply	Constant voltage power supply or SLIDAC	Required
USB Cable	USB A-USB micro B cable	Required
FTDI Cable	Model name: TTL-232R-5V	Recommended
USB Isolator	Model name: 114991949 Manufacturer: Seeed Studio URL: <u>https://www.mouser.jp/ProductDetail/Seeed-</u> <u>Studio/114991949?qs=P1JMDcb91o6Z7ld6yCt%2FVQ==</u> Model name: USB Isolator USB-ISO Manufacturer: OLIMEX URL: <u>https://strawberry-linux.com/catalog/items?code=15043</u>	Required (The items at left are examples; you can use any USB isolator.)
Motor		Required
Load		Required in parameter adjustment
Control PC	OS: Windows 7 or later	Required
Logic Power Supply	Power supply for EEPROM write or external VSP mode evaluation	Not used in Int SR mode; only used for operating the motor in stand-alone mode.

#### • GUI Executable File

The GUI for setting parameters is available.

From the URL below, download the SX682xxM\_Serial\_Interface\_V3p6.exe file.

URL: https://www.semicon.sanken-ele.co.jp/en/support/documentsfordesign/hvmdtools/sx68200m.html#tool

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#### • Downloading an FTDI Driver

An FTDI driver is required for executing the GUI. When any FTDI driver has not been installed in your control PC, follow the steps below to download a proper driver (as of February 4, 2021). The following steps exemplify a procedure to download the driver that supports Windows<sup>®</sup> 64-bit operating systems.



Currently Supported D2XX Drivers:

		Processor Architecture					
Operating System	Release Date	X86 (32- Bit)	X64 (64- Bit)	ARM	MIPS	SH4	Comments
Windows*	2017 -08-30	<u>2.12.28</u>	<u>2.12.28</u>	-	-	-	WHQL Certified.Includes VCP and D2XX. Available as a <u>setup executable</u> Please read the <u>Release Notes</u> and <u>Installation Guides</u> .

Select an appropriate processor architecture that supports your PC envronment from the table.

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- 5) Download and unzip the .zip file you selected.
- 6) Place the **ftd2xx.dll** and **SX682xxM\_Serial\_Interface\_V3p6.exe** files in the same hierarchy.

ftd2xx.dll
SX682xxM\_Serial\_Interface\_V3p6.exe

Note that the file name and file location of a .dill file will depend on which file you downloaded. Your .dll file downloaded through the steps above should be stored as follows:

CDM v2.12.28 WHQL Certified > i386 > ftd2xx.dll

# 2.3. Connecting the Devices

The following steps describe how to connect your demo board and control PC. DO NOT connect any AC power supply at this stage.

- Connect the USB isolator to the control PC. To protect the control PC from any damage, be sure to use the USB isolator you have chosen.
- 2) Connect the USB isolator and the demo board by using a USB cable (Figure 2-3) or FTDI cable (Figure 2-4). Using an FTDI cable enables I<sup>2</sup>C-compatible communications control. Pay attention to the connector orientation so that the cable color and the silkscreen indicator are matched.



LEDs lit by USB bus power

Figure 2-3. Connection by USB Cable



LEDs lit by USB bus power

Figure 2-4. Connection by FTDI Cable

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 To launch the GUI, double-click the SX682xxM\_Serial\_Interface\_V3p6.exe file. Section 4 gives detailed descriptions on the GUI.

PWM       Current Sample       Speed Control       DAG Drv Current       Positive L       FG         PWM Mode       2 ph <ul> <li>CS Range</li> <li>CS Delay</li> <li>O us</li> <li>CS Delay</li> <li>O us</li> <li>SpeedRef Sel</li> <li>Ext VSP</li> <li>SpeedRef Max</li> <li>O Fu</li> <li>Spee</li></ul>	Sank	en	<b>SX682xxM</b> w- A9821	USB-I2C FAIL! Reg12 W 0001	Run Control DIAG Output	Fault 💌	Mask	Clear
I Win Mode       2 Jil       CO Range       1000 300 100 100 100 100 100 100 100 100	PWM		Current Sample	Speed Control	DIAG Drv Curnt	Positive L		
PWM Period         30.5 us         C         C         Delay         0.0 us         SpeedRef Urt         0.1 Hz         Fighrequency         Pdr           PWM DeadTm         000 us         •         SpeedRef Max         0 Fu         SpeedRef Max         Full         PMRSTn Ouput         Read Diag         Clear Fit         Fit           BootC ChrgTm         0 ms         •         SpeedRef Max         0 Fu         SpeedRef Max         0 Fu         PMRSTn Ouput         RESET         TW           Start Up         Mode         Ramp Up         Hot Over Current         Hot Over Current         VSPVM Voltages         VSPRun Max         0.000 V         VSPRun Max         0.000 V         Restart No         5         T         DOT           MM Ext Currt         6.25% Imax         •         Dead Time Compensation         OT         VSPRun Mix         0.000 V         VSPRun Mix         0.000 V         UVM         Restart No         5         •         C         OVM           Hold Time         0.0 (ms)         •         DTCmp Eanb         DTC OFF         UVM Thr/V         0.30 V         ProductNo PN         0         •         C         C         C         C         C         C         C         C         C         C	PWM Mode	2 ph 👻	CS Range -500~500mV -	SpeedRef Sel Ext VSP	FG Output	FG 💌		
PWM DeadTm       0.00 us       •         BootC ChrgTm       0 ms       •         BootC ChrgTm       0 ms       •         Start Up       Mad Over Current       SpeedRef Max       0 Fu         Hard Over Current       Hard Over Current       SpeedRef Max       0 Fu         Hord Dire       0 ms       •         WM Brk Curnt       25% Imax       •         HOCP FilterTm       2 0 us       •         VSP/VM Voltages       VSPRun Max       0.000 V         VSPRun Max       0.000 V       •         VSPRun Min       0.000 V       •         VSPRun Min       0.000 V       •         VSPStart Min       0.000 V       •         Nobe Compensation       •       VSPStart Min       0.000 V         DTCmp Eaabl       DTC OFF       UVM ThrV       0.3 V         DTCmp MaxTm       0.0% DT       •       Password Pwd       000 •         Read Diag	PWM Period	30.5 us 👻	CS Delay 0.0 us -	SpeedRef Unt 0.1 Hz •	FG Frequency	Fdrv		
Badde Cung III       OTINS       V         Start Up       Start Up       Stop Or Fail       ESF OFF         Start Up       HoCP ThreV       150% Ifs       VSP/VM Voltages         MM Brk Curmt       25% Imax       VSP/VM Voltages       Stop On Fail       ESF OFF         MM Brk Curmt       6.25% Imax       VSP/VM Voltages       VSPRun Max       0.000 V       No Restart         Hold Time       0       V       Dead Time Compensation       DTCmp Eaabl       DTC OFF       UVM ThrV       0.300 V       No Restart Torque       Fixed         Hold Time       0       0       Instrate       Off       UVM ThrV       0.30 V       No Restart Torque       Fixed         Hold Time       0       0       Instrate       Off       UVM ThrV       0.30 V       No Restart Torque       Fixed         DTCmp Gain       0       VSP       DTCmp Gain       VSP       VSP Num Nin       0.000 V       No No No No       Read Registers         RampU Frequ       1.6 Hz       Motor Control       Motor Control       ProductNo PN       VSP       Iz2 Registers       Spec Regs         Ki Spess       0.008 Kntp       Ki Speed       0.008 Knci       Ki Curmt       No No No Coor       Run       Cod 000 C1 00	PWM DeadTm	0.00 us 👻	CS MinOn 0.0 us +	SpeedRef Max 0 Fu +	Read Diag	Clear Flt		
Start Up       HOCP ThreV       150% ifs         StartUp Mode       Ramp Up         WM Erk Currt       25% imax          HOCP FriterTm       2.0 us       VSP/VM Voltages         WM Erk Currt       6.25% imax          Hod Time       0       •         Dead Time Compensation       DTC OFF         DTCmp Enabl       DTC OFF         DTCmp Gain       0         DTCmp MaxTm       0.0% DT         Motor Sensorless       Ki Speed       0.008 Kniz         Ki Snsis       0.008 Kniz       Ki Currt       0.008 Kniz         Ki Snsis       0.008 Kniz       Ki Currt       0.008 Kniz         Frequ.nt Lioh       0.04 Hz       OCP Currt       Disable       Run         Run       C22 000       Save	BootC ChrgTm	0 ms 👻		SpeedRef Min 0 Fu -	PMRSTn Ouput	= RESETn		
StartUp Mode       Ramp Up       HOCP Tillet' Till 00% II'S       VSP/UM Voltages       Restart Ctrl       No Restart         WM Brk Curnt       25% Imax       HOCP Hild'Till       0.1 s       HOCP Hild'Till       0.1 s       HOCP Hild'Till       No Restart       Restart No       S       F       HOC         WM Ext Curnt       6.25% Imax       HOCP FilterTill       2.0 us       VSPRum Max       0.000 V       LOS Hold Till       Restart No       5       F       HOC       OVM         Hold Time       0       ms       Dead Time Compensation       DTCmp Enabl       DTC OFF       UVM ThrV       0.3 V       Restart Torque       Fixed       Send Registers         Hold Duyc       1.5%       DTCmp MaxTm       0.0% DT        DTCmp Gain         Co 000 C 1       Co 000 C 1000       Co 000 C 1000       Co 000 C 1000       Not control       Read Registers       Co Co 000 C 1000       Not control       Read Registers       Co Co 000 C 1000       Not control       Restart No 000       Co 000 C 1000       Not control       Restart Son 00       Cd 000 C 1000       Not control       Restart Son 00       Cd 000 C 1000	Start Up		1		Stop On Fail	ESF OFF		
WM Brk Curnt       25% Imax       HOCP FilerTm       0.1 S       Image: Constraint all constraints all cons		Ramp Up	[ ]		ReStart Ctrl	No Restart		
WM Ext Currt       6.25% imax       IOUP Filter (m)       2.0 us       IOUP Filter (m)       IOUP Filter (m)       IOUP Filter (m)       IOUP       IOUP Filter (m)       IOUP       IOUP Filter (m)       IOUP       IOUP Filter (m)       IOUM       IOUP       IOUP </td <td>WM Brk Curnt</td> <td>25% Imax -</td> <td></td> <td></td> <td>Restart No</td> <td>5 🗸</td> <td></td> <td>HOC</td>	WM Brk Curnt	25% Imax -			Restart No	5 🗸		HOC
Hold Time       0       -       Dead Time Compensation       USP SteepV       0.000 V       Restart Torque       Fixed       Send Registers         Hold Time       0.0 (ms)       DTCmp Enabl       DTC OFF       UVM ThrV       0.3 V       Direction       Forward       Send Registers         Hold Time       0.0 (ms)       0%       T       EEPROM       Direction       Forward       Clack-Sum         Hold Romp Up       6%       T       Motor Control       Feeded       ProductNo PN       0       Iz2 Registers       Spec Regs       Check-Sum         RampU Curnt       1.6 % ffs       Ki Speed       0.008 Knsi       Ki Speed       0.008 Knsi       EEPROM       EEPROM       Clack Color       Clack Color       CsUM: 0x44         Motor Sensoriess       Ki Curnt       0.008 Kncip       Ki Curnt       0.008 Kncip       Ki Susis       Clack Color       Claudit       CsUM: 0x44         FreqLint Liow       0.014 z       OCP Curnt       Disable       Run/Stop       Run       C28 000       Save	WM Ext Curnt		HOCP Filter1m 2.0 us		LOS Hold Tm	800 ms 👻		
Hold Time       0.0 [ms]       DTCmp Enabl       DTC OFF       UVM ThrV       0.000 V •       Brake       OFF       Brake       OFF         Hold Dury C       1.5%       •       DTCmp Gain       0       •       DTCmp Gain       0       •       Brake       OFF       Direction       Forward       Read Registers       Read Registers       Check-Sum       Check-Sum       Check-Sum       Check-Sum       Check-Sum       Check-Sum       CSUM: 0x44       CSUM: 0x44 </td <td></td> <td></td> <td>- Dead Time Compensation</td> <td></td> <td>Restart Torque</td> <td>Fixed</td> <td>1</td> <td>UVM</td>			- Dead Time Compensation		Restart Torque	Fixed	1	UVM
Hold DutyC         1.5%         TCmp Gain         0         Check-Sum         Direction         Forward         Read Registers         Check-Sum           Hold DutyC         1.5%         TCmp MaxTm         0.0% DT         EEPROM         Direction         Forward         Check-Sum         Check-Sum <t< td=""><td></td><td></td><td>DTCmp Enabl DTC OFF</td><td></td><td>Brake</td><td>OFF</td><td>Send</td><td>d Registers</td></t<>			DTCmp Enabl DTC OFF		Brake	OFF	Send	d Registers
Hold Rmp Up       6% <ul> <li>TOTCmp MaxTm</li> <li>0.0% DT •</li> <li>Hold Rmp Up</li> <li>6%</li> <li>TOTCmp MaxTm</li> <li>0.0% DT •</li> </ul> EEPROM       I2C Registers       Spec Regs         RampU Frequ       1.6 Hz       •       Motor Control       ProductNo PN       •       I2C Registers       Spec Regs       CSUM: 0x44         RampU Group       1.6 % ifs       •       Motor Control       •       Password Pwd       000 •       C2 000 C3 000       Max6.000         Kis Snsis       0.008 Kntp       •       Ki Curnt       0.008 Kncp       •       EEPROM       C10000 C1 0000       C4 001 C5 021 Diag 0000       C4 001 C5 020 Diag 0000       C2 000 C3 000       Max6.000         Kis Snsis       0.008 Kntp       •       Ki Curnt       0.008 Kncp       •       Ki Curnt       O.008 Kncp       •         FreqLint Low       0.014 Z       •       OCP curnt       Disable       •       Run/Stop       C18 000 C19 000       Load         C18 000 C19 000       C28 000 C29 000       Save       Save       Save       Save			DTCmp Gain 0	0.3 V				· ·
RampU Frequ       1.6 Hz <ul> <li>Motor Control</li> <li>RampU Grequ</li> <li>1.6 % ifs</li> <li>Motor Control</li> <li>Ki Speed</li> <li>0.008 Knsi +</li> <li>Kp Curmt</li> <li>0.008 Knsi +</li> <li>Ki Curmt</li> <li>0.008 Knci +</li> <li>Ki Snsis</li> <li>0.008 Knti +</li> <li>Ki Curmt</li> <li>0.008 Knci +</li> <li>Ki Snsis</li> <li>0.008 Knti +</li> <li>Ki Snsis</li> <li>0.014 z +</li> <li>CO CP curnt</li> <li>Clisable +</li> <li>Run/Stop</li> <li>Cal 000 C10000</li> <li>Cal 000 C21 000</li>             &lt;</ul>	-		DTCmp MaxTm 0.0% DT -	EEPROM				
RampU Currt         It 8 % Ifs         FreqLint Low         O 008 Knit         Password Pwd         0000         C2 000         C3 000         Mask 000           Ki Speed         0.008 Knsi         -         Ki Speed         0.008 Knsi         -         EEPROM         Write         C2 000         C3 000         Mask 000           Ki Spess         Kp Currt         0.008 Knci         -         EEPROM         Write         C6 001         C7 000         Run 000           Ki Snsis         0.008 Knti         -         Max Currt         38% Ifs         -         -         C1000				ProductNo PN 0				
RampU Curnt         11.6 % Ifs         V         Ki Speed         0.008 Knsi         V         EEPROM         Write         C4 001         C5 021         Diag 0000           Motor Sensorless         Kp Curnt         0.008 Kncp         V         EEPROM         Write         C4 001         C5 021         Diag 0000           Kp Snsis         0.008 Kntp         Ki Curnt         0.008 Knci         V         C10 000         C11 000         C12 001         C12 000         C12 000         C12 000         C14 000         C15 000         C14 000         C19 000         C14 000         C15 000         C14 000         C19 000         C10 000<				Password Pwd 000 -				
Motor Sensoriess         Kp Curmt         0.008 Kncp         C8 020         C9 000           Kp Snsls         0.008 Kntp         Ki Curnt         0.008 Knci         C12001         C13 000         C14 000         C14 000         C16 0001         C16 0001         C16 0001         C14 000         C16 000         C16 000         C16 000         C16 000         C14 000         C14 000         C15 000         C14 000         C16 000         C19 000         Load           FreqLmt Low         0.01 Hz         V         OCP Curmt         Disable         Run/Stop         C18 000         C19 000         Load           FreqLmt High         T02 4 Hz         V         FWkn Curmt         -26% Ifs         Run         Run         C29 000         Save	RampU Curnt	1.6 % lfs 🔹	Ki Speed 0.008 Knsi -	EEPROM Write	C4 001 C5 021	Diag 0000		
Kp snsis         I// Uullik knp         V         Ki kunik         O// Uullik knp         Cl2 001         Cl3 000         Default           Ki Snsis         0.008 Knti         V         Max Curnit         38% Ifs         Cl2 001         Cl3 000         Cl4 000         Cl5 000         Load           FreqLmt Low         0.0 Hz         •         OCP Curnit         Disable         Run/Stop         Cl3 000         Cl9 000         Load           FreqLinit Liow         102.4 Hz         •         FWkn Curnit         -26% Ifs         •         Run         C20 000         C29 000         Save	Motor Sensorles	s	Kp Curnt 0.008 Kncp 👻			Run 000		
Ki Snsis         0.008 Knti         •         Max Curnt         38% Ifs         •         C14 000         C15 000         C16 000         C15 000           FreqLmt Low         0.0 Hz         •         OCP Curnt         Disable         •         Run/Stop         C18 000         C19 000         Load           FreqLmt High         T02.4 Hz         •         FWkn Curnt         -26% Ifs         •         Run         C28 000         C28 000         Save	Kp Snsls	0.008 Kntp -	Ki Curnt 0.008 Knci 👻			Default		
FreqLmt Low         0.0 Hz         •         OCP Curnt         Disable         •         Run/Stop         C18 000         C19 000         L08d           FreqLmt High         102.4 Hz         •         FWkn Curnt         -26% Ifs         •         Run         C20 000         C29 000         Save	Ki Snsls	0.008 Knti 👻	Max Curnt 38% Ifs -		C14 000 C15 000			
FreqLmt High 102.4 Hz V FWkn Curnt -26% Ifs V Run C28 000 C29 000 Save	FreqLmt Low	0.0 Hz 🔹	OCP Curnt Disable -	-Run/Stop	C18 000 C19 000	Load		
	FreqLmt High	102.4 Hz 💌	FWkn Curnt -26% Ifs -	Run		Save		

Once the communications between the control PC and the IC become available, the **USB-I2C** indicator displays "OKAY!", changed from its default "FAIL!".

Communications	Communications
Disabled	Enabled
USB-I2C FAIL!	USB-I2C OKAY!

If the error message appears during GUI launch, the following may be possible causes:

- The FT232 driver, an essential interface between the control PC and the IC, have not been downloaded.
- The .dll file and the **SX682xxM\_Serial\_Interface\_V3p6.exe** file are not placed in the same hierarchy.

Go back to *Downloading an FTDI Driver* to check if you have taken all the necessary steps, and then retry to execute the **SX682xxM\_Serial\_Interface\_V3p6.exe** file.

# 2.4. Setting Up the Motor

The following steps explain how to connect the devices, to initialize the GUI settings, and to check the motor operation.

- 1) Connect the motor to the connector CN2.
- 2) Connect the AC power supply to the connector CN1.
- 3) Flip the toggle switch to "L" (i.e., push the switch lever toward the demo board edge).



- 4) Connect the current and voltage probes of your oscilloscope. To measure the U-phase waveform, connect the current probe to the U-phase. To measure the FG waveform, connect the voltage probe to the FG pin of the connector CN3. <u>To measure the DIAG</u> waveform, connect the voltage probe to the DIAG pin of the connector CN3.
- 5) To initialize the GUI, click the **Default** button.

I2C Re	gisters	Spec Regs
C0 047 C2 363 C4 054 C6 005 C8 106	C1 1E9 C3 160 C5 104 C7 0D5 C9 0C6	NVC 000 Mask 000 Diag 0000 Run 092
C10 0C6 C12 0C8	C11 000 C13 00D	Default
C14 100 C16 01E C18 366	C15 209 C17 000 C19 1B3	Load
C20 15C C28 000 C30 000	C21 0AE C29 000 C31 092	Save

6) In the **Motor Sensorless** group box, select a value from the **Winding Ls** list. Select the value you obtained by the calculations in Section 2.1.

-Motor Sensorles	SS	
Kp Snsls	0.5 Kntp	•
Ki Snsls	0.5 Knti	•
FreqLmt Low	0.0 Hz	•
FreqLmt High	512.0 Hz	-
Winding Ls	28 Lu	-
VM Cmpn	Enable	

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#### 7) Turn on the AC power supply.

High voltages are then applied to the demo board. Therefore, extreme care must be taken during the AC power-on. After the first AC power-on, the GUI displays error statuses in red, e.g., POR (power-on reset), on the status column.

Mask	Clear
	FF
Г	POR
Г	ME
Г	WD
Г	OC
Г	EE
Γ	TW
	OT
Γ	LOS
Г	PMF
	HOC
Г	OVM
Γ	UVM

8) Click the **Send Registers** button.



- 9) Click the **Clear** button, or press the RST\_SW on the demo board (see Figure 1-1). Then the IC is reset and all the error statuses in red will turn green.
- To start the motor rotation, click the **Run** button in the **Run/Stop** field. Once you click the **Run** button, the button label switches to "Stop".
- 11) To stop the motor rotation, click the **Stop** button in the **Run/Stop** field. Once you click the **Stop** button, the button label switches to "Run".

# 3. Parameter Tuning

This section provides the guide for parameter adjustment using the GUI. For proper parameter tuning, use the devices, tools, and measuring instruments listed in Table 2-2 and Table 3-1. The following must be taken into account in tuning parameters:

- Tune parameters after AC power-on.
- Tune parameters while measuring IC case temperatures, which should be <100 °C.
- Tune parameters while measuring and checking operational waveforms.
- DO NOT change parameter values drastically (e.g., from a minimum to maximum value). Tune parameters by small increments.

In case of contingency events, click the **Stop** button in the **Run/Stop** field to stop the motor operation or turn off the AC power supply.

No.	Measuring Instrument	Target Parameter	Remarks
1	Rotational speed meter	Rotation speeds	
2	Encoder	Mechanical angles	
3	Torque meter	Torques	
4	Oscilloscope	Current waves etc.	Required
5	Power meter	Electric power, losses, etc.	
6	Thermometer/data logger	Temperatures on and around the IC	Required
7	Digital multimeter	Voltages etc.	

 Table 3-1.
 Required Measuring Instruments

Figure 3-1 shows the relation between the motor operation sequences and parameter tuning.

Note that individual parameters have mutual impacts on the motor operations. Therefore, thoroughly check the motor operations, from startup to stable operations, every time you change the parameters.

Parameter setting values differ according to conditions including loads, power supplies, motors, and specifications.



"Required" refers to tuning is required; the motor will never rotate unless optimal values are set.

"Recommended" refers to tuning is recommended; setting optimal values will reduce power consumption (Section 3.4.1).

Figure 3-1. Motor Operation Sequences vs. Parameter Tuning

# **3.1.** Setting the Conditions

# 3.1.1. Setting Operating Conditions

This section explains how to set operating conditions. Table 3-2 provides the example setting of operating conditions.

Parameter Operating Condition		Related Items			
		GUI Parameter	Demo Board		
PWM Carrier Frequency	17 kHz	PWM Period			
Motor Speed	500 rpm to 1200 rpm	SpeedRef Unt, SpeedRef Drv, SpeedRef Min			
Motor Direction	CW (Forward)	Direction	DIR SW		
Startup Time <sup>(1)</sup>	Within 7 seconds	RampU Frequ, RampU Curnt, Hold Time			
Maximum Phase Current <sup>(2)</sup>	Up to 0.4 A	CS Range, Max Curnt	Shunt resistors, R <sub>Sx</sub>		
IC Case Temperature	$T_C < 100 \ ^\circ C$		IC		

Table 3-2. Example Setting of Operating Conditions

<sup>(2)</sup> Refers to a value estimated from load.

<sup>&</sup>lt;sup>(1)</sup> Refers to a time from when the motor accelerates until when it reaches its command speed.

#### 3.1.2. Shunt Resistance and Reference Current

A reference current value is determined by the shunt resistance, R<sub>Sx</sub>, and a GUI parameter. Table 3-3 lists the reference current values by default parameter values for each demo board.

Care should be taken when you change the parameters so that output currents and applied CSx pin voltages do not exceed their absolute maximum ratings. This also applies to when you change the shunt resistance values.

			Re	ference Current Valu	es
Description	GUI Parameter	Default Parameter Value	$\begin{array}{c} R_{Sx} \mbox{ Setting} \\ Example \ 1 \\ R_{Sx} = 560 \ m\Omega \\ (I_{FS} = 0.89 \ A)^{(1)} \end{array}$	$\begin{array}{c} R_{Sx} \mbox{ Setting} \\ Example \ 2 \\ R_{Sx} = 470 \ m\Omega \\ (I_{FS} = 1.06 \ A)^{(3)} \end{array}$	$\begin{array}{c} R_{Sx} \mbox{ Setting} \\ Example \ 3 \\ R_{Sx} = 360 \ m\Omega \\ (I_{FS} = 1.39 \ A)^{(3)} \end{array}$
Maximum Input Voltage Range for Current-sensing Ope-amp	CS Range	-500 mV to 500 mV	_		_
Maximum Operating Current, I <sub>MX</sub>	Max Curnt	50% Ifs	0.45 A <sup>(2)</sup>	0.53 A <sup>(4)</sup>	0.69 A <sup>(4)</sup>
SOCP Threshold Current, I <sub>LIM</sub>	OCP Curnt	80% Ifs	0.71 A <sup>(3)</sup>	0.85 A <sup>(5)</sup>	1.11 A <sup>(5)</sup>
Field Weakening Current, I <sub>FW</sub>	FWkn Curnt	0% Ifs	0 A <sup>(4)</sup>	0 A <sup>(4)</sup>	0 A <sup>(6)</sup>
Braking Current, I <sub>WM</sub>	WM Brk Curnt	25% Imax	0.11 A <sup>(5)</sup>	0.13 A <sup>(5)</sup>	0.17 A <sup>(7)</sup>
Minimum Braking Current Threshold, I <sub>WM(MIN)</sub>	WM Ext Curnt	6.25% Imax	0.03 A <sup>(6)</sup>	0.03 A <sup>(6)</sup>	0.04 A <sup>(8)</sup>
HOCP Threshold Current, I <sub>HOCP</sub>	HOCP ThreV	150% Ifs	1.34 A <sup>(7)</sup>	1.6 A <sup>(7)</sup>	2.08 A <sup>(9)</sup>

Table 3-3. Reference Current Values by Default Parameter Values

<sup>(1)</sup> Determined by the following equation:

.

$$I_{FS}(A) = \frac{CS \text{ Range (mV)}}{R_{Sx} (m\Omega)}$$

(2)  $I_{MX} = I_{FS} \times 0.5$ .

- <sup>(3)</sup>  $I_{LIM} = I_{FS} \times 0.8$ . <sup>(4)</sup>  $I_{FW} = I_{FS} \times 0$ .
- <sup>(5)</sup>  $I_{WM} = I_{max} \times 0.25$ .
- <sup>(6)</sup>  $I_{WM(MIN)} = I_{max} \times 0.0625$ .

<sup>(7)</sup>  $I_{HOCP} = I_{FS} \times 1.5$ .

#### 3.2. Setting the Start Up Group Box (Startup)

This section describes how to set the parameters in the **Start Up** group box on the GUI. Table 3-4 lists the setting parameters related to the startup operations (motor startup/restart). Be sure to set these parameters after the motor is stopped. During the startup operations, IC temperatures have high tendencies to increase; therefore, care should be taken not to raise case temperatures up to 100  $^{\circ}$ C.

Setting Description	GUI Parameter	Information Required for Setting
Coefficient of Startup Hold Time	Hold Time	A time that the rotor is aligned to its initial position.
Duty Cycle of Startup Hold Current	Hold DutyC	A current that the rotor can be fixed to its initial position.
Ramp-up Time of Hold Current	Hold Rmp Up	With or without hunting
Ramp-up Frequency	RampU Frequ	A motor speed that allows the motor to start running.
Ramp-up Current	RampU Curnt	A torque (current) that allows the motor to start running.

Table 3-4. Setting Description: Startup (Startup/Restart)

Figure 3-2 shows the sequence related to the startup operations (start/restart); Figure 3-3 shows the block diagram of the corresponding components.



Figure 3-2. Sequence: Startup (Startup/Restart)



Figure 3-3. Block Diagram: Startup (Startup/Restart)

# 3.2.1. Hold Time (Startup Hold Time)

From the **Hold Time** list in the **Start Up** group box, select a value of a startup hold time (i.e., a hold time the motor rotor starts to rotate). Adjust the value so that the rotor can be aligned to its initial position within the time you have set. As Figure 3-4 shows, adjust the value so that the rotor will not be aligned to an unstable position.



Figure 3-4. Example of Rotor Fixed to Unstable Position

Table 3-5 provides the overview of the **Hold Time** parameters. Figure 3-5 and Figure 3-6 show the corresponding operational waveforms.

Table 3-3. Tarancer Overview. Hold Thile	Table 3-5.	Parameter Overview: Hold Time
--	------------	-------------------------------

Sotting Decomintion		Parameter Settings		
Setting Description	GUI Parameter	GUI Default	Setting Range	Step
Coefficient of Startup Hold Time	Hold Time	5	0 to 63	1
Startup Hold Time (Automatic Calculation)	Hold Time [ms]*	544.8 ms	0 ms to 6295.0 ms	

\* Automatically calculated based on the value set in the **PWM Period** field under the **PWM** group box.



Figure 3-5. Operational Waveforms (Default: Hold Time = 10)



Figure 3-6. Operational Waveforms (Hold Time = 13)

# 3.2.2. Hold DutyC (Startup Hold Current)

From the **Hold DutyC** list in the **Start Up** group box, select a value of a startup hold current during startup hold time. A startup hold current is excited with a constant PWM duty cycle regardless of DC link voltages. When you adjust the **Hold DutyC** parameter, the following must be taken into account:

- Adjust a setting value so that the rotor will be aligned to its initial position.
- When selecting a higher value from the **Hold DutyC** list, set a value so that an IC case temperature does not exceed 100 °C. (NOTE: The higher the cogging torque, the higher the current.)
- Rotor rotations may affect the FG waveform and phase current waveform.

Table 3-6 lists the overview of the **Hold DutyC** parameter. Figure 3-7 and Figure 3-8 show the corresponding operational waveforms.

Cotting Description		Parameter Settings		
Setting Description	GUI Parameter	GUI Default	Setting Range	Step
Duty Cycle of Startup Hold Current	Hold DutyC	6.1%	1.5% to 22.9%	1.5

Table 3-6. Parameter Overview: Hold DutyC



Figure 3-7. Operational Waveforms (Default: Hold DutyC = 6.1%)

The equation below defines the startup hold current:

$$I_{SHC} = \frac{V_{BB}}{R_{L}} \times \text{ Hold DutyC } \times 2.$$

Where:

$$\begin{split} I_{SHC} \text{ is the startup hold current (A),} \\ V_{BB} \text{ is the main power supply voltage (V),} \\ R_L \text{ is the inter-phase resistance of the load (}\Omega\text{), and} \\ \text{Hold DutyC is the value selected from the Hold DutyC list.} \end{split}$$

Figure 3-8. Operational Waveforms (Hold DutyC = 15.3%)

(4)

200 ms/div

FG: 5 V/div

DIAG: 5 V/div

Iu: 50 mA/div

# 3.2.3. Hold Rmp Up (Ramp-up Time of Startup Hold Current)

From the **Hold Rmp Up** list in the **Start Up** group box, select a value of a startup hold current slope. Allowing a startup hold current to have a slope prevents load-induced hunting, thus ensuring smooth rotor positioning. The lower the **Hold Rmp Up** setting value, the shorter the startup time. The following must be taken into account in adjusting the parameter: load movements, FG waveform, and phase waveform.

Table 3-7 lists the overview of the **Hold Rmp Up** parameter. Figure 3-9 and Figure 3-10 show the corresponding operational waveforms.

Sotting Description	GUI Parameter	Parameter Settings		
Setting Description	GUI Faranieter	GUI Default	Setting Range	Step
Ramp-up Time of Hold Current	Hold Rmp Up	50%	6% to 94%	6

Table 3-7. Parameter Overview: Hold Rmp Up



Figure 3-9. Operational Waveforms (Default: Hold Rmp Up = 50%) Figure 3-10. Operational Waveforms (Hold Rmp Up = 6%)

# 3.2.4. RampU Frequ (Ramp-up Frequency)

From the **RampU Frequ** list in the **Start Up** group box, select a value of a ramp-up frequency when it changes from open-loop to closed-loop frequency control. Increase the **RampU Frequ** setting value gradually, from low to high, according to load conditions. This approach prevents a loss-of-synchronization condition at open-to-closed loop frequency control changeover. Also, thoroughly check the **RampU Curnt** setting value, FG waveform, phase current waveform, and rotor operation when adjusting the parameter. In case of the following conditions, a loss-of-synchronization condition at open-to-closed loop frequency control changeover is more likely to occur:

- A higher RampU Frequ setting value and heavy load
- (This may cause a startup failure because the RampU Frequ setting value becomes unfollowable.)
- A lower **RampU Frequ** setting value and inadequate motor rotation

Once the motor starts to rotate, a phase current frequency automatically increases (accelerates) until it reaches the predetermined ramp-up frequency, set by the **RampU Frequ** list. After the phase current frequency reaches the ramp-up frequency set by the **RampU Frequ** list, the frequency control is changed to closed-loop frequency control.

Table 3-8 lists the overview of the **RampU Frequ** parameter. Figure 3-11 and Figure 3-12 show the corresponding operational waveforms.



Table 3-8. Parameter Overview: RampU Frequ

Accelerated from 5.6 Hz to 20.8 Hz

Figure 3-11. Operational Waveforms (Default: RampU Frequ = 20.8 Hz)

Accelerated from 2.0 Hz to 8.0 Hz

Figure 3-12. Operational Waveforms (RampU Frequ = 8.0 Hz)

# 3.2.5. RampU Curnt (Ramp-up Current)

From the **RampU Curnt** list in the **Start Up** group box, select a value of a phase current during forced commutation. Increase the **RampU Curnt** setting value gradually, from low to high, while checking the rotor condition. Also, thoroughly check the **RampU Frequ** setting value, FG waveform, and phase current waveform when adjusting the parameter. Note that the higher the **RampU Curnt** setting value, the higher the starting torque, thus resulting in an increased loss.

Table 3-9 provides the overview of the **RampU Curnt** parameter. Figure 3-13 and Figure 3-14 show the corresponding operational waveforms.

Sotting Description		Parameter Settings		
Setting Description	GUI Parameter	GUI Default	Setting Range	Step
Ramp-up Current	RampU Curnt	6.3% Ifs	1.6% Ifs to 48.4% Ifs	1.6





Figure 3-13. Operational Waveforms (Default: RampU Curnt = 6.3% Ifs)

Figure 3-14. Operational Waveforms (RampU Curnt = 12.5% Ifs)

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# **3.3.** Setting the Motor Control Group Box (Motor Control)

#### 3.3.1. Kp Curnt and Ki Curnt (Current Control Gains)

After the startup sequence ends, the forced commutation sequence starts. The current control during the forced commutation sequence is determined by the following parameters in the **Motor Control** group box: the **Kp Curnt** for proportional gain setting; the **Ki Curnt** for integral gain setting. Gain design methods include phase margin designing, simulations, and so on. This section describes how to adjust the current control gain parameters by using current waveforms as criteria samples.

The following must be taken into account when you adjust the gain parameters:

- The lower the gain, the slower the response; hence, steady-state deviation increases.
- The higher the gain, the faster the response; hence, steady-state deviation decreases.
- A higher gain causes the motor response to be vibrational. An extremely high gain destabilizes motor operations.

Figure 3-15 illustrates the sequence related to the current control gains; Figure 3-16 illustrates the block diagram of the corresponding components.



Figure 3-15. Sequence: Current Control Gain



Figure 3-16. Block Diagram: Current Control Gains

Table 3-10 provides the overviews of the Kp Curnt and Ki Curnt parameters.

Satting Description	GUI	Parameter Settings				
Setting Description	Parameter	GUI Default	Setting Range	Step	# of Options	
Proportional Gain for Current Control	Kp Curnt	0.5 Kncp (2 <sup>-1</sup> )	0.008 Kncp (2 <sup>-7</sup> ) to 256 Kncp (2 <sup>8</sup> )	(2 <sup>x</sup> )	16	
Integral Gain for Current Control	Ki Curnt	0.5 Knci (2 <sup>-1</sup> )	0.008 Knci (2 <sup>-7</sup> ) to 256 Knci (2 <sup>8</sup> )	(2 <sup>X</sup> )	16	

Table 3-10. Parameter Overview: Kp Curnt, Ki Curnt

This section contains the tuning examples of the **Kp Curnt** and **Ki Curnt** parameters. The setting values for yielding ideal current waveforms depend on motor conditions. Based on the tuning examples, set optimal values while checking motor conditions and phase current waveforms.

#### • Tuning Example 1: Tune Kp Curnt with fixed Ki Curnt

Setting Example 1: Selected 0.5 from the **Ki Curnt** list, and changed the **Kp Curnt** setting value from 0.5 to 64. The result shows overdamping, i.e., the current waveform,  $I_U$ , vibrated and the motor produced an audible noise.

Setting Example 2: Selected 16 from the **Kp Curnt** list, 2 levels down from the previously selected option 64. This tuning yielded no audible noise.



Setting Examples 3 and 4: Selected 0.5 from the **Ki Curnt** list, and decreased the **Kp Curnt** setting value from 0.5 to 0.008. This tuning yielded stable current waveforms and motor operations.

	GUI Default	Setting Example 3	Setting Example 4
Kp Curnt	0.5 Kncp (2 <sup>-1</sup> )	0.031 Kncp (2 <sup>-5</sup> )	0.008 Kncp (2 <sup>-7</sup> )
Ki Curnt	0.5 Knci (2 <sup>-1</sup> )	0.5 Knci (2 <sup>-1</sup> )	0.5 Knci (2 <sup>-1</sup> )
Operational Waveform			
Result	No problem found	No problem found	No problem found

According to the results of Tuning Example 1, the optimal **Kp Curnt** setting values when **Ki Curnt** = 0.5 will range from 0.008 to 16.

#### • Tuning Example 2: Tune Ki Curnt with Kp Curnt = 0.5

With 0.5 set in the **Kp Curnt** list, the **Ki Curnt** setting value was decreased from 0.5 to 0.125. This tuning yielded stable current waveforms and motor operations. However, as Setting Example 5 presents, when the **Ki Curnt** setting value was further decreased to 0.063, the motor produced an abnormal noise even though the current waveform remained followable. And then, Setting Example 6 shows that when the **Ki Curnt** setting value was further decreased to 0.008, the motor caused a loss-of-synchronization condition due to underdamped control.



According to the results of Tuning Example 2, the optimal **Ki Curnt** setting values when **Kp Curnt** = 0.5 will range from 0.125 to 0.5.

#### • Tuning Example 3: Tune Ki Curnt with Kp Curnt = 16

Setting Examples 7 and 8: Selected 16 from the **Kp Curnt** list, and increased the **Ki Curnt** setting value from 0.5 to its maximum value. This tuning yielded stable current waveforms and motor operations.



According to the results of Tuning Example 3, the optimal **Ki Curnt** setting values when **Kp Curnt** = 0.5 will range from 0.5 to 256.

#### • Tuning Example 4: Tune Kp Curnt Ki Curnt both

Setting Example 9: Selected minimum values form the **Kp Curnt** and **Ki Curnt** lists. The motor caused a loss-of-synchronization condition due to underdamped control.

Setting Example 10: Selected 16 from the **Kp Curnt** and Ki **Curnt** lists. This tuning yielded stable motor operations.



The Tuning Example 4 results found that both of the GUI default and Setting Example 10 had stable waveforms. Therefore, employing the setting values used in both cases will cause no problem.

Setting lower values in the Kp Curnt and Ki Curnt lists allows the motor to have better damping and slower responsiveness.

Setting higher values in the Kp Curnt and Ki Curnt lists allows the motor to have worse damping and faster responsiveness.

# 3.3.2. Ki Speed (Speed Control Gain)

From the **Ki Speed** list in the **Motor Control** group box, select a value of an integral gain for speed control. Figure 3-17 shows the sequence related to the speed control gain; Figure 3-18 shows the block diagram of the corresponding component.



Figure 3-17. Sequence: Speed Control Gain



Figure 3-18. Block Diagram: Speed Control Gain

#### 3.4. Setting the Motor Sensorless Group Box (Sensorless Control)

After tuning the current control gains, adjust the values for rotor position estimation and followability gains. This section describes how to set the parameters in the **Motor Sensorless** group box on the GUI.

- Set the **Winding Ls** value to define an estimated rotor position (i.e., define the V<sub>BEMF</sub> phase).
- Set the **Kp Snsls** and **Ki Snsls** values to adjust the responsiveness to any deviation in the estimated rotor position defined by the **Winding Ls** setting value.

These parameters affect not only steady-state motor operations but also motor startup and other operating conditions. Therefore, thoroughly check the motor operations, from startup to stable operations, every time you change the parameters.



Figure 3-19 illustrates the sequence related to the rotor position estimation; Figure 3-20 illustrates the block diagram of the corresponding component.



Figure 3-19. Sequence: Rotor Position Estimation



- Only Iq is controlled when Id = 0 (default).
- Deviation (Iqerr) = q-axis Current Command (Iqref) q-axis Current (Iq)

Figure 3-20. Block Diagram: Rotor Position Estimation

#### 3.4.1. Winding Ls (Motor Constant)

The IC has the function that estimates a rotor position (d-q axis) from the motor's back EMF (BEMF: Back Electromotive Force). The back EMF,  $V_{BEMF}$ , depends on the following motor-related factors: materials, structures, windings, rotation speeds, power supply voltages, etc.

Figure 3-21 exemplifies the  $V_{BEMF}$  phases when the motor load is rapidly changed from light to heavy. In heavy load, the phase current has a delay in the followability to the phase voltage,  $V_{BRG}$ . The motor rotor also causes a mechanical delay; consequently, the  $V_{BEMF}$  shifts into a transient state. As a result, the difference between the phase voltage and the back EFM widens, thus increasing the phase current. The higher the phase current the higher the torque, hence an increase in the motor rotation speed.



Figure 3-21. Example V<sub>BEMF</sub> Phase

Figure 3-22. Schematic Diagram of Phase Current

Circuit efficiency reaches its highest level when the phase current and  $V_{BEMF}$  phases are matched. Select an optimal value from the **Winding Ls** list in the **Motor Sensorless** group box to adjust the estimated rotor position (d-q axis) so that the phase current and  $V_{BEMF}$  phases can match depending on motor specifications, power conditions, loads, etc.

Figure 3-23 illustrates a phase relation between the phase current and  $V_{BEMF}$ . As Figure 3-24 plots, the value calculated in Section 2.1 slightly varies (i.e., causes phase shifts in the phase current). Therefore, be sure to fine-tune the calculated value based on an actual motor rotation speed.



Figure 3-23. Phase Current vs. V<sub>BEMF</sub>



Figure 3-24. Relationship of d-q Axis Coordinate (Phasor Diagram)

Table 3-11 lists the overview of the Winding Ls parameter.

Setting Description	GUI Parameter	Parameter Settings			
		GUI Default	Setting Range	Step	# of Options
Motor Constant	Winding Ls	200 Lu	1 Lu to 1023 Lu	1	1023

Table 3-11.	Parameter Overview: Winding Ls
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The following are the tuning examples of the **Winding Ls** parameter. Among the waveform of the tuning examples listed below, "Photo Tr" represents the rotor's mechanical angle (an actual rotor position). "FG" represents the FG pin voltage (an estimated rotor position determined by the IC).

These tuning examples employed Photo Tr as an oscilloscope trigger to measure  $t_{F-P}$ , a time from the rising edge of an FG signal to the Photo Tr triggering point, under different load conditions. The load conditions are a maximum value (high phase current) and a minimum value (low phase current) under assumed operating conditions. As the Example 2 results indicate, the **Winding Ls** setting value was adjusted so that the  $t_{F-P}$  values can be equalized under each load condition.

#### • Tuning Examples

Conditions: Air purifier; VCC = 15 V, VBB = 150 V,  $T_A = 25 \text{ °C}$ 



# 3.4.2. Kp Snsls and Ki Snsls (Followablitiy Gains)

From the **Kp Snsls** and **Ki Snsls** lists in the **Motor Sensorless** group box, select values of followability gains. The followability gains refer to the responsiveness when an estimated rotor position, which is determined by the **Winding Ls** setting value, becomes deviated due to a rapid change in load.

Each GUI parameter serves as follows: the **Kp Snsls** for setting a proportional gain; the **Ki Snsls** for setting an integer gain. The following must be taken into account in tuning the followability gain parameters:

- The lower the gain, the slower the response; hence, steady-state deviation increases.
- The higher the gain, the faster the response; hence, steady-state deviation decreases.
- A higher gain causes the motor response to be vibrational. An extremely high gain destabilizes motor operations.

Table 3-12 provides the overviews of the Kp Snsls and Ki Snsls parameters.

CLII Deservator	Parameter Settings				
GUI Parameter	GUI Default	Setting Range	Step	# of Options	
Kp Snsls	0.5 Kntp (2 <sup>-1</sup> )	0.008 Kntp (2 <sup>-7</sup> ) to 256 Kntp (2 <sup>8</sup> )	$(2^{X})$	16	
Ki Snsls	0.5 Knti (2 <sup>-1</sup> )	0.008 Knti (2 <sup>-7</sup> ) to 256 Knti (2 <sup>8</sup> )	(2 <sup>x</sup> )	16	

Table 3-12. Parameter Overview: Kp Snsls, Ki Snsls

Be sure to adjust the **Kp Snsls** and **Ki Snsls** setting values while thoroughly checking the responsiveness to any deviation in an estimated position caused by rapid load changes or other disturbing factors. The tuning examples are listed below.

#### • Tuning Examples

Conditions: Torque bench; VCC = 15 V, VBB = 12 V,  $T_A = 25 \degree C$ 

Parameter	Tuning Example 1	Tuning Example 2	Tuning Example 3
Kp Snsls	8 Kntp (2 <sup>3</sup> )	1 Kntp (2 <sup>0</sup> )	0.5 Kntp (2 <sup>-1</sup> )
Ki Snsls	2 Knti (2 <sup>1</sup> )	0.25 Knti (2 <sup>-2</sup> )	0.125 Knti (2 <sup>-3</sup> )
Operational Waveform	Load rapidly varied	Current increased	Load rapidly varied
Result	Followed	Followed but current increased at transient	Loss-of-synchronization
# 3.5. Setting the PWM Group Box (PWM Control)

This section explains how to set the PWM control parameters in the PWM group box, listed in Table 3-13.

Sotting Description		Parameter Settings		
Setting Description	GUI Parameter	GUI Default	Setting Range	
PWM Switching Mode	PWM Mode	2/3 ph Hyst	2 ph, 3 ph, 2/3 ph Hyst	
PWM Period	PWM Period	58.9 µs	30.5 µs to 132.5 µs	
Dead Time	PWM DeadTm	1.50 μs	0 µs to 3.15 µs	
Charging Time of Bootstrap Capacitors	BootC ChegTm	10 ms	0 ms to 100 ms	

Table 3-13.	Setting Description: PWM Control
10010 5 15.	Betting Description. I will control

# 3.5.1. PWM Mode (PWM Switching Mode)

From the **PWM Mode** list in the **PWM** group box, select a value to determine the PWM switching mode. Table 3-14 provides the overview of the **PWM Mode** parameter.

Setting Description	GUI Parameter	Parameter Setting	Function	Remarks
			2-phase PWM switching	Low loss
		3 ph	3-phase PWM switching	Low noise
PWM Switching Mode	PWM Mode	2/3 ph Hyst	Auto-shifting between 2-/3- phase PWM switching modes	With Hysteresis

Table 3-14.	Parameter Overview: PWM Mode

The following are the operational waveforms when "2/3 ph Hyst" is selected.

#### • Tuning Examples



## 3.5.2. PWM Period

From the **PWM Period** list in the **PWM** group box, select a value for the PWM period,  $T_{PR}$ . Table 3-15 provides the overview of the **PWM Period** parameter.

Setting			Parameter Settings		
Description	GUI Parameter	GUI Default	Setting Range	Step	# of Options
PWM Period	PWM Period	58.9 μs (17.0 kHz)	30.5 μs to 132.5 μs (32.8 kHz to 7.5 kHz)	0.4	256

Table 3-15. Parameter Overview: PWM Period

The equation below defines the relationship between the PWM period and carrier frequency:

$$f_{\rm C} = \frac{1}{T_{\rm PR}} \times 1000$$
 (5)

Where:

 $f_C$  is the motor PWM carrier frequency (kHz), and

 $T_{\text{PR}}$  is the period (µs).

The smaller the  $T_{PR}$ , the higher the  $f_C$  and thus an increase in switching loss. Therefore, adjust the **PWM Period** setting value so that an IC case temperature maintain at <100 °C. The following are the examples of PWM period tuning.

#### • Tuning Examples

Conditions: VBB = 100 V, VCC = 15 V, TA = 25 °C; general-purpose motor

	, III 20 0, general pulpose motor		
Example 1 / GUI Default	Example 2	Example 3	
(PWM Period = $58.9 \ \mu s$ )	(PWM Period = $30.5 \ \mu s$ )	(PWM Period = $132.5 \ \mu s$ )	
<sup>3</sup> FG (PWM_UL) <sup>3</sup> PIAG (PWM_UH) <sup>3</sup> I <sub>U</sub> Fc = 17 kHz		<sup>3</sup> - <sup>11</sup> - <sup>12</sup> - <sup>1</sup>	
		1.0 KHZ	
50 µs/div	50 µs/div	50 μs/div	
CHI 10:1         CH2 10:1         CH3 100:1U         Pattern           5.00         V-div         5.00         V-div         Auto           DC         Full         DC         Full         Auto	CHI 10:1         CH2 10:1         CH3 100:10         Pattern           5.00 V/div         5.00 V/div         5.00 A/div         Auto           DC         Full         DC         Full         Auto	OHI 10:1         CH2 10:1         CH3 106:110         Pattern           5.00 V/div         5.00 V/div         0.500 A/div         Auto           DC         Pull         DC         Pull	

## 3.5.3. PWM DeadTm (Dead Time)

From the **PWM DeadTm** list in the **PWM** group box, select a value for a dead time. A shorter dead time results in a current waveform more approximated to a sine wave. However, in case any high-side power MOSFET of the three phases and its corresponding low-side power MOSFET both turn on at once, a short-circuit condition may occur. Therefore, be sure to set a dead time within the recommended operational range ( $\geq 1.5 \ \mu s$ ). For more details, refer to the SX68200M series data sheet.

Table 3-16 lists the overview of the PWM DeadTm parameter.

Table 3-16.	Parameter Overview: PWM DeadTm
14010 0 101	

Satting Decorintion	GUI Parameter	Parameter Settings			
Setting Description	GUI Faranielei	GUI Default	Setting Range	Step	# of Options
Dead Time	PWM DeadTm	1.50 μs	0 μs* to 3.15 μs	0.05	64

\* Any value out of the recommended operational range is selectable but prohibited. Be sure to set a value within the range.

The following are the examples of dead time tuning.

### • Tuning Examples



\* Temporarily set as an experimental value; be sure to set a value within the recommended operating range.

# 3.5.4. BootC ChrgTm (Charging Time of Bootstrap Capacitor)

From the **BootC ChrgTm** list in the **PWM** group box, select a value to determine the charging time of bootstrap capacitors. A charging time depends on the capacitance of the bootstrap capacitor,  $C_{Bx}$ . Select a value to have an adequate charging time even when  $C_{Bx}$  is electrically uncharged, e.g., the first startup.

Table 3-17 provides the overview of the BootC ChrgTm parameter.

Sotting Description	GUI Parameter	Parameter Settings		Remarks	
Setting Description	GUI Parameter	GUI Default	Setting Range	Kemarks	
Charging Time of Bootstrap Capacitors	BootC ChrgTm	10 ms	0 ms to 100 ms	Select from the following options in the list: 1 ms, 2 ms, 5 ms, 10 ms, 20 ms, 50 ms, 100 ms.	

Table 3-17.	Parameter Overview: BootC ChrgTm
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The following are the examples of bootstrap charging time tuning. Example 1 shows that the adequate charging time resulted in a successful motor startup. In Example 2, on the other hand, the inadequate charging time resulted in a motor startup failure. Adjust the **BootC ChrgTm** setting value so that the motor can start successfully.

# • Tuning Examples



## 3.6. Setting the Speed Control and VSP/VM Voltages Group Boxes (Rotation Speed)

This section explains how to set the parameters pertaining to the motor rotation speed control, as listed in Table 3-18 and Table 3-19. In the **SpeedRef Sel** field under the **Speed Control** group box, select the motor speed control ("Int SR" or "Ext VSP") by clicking the button.

- When "Int SR" is selected: Adjust the following parameter in the **Speed Control** group box: SpeedRef Unt; SpeedRef Drv. No adjustment is required for the parameters in the **VSP/VM Voltages** group box. For more details, see Section 3.6.1.
- When "Ext VSP" is selected:

Adjust the following parameter in the **Speed Control** group box: SpeedRef Unt; SpeedRef Max; SpeedRef Min. Adjust the following parameter in the **VSP/VM Voltages** group box: VSPRun Max; VSPStart Min; VSPRun Min; VSP SleepV.

For more details, see Section 3.6.2.

Satting Decomintion	GUI Parameter	Parameter Settings		
Setting Description	GUI Parameter	GUI Default	Setting Range	
Speed Control Mode	SpeedRef Sel	Int SR	Int SR: controlled by internal register settings Ext VSP: controlled by the VSP pin voltage	
Multiplier of Reference Speed	SpeedRef Unt	1.0 Hz	0 Hz to 1.6 Hz	
Reference Speed	SpeedRef Drv <sup>(1)</sup>	$30 \ f_{\rm U}$	0 $f_U$ to 1023 $f_U$	
Maximum Reference Speed	SpeedRef Max <sup>(2)</sup>	$250 \; f_{\rm U}$	0 f <sub>U</sub> to 1023 f <sub>U</sub>	
Minimum Reference Speed	SpeedRef Min	$0 \; f_{\rm U}$	0 f <sub>U</sub> to 1023 f <sub>U</sub>	

Table 3-18. Parameter Overview: Speed Control

<sup>(1)</sup> When "Int SR" is selected in the **SpeedRef Sel** field.

<sup>(2)</sup> When "Ext VSP" is selected in the **SpeedRef Sel** field.

Setting Description		Parameter Settings		
Setting Description	GUI Parameter	GUI Default	Setting Range	
Maximum Speed Voltage (V <sub>SMX</sub> )	VSPRun Max	5.000 V	0 V to 5.879 V	
Excitation Start Voltage (V <sub>SST</sub> )	VSPStart Min	2.500 V	0 V to 5.879 V	
Minimum Speed Voltage (V <sub>SMN</sub> )	VSPRun Min	2.000 V	0 V to 5.879 V	
Low Power Consumption Mode Transition Voltage (V <sub>SSN</sub> )	VSP SleepV	1.000 V	0 V to 5.879 V	

#### Table 3-19. Parameter Overview: VSP/VM Voltages

#### 3.6.1. Int SR (Internal Control Mode)

In Int SR mode, the motor rotation speed is controlled by the internal register settings. Which means that you can control the motor rotation speed directly through the GUI. This mode does not support the motor rotation speed control by the VSP pin voltage. Adjust the parameters to yield your ideal motor control.

The equation below defines a motor rotation speed:

$$S = \frac{60 \times \text{SpeedRef Unt} \times \text{SpeedRef Drv}}{N_{PP}}.$$

(6)

Where:

S is the motor rotation speed (rpm),

SpeedRef Unt is the multiplier of the reference speed (Hz), SpeedRef Drv is the positive integer that determines the reference speed, and  $N_{PP}$  is the number of magnetic pole pairs.

For example, when  $N_{PP} = 4$  (8 poles), SpeedRef Unt = 1.0 Hz, SpeedRef Drv = 30 f<sub>U</sub>, the motor rotation speed can be defined as follows:

$$S = \frac{60 \times 30 \times 1.0}{4} = 450 \text{ rpm} \,.$$

#### **3.6.2.** Ext VSP (External Control Mode)

In Ext VSP mode, the motor rotation speed is controlled by the VSP pin voltage (see Figure 3-25). Adjust the parameters to yield your ideal motor control. However, the VSP pin startup voltage ( $V_{SSX} = 1.26$  V) cannot be changed.

Writing the adjusted parameters to the EEPROM enables the motor to be controlled in stand-alone mode (see Section 4.4).



Figure 3-25. VSP Pin Input Voltage vs. Reference Motor Rotation Speed

The equations below define motor rotation speeds:

$$f_{RH} = \text{SpeedRef Unt} \times \text{SpeedRef Max}.$$

$$f_{RL} = \text{SpeedRef Unt} \times \text{SpeedRef Min}.$$
(8)

Where:

 $f_{RH}$  is the maximum reference speed (Hz),

f<sub>RL</sub> is the minimum reference speed (Hz),

SpeedRef Unt is the multiplier of the reference speed (Hz),

SpeedRef Max is the positive integer that defines the maximum reference speed, and SpeedRef Min is the positive integer that defines the minimum reference speed.

$$S_{MAX} = \frac{f_{RH} \times 60}{N_{PP}}.$$
(9)

$$S_{\rm MIN} = \frac{f_{\rm RL} \times 60}{N_{\rm PP}}.$$
 (10)

Where:

 $S_{MAX}$  is the maximum rotation speed (rpm),  $S_{MIN}$  is the minimum rotation speed (rpm), and  $N_{PP}$  is the number of magnetic pole pairs. For example, when  $N_{PP} = 4$  (8 poles), SpeedRef Unt = 1.0 Hz, SpeedRef Max = 250 f<sub>U</sub>, SpeedRef Min = 0 f<sub>U</sub>, S<sub>MAX</sub> and S<sub>MIN</sub> can be defined as follows:

$$S_{MAX} = \frac{250 \times 1.0 \times 60}{4} = 3750 \text{ rpm}$$
 , and

 $S_{MIN} = \frac{0 \times 1.0 \times 60}{4} = 0 \text{ rpm} \,. \label{eq:smin}$ 

#### • Notes on Powering On the AC Power Supply

In Ext VSP mode, before you power on the AC power supply, be sure to twist the VSP pin voltage-adjusting resistor, VSP\_VR, fully counterclockwise. This is to protect the motor to start suddenly.



Twist the VSP\_VR fully counterclockwise.

When you twist the VSP\_VR fully counterclockwise, the VSP pin input voltage,  $V_{SP}$ , is 1.50 V at AC power-on. Adjust VSP\_VR so that  $V_{SP}$  is maintained below the excitation start voltage,  $V_{SST}$ . On the GUI, the  $V_{SST}$  value (i.e., the **VSPStart Min** list) is set to 2.5 V by default.

Table 3-20 provides the VSP\_VR vs. V<sub>SP</sub> relationship.

VCC -						VSP	_VR	
R105 €	IPM1	VCC	R105	R106	R116	Between	Between	$V_{SP}$
						1 and 2	2 and 3	
$\begin{bmatrix} 1 & V_{SP} \end{bmatrix}$	120 kΩ					$0 \ k \Omega^{(1)}$	$20 \ k\Omega^{(1)}$	5.06 V
$VSP_VR \ge 4$	$VSP_VR \ge 2 (4) (4) (4) (4) (4) (4) (4) (4) (4) (4)$					5 kΩ	15 kΩ	4.18 V
						10 kΩ	10 kΩ	3.31 V
R106 Ş		15 V	47 kΩ	5.6 kΩ	2.2 kΩ	15 kΩ	5 kΩ	2.42 V
R116						$0 \ k \Omega^{(2)}$	$0 \ k \Omega^{(2)}$	1.50 V

Table 3-20.	VSP Pin Voltage-adjusting Resistor	, VSP_VR vs. VSP Pin Input Voltage, V <sub>SP</sub>
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<sup>&</sup>lt;sup>(1)</sup> Refers to the value when twisted fully clockwise.

<sup>&</sup>lt;sup>(2)</sup> Refers to the value when twisted fully counterclockwise.

## 3.7. Setting the Dead Time Compensation Group Box

In case any of the high-side power MOSFETs and its corresponding low-side power MOSFET turn on at the same time, a short-circuit condition may occur. For protecting the power MOSFETs of the three phases from such short-circuit condition, a dead time must be set between a turn-off of each high- or low-side power MOSFET and the next turn-on of its paring low- or high-side power MOSFET. However, setting the dead time,  $t_{DEAD}$ , will cause disturbance in waveforms due to errors for a command voltage. The dead time compensation is the function to correct such disturbance in current waveforms. The following are the positive effects obtained by setting the dead time compensation:

- Reduction in audible noise
- Suppression in mechanical oscillation by current waveform becoming more sinusoidal
- (but ineffective depending on load)

For comparison, we also show the operational waveform when the dead time compensation is enabled and those which the function is disabled.



This section describes how to set the dead time compensation parameters in the **Dead Time Compensation** group box, as listed in Table 3-21.

Satting Decominition	GUI Parameter	Paramete	r Settings	
Setting Description	GUI Parameter	GUI Default	Setting Range	
Enable/Disable of Dead Time Compensation	DTCmp Enabl	DTC OFF	DTC OFF, DTC ON	
Dead Time Compensation Voltage Slope	DTCmp Gain	0	0 to 15	
Maximum Value of Dead Time Compensation Voltage Amplitude	DTCmp MaxTm	0.0% DT	0.0% DT to 93.8% DT	

# 3.7.1. DTCmp Enabl (Enable/Disable of Dead Time Compensation)

By clicking the button in the **DTCmp Enabl** field under the **Dead Time Compensation** group box, you can select the dead time compensation to be enabled or disabled. Table 3-22 lists the overview of the **DTCmp Enabl** parameters.

Setting Description	GUI Parameter	Parameter Setting	Function
Enable/Disable of		DTC OFF	Disables the dead time compensation.
Dead Time Compensation	DTCmp Enabl	DTC ON	Enables the dead time compensation.

Table 3-22. Parameter Overview: DTCmp Enabl

At the timing when the polarity of a phase current undergoes a positive-to-negative transition (and vice versa), a dead time causes disturbance in the current waveform. Selecting "DTC ON" enables the dead time compensation and thus corrects the disturbed current waveform with its dead time compensation voltage being applied regardless of a command voltage (see Figure 3-26).



Figure 3-26. Dead Time Compensation Voltage

Section 3.7.2 explains how to adjust the dead time compensation voltage slope.

Section 3.7.3 describes how to adjust a maximum value of the dead time compensation voltage amplitude.

# 3.7.2. DTCmp Gain (Dead Time Compensation Voltage Slope)

From the **DTCmp Gain** list in the **Dead Time Compensation** group box, select a value to adjust a slope (i.e., gain) of the dead time compensation voltage. Table 3-23 lists the overview of the **DTCmp Gain** parameter.

Satting Decominition		Parameter Settings			
Setting Description	GUI Parameter	GUI Default	Setting Range	# of Options	
Dead Time Compensation Voltage Slope	DTCmp Gain	0	0 to 15	1	16

Table 3-23. Parameter Overview: DTCmp Gain

The higher the **DTCmp Gain** setting value, the steeper the slope of the dead time compensation voltage becomes. When the **DTCmp Gain** parameter is set to 15 (at maximum), the dead time compensation voltage will have a slope of about 90° (see Figure 3-27).



Figure 3-27. Dead Time Compensation Voltage vs. DTCmp Gain

#### 3.7.3. DTCmp MaxTm (Maximum Value of Dead Time Compensation Voltage Amplitude)

From the **DTCmp MaxTm** list in the **Dead Time Compensation** group box, select a value to adjust a maximum value of the dead time compensation voltage amplitude. Table 3-24 provides the overview of the **DTCmp MaxTm** parameter.

Sotting Description		Parameter Settings			
Setting Description	GUI Parameter	GUI Default Setting Range		Step	# of Options
Maximum Value of Dead Time Compensation Voltage Amplitude	DTCmp MaxTm	0.0% DT	0.0% DT to 93.8% DT	6.3% DT	16

Table 3-24.	Parameter Overvie	w: DTCmp MaxTm
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Figure 3-28 shows a relationship between the dead time compensation voltage and the DTCmp MaxTm parameter.



Figure 3-28. Dead Time Compensation Voltage vs. DTCmp MaxTm

The equation below defines the dead time compensation voltage amplitude, DT:

 $DT = V_{DC} \times t_{DEAD} \times f_{C}$ .

Where:

DT is the dead time compensation voltage amplitude (V),  $V_{DC}$  is the DC-link voltage (V),  $t_{DEAD}$  is the dead time (s), and  $f_C$  is the PWM carrier frequency (Hz).

For example, when  $V_{DC} = 280$  V,  $t_{DEAD} = 1.5$  µs, and  $f_C = 20$  kHz, the dead time compensation voltage amplitude can be obtained as follows:

 $DT = 280 \times 1.5 \times 10^{-6} \times 20 \times 10^{3} = 8.4 V.$ 

At this time, if the **DTCmp MaxTm** parameter is set to 93.8% DT, the maximum value of the dead time compensation voltage amplitude will be:  $8.4 \times 0.938 = 7.88$  V.

### **3.8.** Setting the Braking Operations

There are two braking methods you can choose from: the WM-Brk (Windmill Brake) operation and the manual braking operation. These braking operations are carried out by turning on the low-side power MOSFETs at once.

Table 3-25 provides the overviews of the braking operation parameters.

Sotting Description	CIII Deremeter	Parameter Settings			
Setting Description	GUI Parameter	GUI Default	Setting Range	Step	
Braking Current	WM Brk Curnt	25% Imax	25% Imax to 100% Imax	25% Imax	
Minimum Braking Current Threshold	WM Ext Curnt	6.25% Imax	6.25% Imax to 25% Imax	6.25% Imax	

Table 3-25. Parameter Overview: Startup (Braking Operation)

# 3.8.1. WM Brk Curnt and WM Ext Curnt (WM-Brk Operation)

When you need to start the motor from an idle state, perform the braking operation, i.e., WM-Brk (Windmill Brake), prior to the startup sequence to bring the motor to a standstill.

If a huge load inertial, such as a fan motor, brings a motor to a sudden stop, noise will occur. To reduce such noise, adjust each parameter in the **Start Up** group box: the **WM Brk Curnt** list for setting a braking current; the **WM Ext Curnt** list for setting a minimum braking current threshold.

The following are the operational waveforms according to the WM Brk Curnt and WM Ext Curnt setting values.

#### • Setting Examples

Conditions: Fan motor; DC-link = 100 V, VCC = 15 V,

 $R_{Sx} = 100 \text{ m}\Omega$ , CS Range = 500 mV, Max Curnt = 38% Ifs (Imax = 1.9 A)



# 3.8.2. Run/Stop and Brake (Manual Braking Operation)

When the motor is running (i.e., when the switching button in the **Run/Stop** field indicates "Stop"), the motor can be stopped manually. To perform the manual braking operation, click the switching button in the **Brake** filed under the **Run Control** group box. Note that the switching button contains the label indicating a current braking operation state (see Table 3-26).

Once you click the OFF button in the Brake field, the motor stops running and the button label switches to "ON".

Once you click the ON button in the Brake field, the motor restarts to run and the button label switches to "OFF".

A braking current during the manual braking operation is the maximum operating current (Imax). Table 3-26 lists the overview of the manual braking operation settings.

Sotting Description		Parameter Settings		
Setting Description	GUI Parameter	GUI Default	Button Label and Braking State	
Manual Braking Operation	Brake	OFF	OFF: Normal operation (brake off) ON: Braking operation (brake on)	

Table 3-26.	Setting Description:	Manual Braking Operation
-------------	----------------------	--------------------------

The following are the operational waveforms of setting examples according to the maximum operating current (Imax).

#### • Setting Examples

Conditions: Fan motor; DC-link = 100 V, VCC = 15 V, rotational frequency = 30 Hz,



#### **3.9.** Setting the Restart Operation

This section gives details on how to set the motor's restart operation.

The following subsections contain the overviews of each parameter for the restart operation.

### 3.9.1. ReStart Ctrl (Enable/Disable of Restart)

This parameter sets whether to enable or disable the motor's restart operation upon loss-of-synchronization detection. "No Restart" — The restart operation is disabled.

"Restart" — The restart operation is enabled.

When you select "Restart", be sure to set the following related parameters as instructed below. Otherwise, the motor will not restart properly.

- In the **Read Diag** field, select "No Clear". If you select "Clear Fit", the number of restarts is reset each time the motor restarts and the motor's first startup operation is repeated infinitely (see Sections 3.9.2 and 3.9.3).
- In the **Stop On Fail** field, select "ESF ON". If you select "ESF OFF", the motor does not restart but will keep running even after a loss-of-synchronization condition is detected.

#### 3.9.2. Restart No (Number of Restarts)

This parameter determines how many times the motor to be restarted. Select from the following options in the list: 5, 10, 20, Infinite. Note that each numeric value includes the first startup.

#### 3.9.3. Restart Torque

This parameter sets whether to fix or vary the ramp-up current at restart.

"Fixed" — The ramp-up current is fixed to the value selected in the **RampU Curnt** list.

"Spread" — The ramp-up current is variable. Table 3-27 lists the overview of the variable ramp-up current setting.

Number of Restarts	Ramp-up Current Value*	Example: RampU Curnt = 15.6% Ifs
First Startup	RampU Curnt setting value	15.6% Ifs
Restart (1st)	RampU Curnt setting value	15.6% Ifs
Restart (2nd)	RampU Curnt setting value + 1 step	17.2% Ifs
Restart (3rd)	RampU Curnt setting value - 1 step	14.1% Ifs
Restart (4th)	RampU Curnt setting value + 2 steps	18.8% Ifs
Restart (5th)	RampU Curnt setting value – 2 steps	12.5% Ifs

Table 3-27. 0	Overview:	Variable	Ramp-up	Current
---------------	-----------	----------	---------	---------

\* 1 step = 1.6%

For more details on the ramp-up current, see Section 3.2.5.

The following are the operational waveforms when "Fixed" is selected and those which "Spread" is selected, respectively, in the **Restart Torque** field.





### • Operational Waveforms at Restart with Variable Ramp-up Current

# **3.10.** Setting the Run Control Group Box (DIAG/FG Pin Output Signals)

The **Run Control** group box helps you determine which pin should output which signal: the **DIAG Output** list for setting the DIAG pin output signal; the **FG Output** list for setting the FG pin output signal.

DIAG Output						
DIAG[4:0]	Parameter	DIAG Pin Output Signal				
0	Fault <sup>(1)</sup>	General fault flag (FF)				
1	LOS	Loss of synchronization (LOS)				
2	Temperature	Temperature output of control MIC				
3	Clock	Clock				
4	PWMDIR	PWMDIR <sup>(2)</sup>				
5	SHTRIG	SHTRIG <sup>(2)</sup>				
6	ADDONE	ADDONE <sup>(2)</sup>				
7	CLFLK_SYN	CLFLK_SYN <sup>(2)</sup>				
8	CLFLK_ASYN	CLFLK_ASYN <sup>(2)</sup>				
9	UH	PWM output (HIN1)				
10	UL	PWM output (LIN1)				
11	VH	PWM output (HIN2)				
12	VL	PWM output (LIN2)				
13	WH	PWM output (HIN3)				
14	WL	PWM output (LIN3)				
15	WDTMO	Watchdog timeout				
16	WDACT	Watchdog active				
17	PMFLTn	Power module fault (PMF)				
18	PMRSTn	Power module fault (PMF) reset				
19	НОСР	Hard overcurrent (HOC)				
20	VAR1	q-axis current				
21	VAR2					
22	VAR3	_				
23	VAR4	_				
24–31	Reserved	Reserved				

• FG Ou	itput	
FG[4:0]	Parameter	FG Pin Output Signal
0	FG <sup>(1)</sup>	Motor speed
1	FG <sup>(1)</sup>	Motor speed
2	FG <sup>(1)</sup>	Motor speed
3	FG <sup>(1)</sup>	Motor speed
4	PWMDIR	PWMDIR <sup>(2)</sup>
5	SHTRIG	SHTRIG <sup>(2)</sup>
6	ADDONE	ADDONE <sup>(2)</sup>
7	CLFLK_SYN	CLFLK_SYN <sup>(2)</sup>
8	CLFLK_ASYN	CLFLK_ASYN <sup>(2)</sup>
9	UH	PWM output (HIN1)
10	UL	PWM output (LIN1)
11	VH	PWM output (HIN2)
12	VL	PWM output (LIN2)
13	WH	PWM output (HIN3)
14	WL	PWM output (LIN3)
15	WDTMO	Watchdog timeout
16	WDACT	Watchdog active
17	PMFLTn	Power module fault (PMF)
18	PMRSTn	Power module fault (PMF) reset
19	НОСР	Hard overcurrent (HOC)
20	VAR1	q-axis current
21	VAR2	_
22	VAR3	_
23	VAR4	_
24-31	Reserved	Reserved

<sup>(1)</sup> Set as the GUI default.

<sup>(2)</sup> Not used in motor designing.

# 4. GUI

### 4.1. Settings Window Overview

Figure 4-1 explains the window of the GUI (Graphic User Interface); Table 4-1 provides the functional descriptions of the individual GUI elements such as parameters and indications.

Γ	SX682xxM Serial Interface V3.			×	;
			66	67	
	SanKen	SX682xxM Reg12 W 0001 47 DIAG Output Fault	Mask	Clear	
		48 DIAG Dry Curnt Positive L	Г	FF	
1	PWM Mode 2 ph	20 CS Range 500-500mV 35 Speed Control 49 FG Output FG -		ME	
2	PWM Period 30.5 us	21 CS Delay 0.0 us 36 SpeedRef Unt 0.1 Hz • 50 FG Frequency Fdrv		WD	
3	PWM DeadTm 0.00 us	22 CS MinOn 0.0 us 37 SpeedRef Max 0 Fu + 51 Read Diag Clear Fit		OC EE	
4	BootC ChrgTm 0 ms	▼ 38 SpeedRef Min 0 Fu ▼ 52 PMRSTn Ouput = RESETn		TW	
1	Start Up	23 HOCP ThreV 150% Ifs		OT LOS	
5	StartUp Mode Ramp U			PMF	
6	WM Brk Curnt 25% Imax	25 HOCP FilterTm 2.0 us 40 VSPStart Min 0.000 V • 55 Restart No 5 •		HOC	
7	WM Ext Curnt 6.25% Ima	25 100 - 100 - 100 - 56 LOS Hold Tm 800 ms -		OVM UVM	
8	Hold Time 0	Dead Time Compensation     42     VSP SleepV     0.000 V     57     Restart Torque     Fixed	Sond	Registers 68	
9	Hold Time 0.0 [ms]	26 DTCmp Enabl DTC OFF 43 UVM ThrV 0.3 V 58 Brake OFF		- 00	
10	Hold DutyC 1.5%	27 DTCmp Gain 0 59 Direction Forward	Check	-Sum 09	
11	Hold Rmp Up 6%	28 DTCmp MaxTm 0.0% DT + EEPROM 44 ProductNo PN 0 + I2C Registers Spec Regs	CS	UM: 0x44 70	
12	RampU Frequ 1.6 Hz	Motor Control 45 Descured Dud 000 C1 000 C1 000 NVC 000			
13	RampU Curnt 1.6 % Ifs	29 Ki Speed 0.008 Knsi - 46 EEDDOM With 1 C4 001 C5 021 Diag 0000	<b>C2</b>		
10	Motor Sensorless	30 Kp Curnt 0.008 Kncp 40 LEPROM Wile C6 001 C7 000 Run 000	62		
14	Kp Snsls 0.008 Kntp	31 Ki Curnt 0.008 Knci - C10 000 C11 000 Default	63		
15	Ki Snsls 0.008 Knti	32 Max Curnt 38% Ifs	<i>с</i> 1		
16	FreqLmt Low 0.0 Hz	33 OCP Curnt Disable  Run/Stop Load Load Load	64		
17	FreqLmt High 102.4 Hz		65		
18	Winding Ls 1 Lu	▼ 60			
19	VM Cmpn Disable				
		- 01			

Figure 4-1. GUI Settings Window

		Table 4-1. GUI Settings Window: Elements and Functions
No.	Group Box/ GUI Parameter	Description
PWM	1	
1	PWM Mode	The drop-down list to select the PWM switching mode.
2	PWM Period	The drop-down list to set the PWM period.
3	PWM DeadTm	The drop-down list to set the dead time.
4	BootC ChrgTm	The drop-down list to set the charging time of bootstrap capacitors.
Start	Up	
5	StartUp Mode	The toggle button to select the startup mode.
6	WM Brk Curnt	The drop-down list to set the braking current.
7	WM Ext Curnt	The drop-down list to set the minimum braking current threshold.
8	Hold Time	The drop-down list to set the coefficient of a startup hold time.
9	Hold Time [ms]	The non-editable text field that indicates the startup hold time automatically calculated.
10	Hold DutyC	The drop-down list to set the duty cycle of startup hold current.
11	Hold Rmp Up	The drop-down list to set the ramp-up time of hold current.
12	RampU Frequ	The drop-down list to set the ramp-up frequency.
13	RampU Curnt	The drop-down list to set the ramp-up current.
Moro	or Sensorless	
14	Kp Snsls	The drop-down list to set the proportional gain for adjusting an estimated rotor position.
15	Ki Snsls	The drop-down list to set the integral gain for adjusting an estimated rotor position.
16	FreqLmt Low	The drop-down list to set the lower limit of an electrical angle.
17	FreqLmt High	The drop-down list to set the upper limit of an electrical angle.
18	Winding Ls	The drop-down list to set the motor constant.
19	VM Cmpn	The toggle button to enable or disable the compensation of DC link voltage fluctuations.
Curre	ent Sample	
20	CS Range	The drop-down list to set the maximum input voltage range of current-sensing ope- amps.
21	CS Delay	The drop-down list to set the delay time of current detection.
22	CS MinOn	The drop-down list to set the minimum on-time for current detection.
Hard	Over Current	
23	HOCP ThreV	The toggle button to select the HOCP threshold current.
24	HOCP HoldTm	The drop-down list to set the HOCP hold time.
25	HOCP FilterTm	The drop-down list to set the HOCP filtering time.
Dead	Time Compensation	
26	DTCmp Enabl	The toggle button to enable or disable the dead time compensation.
27	DTCmp Gain	The drop-down list to set the slope of the dead time compensation voltage.
28	DTCmp MaxTm	The drop-down list to set the maximum value of the dead time compensation voltage amplitude.
Moto	or Control	
29	Ki Speed	The drop-down list to set the integral gain for motor speed control.
30	Kp Curnt	The drop-down list to set the proportional gain for current control.
31	Ki Curnt	The drop-down list to set the integral gain for current control.
32	Max Curnt	The drop-down list to set the maximum operating current.
32 33	Max Curnt OCP Curnt	The drop-down list to set the maximum operating current.The drop-down list to set the SOCP threshold current.

No.	Group Box/ GUI Parameter	Description				
Spee	Speed Control					
35	SpeedRef Sel	The toggle button to select the speed control mode.				
36	SpeedRef Unt	The drop-down list to set the multiplier of a reference speed.				
37	SpeedRef Drv <sup>(1)</sup> / SpeedRef Max <sup>(2)</sup>	The drop-down list to set the reference speed <sup><math>(1)</math></sup> or the maximum reference speed <sup><math>(2)</math></sup> .				
38	SpeedRef Min	The drop-down list to set the minimum reference speed.				
VSP/	VM Voltages					
39	VSPRun Max	The drop-down list to set the maximum speed voltage (V <sub>SMX</sub> ).				
40	VSPStart Min	The drop-down list to set the excitation start voltage (V <sub>SST</sub> ).				
41	VSPRun Min	The drop-down list to set the minimum speed voltage (V <sub>SMN</sub> ).				
42	VSP SleepV	The drop-down list to set the low power consumption mode transition voltage ( $V_{SSN}$ ).				
43	UVM ThrV	The toggle button to select the VM pin UVP threshold voltage ("0.3 V" or "0.6 V").				
EEPI	ROM					
44	ProductNo PN	The drop-down list to assign the identification number of the EEPROM.				
45	Password Pwd	The command button and drop-down list to set the password to the EEPROM.				
46	EEPROM	The command button to execute a write to the EEPROM.				
Run	Control					
47	DIAG Output	The drop-down list to set the DIAG pin output signal.				
48	DIAG Drv Curnt	Executable only when "Drv Curnt" is selected in the <b>DIAG Output</b> list. The toggle button to select the DIAG output logic ("Positive L" or "Negative L").				
49	FG Output	The drop-down list to set the FG pin output signal.				
50	FG Frequency	The toggle button to select the FG pin output pulse frequency: "Fdrv" — 1 pulse per 360° electrical angle "3*Fdrv" — 3 pulses per 360° electrical angle				
51	Read Diag	The toggle button to select whether to clear the DIAG pin status after the GUI reads it.				
52	PMRSTn Ouput	The toggle button to select whether to put the gate-drive MIC into a standby state at the reset operation by the RESETn pin.				
53	Stop On Fail	The toggle button to select whether to stop the motor run at fault detection, i.e., power module fault, loss of synchronization, or thermal shutdown.				
54	ReStart Ctrl	The toggle button to select whether to restart motor operations when a loss-of- synchronization (LOS) condition is detected.				
55	Restart No	The drop-down list to set the number of restarts allowed after a startup failure.				
56	LOS Hold Tm	The drop-down list to set the hold time after an LOS (loss of synchronization) fault occurs.				
57	Restart Torque	The toggle button to select the ramp-up current for motor restart ("Fixed" or "Spread").				
58	Brake	The toggle button to turn on or off the manual braking operation.				
59	Direction	The toggle button to select the direction of motor rotation ("Forward" or "Reverse").				

<sup>(1)</sup> When "Int SR" is selected in the **SpeedRef Sel** field.

<sup>(2)</sup> When "Ext VSP" is selected in the **SpeedRef Sel** field.

No.	Group Box/ GUI Parameter	Description
Othe		
60	Run/Stop	The field that contains the toggle button to start or stop the motor run ("Run" or "Stop").
61	I2C Registers	The pane containing the non-editable text field that displays the register values (parameters).
62	Spec Regs	The pane containing the non-editable text field that displays the status register values.
63	Default	The command button to read the default parameters (i.e., to initialize the GUI).
64	Load	The command button to import a parameter file (.rst format).
65	Save	The command button to save a parameter file (.rst format).
66	Mask	The column of check boxes to disable the corresponding diagnostic function (by selecting the check box).
67	Clear	<ul> <li>The command button to reset the status indicators displaying error statuses in red.</li> <li>FF: General fault flag</li> <li>POR: V3 pin undervoltage (power-on reset)</li> <li>ME: Memory error</li> <li>WD: Watchdog timeout</li> <li>OC: SOCP operation</li> <li>EE: EEPROM overwrite limit</li> <li>TW: Thermal warning for control MIC</li> <li>OT: Thermal shutdown for control MIC</li> <li>LOS: Loss of synchronization</li> <li>PMF: Power module fault</li> <li>HOC: Hard overcurrent</li> <li>OVM: VM pin overvoltage</li> <li>UVM: VM pin undervoltage</li> </ul>
68	Send Registers	The command button to transmit the register values displayed on the GUI.
69	Read Registers	The command button to read the register values of the EEPROM.
70	Check-Sum	The group box containing the non-editable text field that indicates the sum of all the register values.

#### 4.2. Locking by Password

The IC has the function to enable the password-locked mode that protects the EEPROM from overwrite or read operations. For more details, refer to the SX68200M series data sheet.

For GUI-assisted password locking and unlocking procedures, a logic power supply is required to apply voltages to the VCCx and VPP pins. <u>When using both of an AC power supply and a logic power supply in these procedures, make sure that the logic power supply has a floating connection.</u> In case both supplies are connected to the same ground, your demo board may have an overcurrent and thus permanent damage.

The following subsections contain the procedure using both an AC power supply (as the VCCx pin voltage supply) and a logic power supply (for the VPP pin voltage application).

#### 4.2.1. Locking Procedure: Setting a Password

- 1) Power on the AC power supply.
  - A voltage of VCC =15 V is applied.
- Apply 24 V to the VPP pin.
   Before applying the voltage, make sure that the logic power supply has a floating connection.
- From the **Password Pwd** list in the **EEPROM** group box, select a password you want to set.



- 4) Click the **Password Pwd** button.
- 5) Click the **Write** button in the **EEPROM** field. The confirmation message below then appears.



- 6) After acknowledging the message content, click **Yes**.
- 7) Turn off the logic power supply.
- 8) Turn off the AC power supply.

You have enabled the locked mode.

During the locked mode setting, if you click the **Read Registers** button, the GUI displays random numbers in the **I2C Registers** field where the register values appear. The identification number is the value set in the **ProductNo PN** list, which will also be reflected in the register value display. By setting the identification number, you can recognize the parameters even while setting the locked mode.

#### 4.2.2. Unlocking Procedure: Cancelling the Password

- 1) Power on the AC power supply. A voltage of VCC =15 V is applied.
- 2) Apply 24 V to the VPP pin.
- Before applying the voltage, make sure that the logic power supply has a floating connection.
- 3) From the **Password Pwd** list in the **EEPROM** group box, select the password you have set.

EEPROM	
ProductNo PN	0 -
Password Pwd	000 🖵
EEPROM	Write

- 4) Click the **Password Pwd** button.
- 5) Wait for about 15 seconds. You have disabled the locked mode.
- 6) Turn off the logic power supply.
- 7) Turn off the AC power supply.

If you click the **Read Registers** button without turning off the AC power supply, the GUI displays random numbers in the **I2C Registers** field where the register values appear. To read proper register values, turn on the AC power supply again, and then click the **Read Registers** button.

### 4.3. Generating a Parameter File

To save a parameter file (.rst), which contains the tuned parameter values, to your computer, click the **Save** button at the bottom right of the GUI. The saved parameter file is editable, i.e., it can be opened in a general text editor. To import an edited parameter file into the GUI, click the **Load** button.

You can also use a programmer to import a parameter file and to write a parameter to the IC. Section 4.4.2 gives detailed explanations on the parameter writing.

Figure 4-2 shows the parameter file containing the GUI default values. The configuration register 11 (hereafter "Config[11]") is the register for setting a security password to the EEPROM. When you set a value other than "0" to the Config[11], reading from the EEPROM via the serial communications will cause the IC to output random numbers (except for specified registers). Therefore, performing a verify operation results in an error. Care must be taken when you make a change to the Config[11].



Figure 4-2. Default Parameter File

### 4.4. Writing Parameters

You can write (save) parameters to the EEPROM embedded in the IC. Writing parameters to the EEPROM allows the motor to be controlled in stand-alone mode, not via the serial communications but via analog voltage applied to the VSP pin.

There are two ways to perform write operations: using the GUI or using a programmer from Elnec s.r.o.

### 4.4.1. Writing Parameters with the GUI

Writing the GUI parameter values to the EEPROM requires a logic power supply, which is used for applying voltages to the VCCx, VSP, and VPP pins.

This section explains the writing procedure using the GUI.

- 1) Connect the demo boad and the control PC. See Steps 1) to 2) in Section 2.3.
- 2) Twist the VSP pin voltage-adjusting resistor, VSP\_VR, fully counterclockwise.
  With this setting, applying a 1.5 V voltage to the VCCx pin allows a 1.5 V voltage to be applied to the VSP pin as well. For more details, see Table 3-20.
- 3) In the VSP/VM Voltages group box, set the VSP SleepV and VSPRun Min parameters. Be sure to set the parameters to fall within the range below (see Section 3.6): VSP SleepV < VSP pin voltage (1.5 V) < VSPRun Min.</p>
- 4) Apply 15 V to the VCCx pin. Voltages are applied respectively as follows: VCC = 15 V,  $V_{SP} = 1.5$  V.
- 5) Apply 24 V to the VPP pin as the EEPROM write supply voltage,  $V_{PP}$ .
- 6) To launch the GUI, double-click the SX682xxM\_Serial\_Interface\_V3p6.exe file. Once the communications between the control PC and the IC become available, the USB-I2C indicator displays "OKAY!", changed from its default "FAIL!".

Communications	Communications		
Disabled	Enabled		
USB-I2C FAIL!	USB-I2C OKAY!		

- 7) Check the SpeedRef Sel field setting in the Speed Control group box. When "Ext VSP" is selected, go to Step 8).
   When "Int SR" is selected, go to Step 9).
- 8) In the **Run/Stop** field, click the **Run** button.
- 9) From the **ProductNo PN** list in the **EEPROM** group box, select a value to be assigned as the EEPROM identification number.



10) Under the EEPROM group box, click the Write button in the EEPROM field.

A parameter writing process then starts. DO NOT operate the GUI until the writing process ends. As in the image below, the status indicator right under the **USB-I2C** indicator starts to display the registers currently being written, one after another. As a sign of completion, the status indicator stops switching and changes the letter in its display from "W" to "R".



After the writing process completes, the NVC counter value (i.e., the number of writes) is incremented.



### 4.4.2. Writing Parameters with a Programmer

This section describes how to write parameters with the programmer from Elnec. To write parameters to the IC, import the parameter file (.rst) into your programmer.

The procedure we introduce in this section is one example of writing parameters, which has been confirmed as of February 4, 2021. For more details, refer to the corresponding user manuals provided by Elnec.

#### Preparing the Hardware and Software

1) Prepare the devices listed in Table 4-2, below.

Device	Description	Remarks
Universal Programmer	Model name: BeeProg2 Manufacturer: Elnec s.r.o. URL: https://www.elnec.com/en/products/universal- programmers/beeprog2/	For mass production, the production programmer BeeHive204 is also available.
Adopter	Model name: DIL48/SOIC36-1.01 ZIF-CS SX6-1 Manufacturer: Elnec s.r.o. URL: https://www.elnec.com/en/products/programming- adapters/DIL48_SOIC36-1.01_ZIF-CS_SX6-1/	

Table 4-2. Required Devices

2) From the URL below, download and install the software (Reglar SW). URL: <u>https://www.elnec.com/en/</u>



- 3) Connect the adaptor to the universal programmer.
- 4) Connect the universal programmer to your PC.
- 5) Turn on the universal programmer.
- 6) <u>To launch</u> the software you downloaded, double-click the **Elnec PG4UW** icon.



Then the two windows below open.



7) In the **Find programmer** window, establish a connection between the programmer and your PC.



#### Importing a Parameter File (.rst) into the Programmer

8) Click the **Select** button on the toolbar.

Doad -		- 🍥		2		*	<sup>2</sup> / <sub>₹</sub> FF	<b>*</b>	*	*	<b>K</b>
Load	Save	Load prj	Save prj	View/Edit	Select/def.	Select	Blank	Read	Verify	Program	Erase

#### Then the window below opens.

😴 Select device			×
All Only selected ty	ype Only selected manufacturer		
	· · · · · · · · · · · · · · · · · · ·		
Manufacturer	Name	Adapter/module or note	
Generic-EPROM	2716 (25V/5V/STD)	Note: no adapter required	A
Generic-EPROM	2716A (21V/5V/STD)	Note: no adapter required	
Generic-EPROM	2716B (12.5V/6V/Intel)	Note: no adapter required	
Generic-EPROM	2732 (25V/5V/STD)	Note: no adapter required	
Generic-EPROM	2732A (21V/5V/STD)	Note: no adapter required	
Generic-EPROM	2732B (12.5V/6V/Intel)	Note: no adapter required	
Generic-EPROM	2764 (21V/6V/Intel)	Note: no adapter required	
Generic-EPROM	2764 [PLCC32]	See Device info <ctrl+f1></ctrl+f1>	
Generic-EPROM	2764A (12.5V/6V/Intel)	Note: no adapter required	
Generic-EPROM	2764A [PLCC32]	See Device info <ctrl+f1></ctrl+f1>	
Generic-EPROM	27C64 (12.75V/6.25V/QP)	Note: no adapter required	
Generic-EPROM	27C64 [PLCC32]	See Device info <ctrl+f1></ctrl+f1>	
Generic-EPROM	27128 (21V/6V/Intel)	Note: no adapter required	
Generic-EPROM	27128 [PLCC32]	See Device info <ctrl+f1></ctrl+f1>	
Generic-EPROM	27128A (12.5V/6V/Intel)	Note: no adapter required	
Generic-EPROM	27128A [PLCC32]	See Device info <ctrl+f1></ctrl+f1>	
Generic-EPROM	27C128 (12.75V/6.25V/QP)	Note: no adapter required	
Generic-EPROM	27C128 IPL CC321	See Device info 20H+F15	*
Search:			
Use s	earch pattern exactly as typed (Alt+E) 🧻	08818 found	
-	ant search and "x" characters replacement	t (Alt+T) 108818 found	
📃 Highlig	ht matching fragments		
		OK S Cancel	

9) In the Select device window, select the IC you want to write.

A       Objective       Objective <t< th=""><th>New Andoreview       Adgete/Mode or rife         Demo: EPROM       2704 (25%/26%)       Note no adquer requeed         Demo: EPROM       2704 (25%/26%)       Note no adquer requeed         Demo: EPROM       2705 (25%/26%)       See Dence ario (2047)         Demo: EPROM       2704 (12%/26%/26%)       See Dence ario (2047)         Demo: EPROM       2705 (25%/26%)       Note no adquer requeed         Demo: EPROM       2705 (12%/26%/26%)       See Dence ario (2047)         Demo: EPROM       2705 (12%/26%/26%)       Note no adquer requeed         Demo: EPROM       2705 (12%/26%/26%)       Note no adquer requee</th><th>Marulaciture       Name       Adgeter/module or note         Generic EPROM       27156 (25V/95/150)       Note no adgeter required         Generic EPROM       27156 (25V/95/150)       Note no adgeter required         Generic EPROM       2716 (25V/95/150)       Note no adgeter required         Generic EPROM       2736 (25V/95/150)       Note no adgeter required         Generic EPROM       2732 (21V/95/150)       Note no adgeter required         Generic EPROM       2732 (12V/95/164)       Note no adgeter required         Generic EPROM       2738 (12V/95/164)       Note no adgeter required         Generic EPROM       2734 (21V/95/164)       Note no adgeter required         Generic EPROM       2744 (21V/95/164)       Note no adgeter required         Generic EPROM       2764 (12/07/95/164)       Note no adgeter required         Generic EPROM       2764 (12/07/95/164)       Note no adgeter required         Generic EPROM       2764 (12/07/96/164)       Note no adgeter required         Generic EPROM       2764 (21/06/164)       Note no adgeter required         Generic EPROM       2764 (21/06/164)       Note no adgeter required         Generic EPROM       2728 (12/07/164)       Note no adgeter required         Generic EPROM       2728 (12/07/164)       Note no adgeterequired</th></t<>	New Andoreview       Adgete/Mode or rife         Demo: EPROM       2704 (25%/26%)       Note no adquer requeed         Demo: EPROM       2704 (25%/26%)       Note no adquer requeed         Demo: EPROM       2705 (25%/26%)       See Dence ario (2047)         Demo: EPROM       2704 (12%/26%/26%)       See Dence ario (2047)         Demo: EPROM       2705 (25%/26%)       Note no adquer requeed         Demo: EPROM       2705 (12%/26%/26%)       See Dence ario (2047)         Demo: EPROM       2705 (12%/26%/26%)       Note no adquer requeed         Demo: EPROM       2705 (12%/26%/26%)       Note no adquer requee	Marulaciture       Name       Adgeter/module or note         Generic EPROM       27156 (25V/95/150)       Note no adgeter required         Generic EPROM       27156 (25V/95/150)       Note no adgeter required         Generic EPROM       2716 (25V/95/150)       Note no adgeter required         Generic EPROM       2736 (25V/95/150)       Note no adgeter required         Generic EPROM       2732 (21V/95/150)       Note no adgeter required         Generic EPROM       2732 (12V/95/164)       Note no adgeter required         Generic EPROM       2738 (12V/95/164)       Note no adgeter required         Generic EPROM       2734 (21V/95/164)       Note no adgeter required         Generic EPROM       2744 (21V/95/164)       Note no adgeter required         Generic EPROM       2764 (12/07/95/164)       Note no adgeter required         Generic EPROM       2764 (12/07/95/164)       Note no adgeter required         Generic EPROM       2764 (12/07/96/164)       Note no adgeter required         Generic EPROM       2764 (21/06/164)       Note no adgeter required         Generic EPROM       2764 (21/06/164)       Note no adgeter required         Generic EPROM       2728 (12/07/164)       Note no adgeter required         Generic EPROM       2728 (12/07/164)       Note no adgeterequired
biteme:       EVENDIA       2715 (250/30/2510)       Note no adgeter required         biteme:       EVENDIA       2716 (210/30/2510)       Note no adgeter required         biteme:       EVENDIA       2726 (210/30/2510)       Note no adgeter required         biteme:       EVENDIA       2736 (210/30/2510)       Note no adgeter required         biteme:       EVENDIA       2734 (210/30/2010)       Note no adgeter required         biteme:       EVENDIA       2734 (210/30/2010)       See Device into CMHTh         biteme:       EVENDIA       2734 (210/30/2010)       See Device into CMHTh         biteme:       EVENDIA       2734 (210/30/2010)       See Device into CMHTh         biteme:       EVENC       27358 (210/30/2010)       Note no adgeter required         biteme:       EVENC       27358 (210/30/2010)       Note no adgeter required         biteme:       EVENC       27358 (210/30/2010)       Note no adgeter required         biteme:       EVENC       27358 (210/30/2010)       No	Detect EPSDM       2715 (523/02/210)       Note: no addres regated         Detect EPSDM       2716 (123/02/100)       Note: no addres regated         Detect EPSDM       2716 (123/02/100)       Note: no addres regated         Detect EPSDM       2716 (123/02/100)       Note: no addres regated         Detect EPSDM       2723 (125/02/02/10)       Note: no addres regated         Detect EPSDM       2723 (125/02/02/10)       Note: no addres regated         Detect EPSDM       2724 (127/02/148)       Note: no addres regated         Detect EPSDM       2724 (127/02/148)       Note: no addres regated         Detect EPSDM       2724 (12.00/148)       Note: no addres regated         Detect EPSDM       27238 (12.00/148)       Note: no addres regated	Device E950M       2716 (250/50/510)       Note invasion         Device E970M       2716 (210/50/510)       Note no adgeter required         Device E970M       2726 (210/50/510)       Note no adgeter required         Device E970M       2736 (210/50/510)       Note no adgeter required         Device E970M       2734 (210/50/64/e8)       Note no adgeter required         Device F970M       2734 (210/50/64/e8)       Note no adgeter required         Device F970M       2744 (210/50/64/e8)       Note no adgeter required         Device F970M       2744 (210/50/64/e8)       Note no adgeter required         Device F970M       2744 (210/50/64/e8)       Note no adgeter required         Device F970M       2764 (210/50/64/e8)       Note no adgeter required         Device F970M       27168 (210/50/64/e8)       Note no adgeter required         Device F970M       27168 (210/50/64/e8)       Note no adgeter required         Device F970M       27168 (120/56/64/e8)       Note no adgeter required         Device F970M       27168 (120/56/64/e8)       Note no adgeter requi
Device EPROM       2716 (25//5//510)       Note no adgeter required         Device EPROM       2716 (25//5//510)       Note no adgeter required         Device EPROM       2720 (25//5//510)       Note no adgeter required         Device EPROM       2728 (25//5//510)       Note no adgeter required         Device FPROM       2728 (25//5//510)       Note no adgeter required         Device FPROM       2728 (27//5//100)       Note no adgeter required         Device FPROM       2784 (PLC02)       See Device into CMrTh         Device FPROM       2764 (PLC02)       See Device into CMrTh         Device FPROM       2768 (PLC02)       See Device into CMrTh         Device FPROM       27768	Defense EF30M       2725 (52/07/0310)       Note no adplore regard         Defense EF80M       2726 (12/07/0310)       Note no adplore regard         Defense EF80M       2720 (59/07/10)       Note no adplore regard         Defense EF80M       2724 (57/07/144)       Note no adplore regard         Defense EF80M       27238 (12/07/07/144)       Note no adplore regard	Device EPriOM       2716 (25//57/210)       Note no adapter required         Device EPRIOM       2716 (25//57/210)       Note no adapter required         Device EPRIOM       2716 (25//57/210)       Note no adapter required         Device EPRIOM       2720 (25//57/210)       Note no adapter required         Device EPRIOM       2726 (25//57/210)       Note no adapter required         Device EPRIOM       2728 (25//57/210)       Note no adapter required         Device EPRIOM       2728 (27//57/210)       Note no adapter required         Device FFROM       2728 (27//57/210)       Note no adapter required         Device FFROM       2784 (FLC22)       See Device into CMI+Th         Device FFROM       2764 (FLC22)       See Device into CMI+Th         Device FFROM       2764 (FLC22)       See Device into CMI+Th         Device FFROM       2764 (FLC22)       See Device into CMI+Th         Device FFROM       27768 (FLC20)       See Device into CMI+Th         Device FFROM <t< th=""></t<>
General EPROM       27164 (21V/PV/STD)       Note no adapter required         General EPROM       2722 (21V/PV/STD)       Note no adapter required         General EPROM       2723 (12 V/PV/STD)       Note no adapter required         General EPROM       2734 (12 V/PV/STNe)       Note no adapter required         General EPROM       2764 (12 V/PV/Stne)       Note no adapter required         General EPROM       2764 (12 V/PV/Stne)       Note no adapter required         General EPROM       2764 (12 V/PV/Stne)       Note no adapter required         General EPROM       2764 (12 V/PV/Stne)       Note no adapter required         General EPROM       27164 (12 V/PV/Stne)       Note no adapter required         General EPROM       27126 (12 D/V/Stre)       Note no adapter required         General EPROM       27126 (12 D/V/Stre)       Note no adapter required         General EPROM       27126 (12 D/V/Stre)       Note no adapter required         General EPROM       27126 (12 D/V/Stre)       Note no adapter required         General EPROM       27128 (12 D/V/Stre)	Serecc EPROM 2754 (21V/9V/STD) Note no adque requeed Serecc EPROM 2723 (22V/9V/STD) Note no adque requeed Serecc EPROM 2723 (22V/9V/STD) Note no adque requeed Serecc EPROM 2724 (2V/9V/StD) Note no adque requeed Serecc EPROM 2744 (2V/9V/Steel) Note no adque requeed Serecc EPROM 2748 (2V/9V/Steel) Note no adque requeed Serecc EPROM 274	Generic EPROM       27164 (21X/90/STD)       Note: no adapter required         Generic EPROM       27168 (125X/90/STD)       Note: no adapter required         Generic EPROM       2726 (21X/90/STD)       Note: no adapter required         Generic EPROM       2726 (125X/90/STD)       Note: no adapter required         Generic EPROM       2726 (21X/90/STD)       Note: no adapter required         Generic EPROM       2726 (12X/90/Stell)       Note: no adapter required         Generic EPROM       2764 (12X/90/Stell)       Note: no adapter required         Generic EPROM       27764 (12X/90/Stell)       Note: no adapter required         Generic EPROM       27728 (12X/90/Stell)       Note: no adapter required         Generic EPROM       27728 (12X/90/Stell)       Note: no adapter required         Generic EPROM       27728
servec EPRION 2726 (12.9V/9V/14e) Note: no adapter required servec EPRION 2726 (12.9V/9V/1510) Note: no adapter required servec EPRION 2726 (12.9V/9V/14e) Note: no adapter required servec EPRION 2744 (12.9V/9V/14e) Note: no adapter required servec EPRION 27454 (12.9V/9V/14e) Note: no adapter required servec EPRION 27458 (12.9V/9V/14e) Note: no ad	service_EPRION       27168 [12:59/07/Area]       Note no adgete required         service_EPRION       2732 [12:99/07/Area]       Note no adgete required         service_EPRION       2733 [12:99/07/Area]       Note no adgete required         service_EPRION       2734 [12:99/07/Area]       Note no adgeter required         service_EPRION       2734 [12:99/07/Area]       Note no adgeter required         service_EPRION       2734 [12:99/07/Area]       Note no adgeter required         service_EPRION       2704 [12:29/07/Area]       Note no adgeter required         service_EPRION       27024 [12:99/07/Area]       Note no adgeter required         service_EPRION       27128 [12:99/07/Area]       See Device ir/o (CM=F15)         service_EPRION	inversion: EPRIOM       27168 [12.9V/8V/Meta]       Note: no adapter required         inversion: EPRIOM       2732 (29/9V/510)       Note: no adapter required         inversio: EPRIOM       2732 (29/9V/510)       Note: no adapter required         inversio: EPRIOM       2734 (21/9V/71144)       Note: no adapter required         inversio: EPRIOM       2734 (21/9V/71144)       Note: no adapter required         inversio: EPRIOM       2744 (12.9V/8V/1444)       Note: no adapter required         inversio: EPRIOM       2744 (12.9V/8V/1444)       Note: no adapter required         inversio: EPRIOM       2764 (12.9V/8V/1444)       Note: no adapter required         inversio: EPRIOM       27764 (12.9V/8V/1444)       Note: no adapter required         inversio: EPRIOM       27726 (12.9V/8V/1444)       Note: no adapter required         inversio: EPRIOM       27726 (12.7W/82.7W/82)       See Divice info (CM+F1)
nerec EPROM 2732 (29//9//510) Note: no adgete: required nerec EPROM 2732 (21//9//510) Note: no adgete: required nerec EPROM 2734 (21//9//rel) Note: no adgete: required nerec EPROM 2744 (PLCC2) See Device into (ChFT): nerec EPROM 2748 (PLCC2) See Device into (ChFT): Note: no adgete: required nerec EPROM 2748 (PLCC2) See Device into (ChFT): See Device into (ChFT)	invesc.EPROM       2732 (29//9/510)       Note: no adapter required         invesc.EPROM       2733 (21//9/14)       Note: no adapter required         invesc.EPROM       2734 (21//9/14)       Note: no adapter required         invesc.EPROM       2734 (21//9/14)       Note: no adapter required         invesc.EPROM       2744 (21//9/14)       Note: no adapter required         invesc.EPROM       27128 (21//9/14)       Note: no adapter required         invesc.EPROM       27128 (21//9/14)       Note: no adapter required         invesc.EPROM       27128 (12/9/16)//144       Note: no adapter required         invesc.EPROM       27128 (12/9/16) /144       Note: no adapter required         invesc.EPROM       27128 (12/9/16) /144       Note: no adapter re	Interic EPRION 2732 (29/19/1510) Note: no adapter required interic EPRION 27328 (21/19/15/1510) Note: no adapter required interic EPRION 2738 (21/19/15/1510) Note: no adapter required interic EPRION 2744 (PLCC2) See Device into CN+1715 interic EPRION 27728 (PLCC2)
energic EPRIOM       2732b (21V/9V/StD)       Note: no adapter required         energic EPRIOM       2732b (12V/9V/Stel)       Note: no adapter required         energic EPRIOM       2744 (PLCC2)       See Device into cOMPTs         energic EPRIOM       2764b (122V/9V/Stel)       Note: no adapter required         energic EPRIOM       27728 (122V/9V/Stel)       Note: no adapter required         energic EPRIO	energic EPROM       2732a (21V/9V/14e)       Note: no adapter required         energic EPROM       2734 (22V/0V/14e)       Note: no adapter required         energic EPROM       2764 (1220V/0V/14e)       Note: no adapter required         energic EPROM       2764 (22V/0V/14e)       Note: no adapter required         energic EPROM       2764 (122V/0V/14e)       Note: no adapter required         energic EPROM       2764 (122V/0V/14e)       Note: no adapter required         energic EPROM       2764 (122V/0V/14e)       Note: no adapter required         energic EPROM       2752 (122V/0V/14e)       Note: no adapter required         energic EPROM       27528 (PLC02)       See Device info (C04F15         energic EPROM       27528 (PLC02)       See Device info (004F1	energic EPRIOM       2732A (21V/9V/stel)       Note: no adapter required         energic EPRIOM       2732A (22V/9V/stel)       Note: no adapter required         energic EPRIOM       2754 (122V/9V/stel)       Note: no adapter required         energic EPRIOM       2758 (122V/stel)       See Device info (ChirF1)         energic EPRIOM       2758 (122V/stel)       See Device info (ChirF1)         energic EPRIOM       2758 (122V/stel)       Note: no adapter required         energic EPRIOM
energic EPRIOM       2732b (21V/9V/StD)       Note: no adapter required         energic EPRIOM       2732b (12V/9V/Stel)       Note: no adapter required         energic EPRIOM       2744 (PLCC2)       See Device into cOMPTs         energic EPRIOM       2764b (122V/9V/Stel)       Note: no adapter required         energic EPRIOM       27728 (122V/9V/Stel)       Note: no adapter required         energic EPRIO	energic EPROM       2732a (21V/9V/14e)       Note: no adapter required         energic EPROM       2734 (22V/0V/14e)       Note: no adapter required         energic EPROM       2764 (1220V/0V/14e)       Note: no adapter required         energic EPROM       2764 (22V/0V/14e)       Note: no adapter required         energic EPROM       2764 (122V/0V/14e)       Note: no adapter required         energic EPROM       2764 (122V/0V/14e)       Note: no adapter required         energic EPROM       2764 (122V/0V/14e)       Note: no adapter required         energic EPROM       2752 (122V/0V/14e)       Note: no adapter required         energic EPROM       27528 (PLC02)       See Device info (C04F15         energic EPROM       27528 (PLC02)       See Device info (004F1	energic EPRIOM       2732A (21V/9V/stel)       Note: no adapter required         energic EPRIOM       2732A (22V/9V/stel)       Note: no adapter required         energic EPRIOM       2754 (122V/9V/stel)       Note: no adapter required         energic EPRIOM       2758 (122V/stel)       See Device info (ChirF1)         energic EPRIOM       2758 (122V/stel)       See Device info (ChirF1)         energic EPRIOM       2758 (122V/stel)       Note: no adapter required         energic EPRIOM
sector EPRION       2744 (21/V/0/Intel)       Note no adapter required         merric EPRION       2744 (21/V/0/Intel)       See Device into (CMFT)-         merric EPRION       2764 (21/V/0/Intel)       Note no adapter required         merric EPRION       27128 (21/V/0/Intel)       Note no adapter required         merric EPRION       27128 (21/V/0/Intel)       Note no adapter required         merric EPRION       27128 (12/V/0/Intel)       Note no adapter required         Tolerart reacth and "N" characters rep	<pre>mmic EPROM 2764 (21V/W/free) Note: no adapter required mmic EPROM 2764 (21V/W/free) Note: no adapter required mmic EPROM 2764 (2129/W/2014) Note: no adapter required mmic EPROM 27054 (1229/W/2014) See Device into (Cht+F1) mmic EPROM 27128 (1229/W/2014) Note: no adapter required mmic EPROM 27128 (1229/W/2014) Note: No</pre>	nexic EPROM 2744 (21V/0V/htel) Note: no adapter required nexic EPROM 2744 (21V/0V/htel) See Device into (CM+F15 nexic EPROM 2764 (0) (2259/CP) Note: no adapter required nexic EPROM 2764 (0) (2259/CP) Note: no adapter required nexic EPROM 27128 (CC22) See Device into (CM+F15 nexic EPROM 27128 (CC22) See Device into (CM+F15 Note: TROM 27128 (CC22) See Device into (CM+F15 Note: TROM 27128 (CC22) See Device into (CM+F15 Note: TROM 27128 (CC22) (CC22) See Device into (CM+F15 Note: TROM 27128 (CC22) See Device into (CM+F15 Note: TROM 27
memol EPROM       2754 [FLCC2]       See Device n/o (CM+F1)         memol EPROM       2764 [12 90//01/mel]       Note: no adapter required         memol EPROM       2764 [12 90//01/mel]       Note: no adapter required         memol EPROM       2764 [12 90//01/mel]       Note: no adapter required         memol EPROM       2764 [12 90//01/mel]       Note: no adapter required         memol EPROM       2764 [12 90//01/mel]       Note: no adapter required         memol EPROM       2764 [12 90//01/mel]       Note: no adapter required         memol EPROM       2764 [12 90//01/mel]       Note: no adapter required         memol EPROM       27128 [12 90//01/mel]       Note: no adapter required         memol EPROM       27128 [12 90//01/mel]       Note: no adapter required         memol EPROM       27128 [12 90//01/mel]       Note: no adapter required         memol EPROM       27128 [12 90//01/mel]       Note: no adapter required         memol EPROM       27128 [12 70//01/mel]       Note: no adapter required         memol EPROM       27128 [12 90//01/mel]       Note: no adapter required         memol EPROM       27129 [12 70//01/mel]       See Texase length(CM+F1)         Seatch       Wite: nearth add's'c' characteri replacement       Note: no adapter required         Wite: nearth add's'c' characteri	memol EPROM       2764 [PLCD2]       See Device into <0hi+F1>         memol EPROM       2764 [12:9V/6/Viel]       Note: no adquire required         memol EPROM       27728 [FLCC2]       See Device into <0hi+F1>         memol EPROM       27728 [FLC23]       See Device into <0hi+F1>         memol EPROM       277128 [FLC23]       See Device into <0hi+F1>         Seetch	memol:EPROM       2754 [FLCC2]       See Device into cON+F1>         memol:EPROM       2754 [12:95/67/Mel]       Note: no adapter required         memol:EPROM       27564 [12:95/67/Mel]       Note: no adapter required         memol:EPROM       2758 [FLCC2]       See Device into CM+F1>         memol:EPROM       27128 [12:95/67/Mel]       Note: no adapter required         memol:EPROM       27128 [FLCC2]       See Device into CM+F1>         see:EPROM       27129 [FLCC2]
memo: EPROM       27544 (12.9)//9//rise)       Note: no adapter required         memo: EPROM       2764 (12.9)//9//rise)       See Device into CM-F1>         memo: EPROM       27054 (12.9)//9//rise)       Note: no adapter required         memo: EPROM       27054 (12.9)//9//rise)       Note: no adapter required         memo: EPROM       27054 (12.9)//9//rise)       Note: no adapter required         memo: EPROM       27128 (12.9)//9//rise)       Note: no adapter required         memo: EPROM       27129 (12.9)//9//rise)       Note: no adapter required         memo: EPROM       27129 (12.9)//9//rise)       Note: no adapter required         memo: EPROM       27129 (12.9)//9//rise)       See Device into (CM-F1>         Seenth       Vice: reacth and "V" characters: replacement; (N+T)       1000118 flound         Hig/dg/d	envice EPROM       27644 [12.9V/6V/rHel]       Note no adapter regared         envice EPROM       27644 [12.9V/6V/rHel]       See Device No CHI/TD         envice EPROM       27044 [PLCC2]       See Device No CHI/TD         envice EPROM       27044 [PLCC2]       See Device No CHI/TD         envice EPROM       27044 [PLCC2]       See Device No CHI/TD         envice EPROM       27034 [PLCC2]       See Device No CHI/TD         envice EPROM       27128 [PLCC2]       See Device No CHI/TD         envice EPROM       27129 [PLCC2]       See Device No CHI/TD	mmic EPROM       27544 (12.97/67/html)       Note: no adapter required         mmic EPROM       27744 (PLCC2)       See Device into (CM+F1)         mmic EPROM       27054 (PLCC2)       See Device into (CM+F1)         mmic EPROM       27054 (PLCC2)       See Device into (CM+F1)         mmic EPROM       27128 (CV/67/html)       Note: no adapter required         mmic EPROM       27128 (PLCC2)       See Device into (CM+F1)         mmic EPROM       27128 (PLC22)       See Device into (CM+F1)         seet.       Seet.       See Device into (CM+F1)         seet.       Seet.       Seet.       Seet. <t< td=""></t<>
remo: EPROM 27044 (PLOC2) See Device r/o - CM+T1- meno: EPROM 27054 (PLOC2) See Device r/o - CM+T1- meno: EPROM 27038 (PLOC2) See Device r/o - CM+T1- meno: EPROM 27128 (PLOC2) See Device r/o - CM+T1- See device See CM- CM-T1- See device See CM- CM-T1- See device See CM- CM-T1- See device See CM- CM-T1- See CM- CM- CM- CM-T1- See CM- CM- CM- CM-T1- See CM- CM- CM-T1- See CM- CM- CM- CM-T1- See CM- CM- CM- CM- CM- See CM- CM- CM- CM- CM- See CM- CM- See CM- CM- CM- See CM-	remoic FPROM 27644 (PLCC12) See Device into "Chief" is immode FPROM 27064 (PLCC12) See Device into "Chief" is immode FPROM 27038 (PLCC12) See Device into "Chief" is immode FPROM 27128 (PLC12) See Device into "Chief" is immode FPROM 27128 (PLC12) See Device into "Chief" is immode FPROM 27128 (PLC12) See Device into "Chief" is immode FPROM 2	remol (FRIDM 27044 (FLCC2) See Device viol (ChiFT)- ment (FRIDM 27054 (FLCC2) See Device viol (ChiFT)- ment (FRIDM 27128 (FLCC2) (FLCC2) See Device viol (ChiFT)- ment (FRIDM 27128 (FLCC2) (FLCC2) See Device viol (ChiFT)- ment (FRIDM 27128 (FLCC2) (FLCC2) (FLCC2) (FLCC2) See Device viol (ChiFT)- ment (FRIDM 27128 (FLCC2) (FL
resec-EPROM       27054 (12.75%,829%)       Note no adapter required         resec-EPROM       27054 (12.75%,829%)       See Device rHo COM-F15         resec-EPROM       27128 (12.5%,829%)       Note no adapter required         resective       Wite reacth pattern excity an typed (wite)       See Travers left (14.6%)         Vite reacth resects and "x" characteri replacement (wite)       108818 found         Highlight metching fragments       Second       Second         Select device       Second       Second	news-EPROM 27054 [12.79/6.29/09] Note no adapter regulard news-EPROM 27058 [PLCC32] See Device into (Chi-FTo news-EPROM 27128 [PLCC32] See Device into (Chi-FTo Note no adapter regulard See Device into (Chi-FTo See Device	Interic EPRIDM 27054 (12.75% 25% 0P) Note: no adapter required interic EPRIDM 27054 (FLC32) See Device into (CM+F1> interic EPRIDM 27128 (FLC5%) (FLC5%) Note: no adapter required interic EPRIDM 27128 (FLC5%) Note: no adapter required interic EPRIDM 27126 (FLC5%) See Device into (CM+F1> interic EP
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energic EPRIOM 27C128 (12.7%/6.2%/0/1) Note: no adapter required count of EPRIOM 27C128 (12.7%/6.2%/0/1) Search 27C128 (12.7%/6.2%/0/1) Use rearch pattern exactly as typed (14.6%) 100818 found Highlight matching fragments Select device Select device	Construction     C	emeric EPROM 27/128 (12.79//6.29//0P) Note: no adapter required  from://EPROM 27/128 (12.79//6.29//0P)  Search Use: search and "%" characters: replacement. (M+1) 10818 found  Tolerant search and "%" characters: replacement. (M+1) 10818 found  Highlight matching fragments
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Concert search and "A" characters replacement (Vol-1) 100018 found Highlight matching tragments Select device	Colevant search and "A" characters replacement (M+T) 108018 found Highlight matching fragments C C C C C C C C C C C C C C C C C C C	Tolevant search and "A" characters replacement (All+1) 108818 found     Highlight matching fragments
	Manufacturer Name Adapter/Inodule or note	
	exercises second constrained and the IC you want to wr	-2 Select the IC you want
	telestocking ocketocking of the IC you want to	Manufacturer Name Adapter/module or note

10) Click the Load button on the toolbar.



#### Then the window below opens.

💆 Load file					×
Recent folders: C:\P	arameters\			- 4	3 🖹
ファイルの場所①	🕌 Parameters		• 0 🦻	• 📰 💙	
名前	*		更新日時		種類
Parameters.r	st		2018/01/1	5 18:42	RST
4					
77-1ル名(N):	Parameters <i>r</i> st		-		
ファイルの種類(1):	All files (**)			キャン	
23-1 DADIERRUDA	All files (*,*)		•	4421	200
				?	lelp
File format		Additional op			
Automatic file format recognition		Swap bytes			
Selected file format:		Erase buffer before loading			
Binary	Ŧ	Erase value:	FF h		
Buffer offset for loadi	ng				
None					
- For Binary and H	ex file formats:				
Positive offset:	0000000000 h [s16]				
- For Hex file form					
Negative offset:	0000000000 h (x8)				
Automatic negat	ive offset				
					.41

11) From the Load file window, import the parameter file (.rst) you want to write.



In the main window, the **Programmer activity log** group box will be updated.

Once the loading process completes, the event "File loading successful." is added to the activity log. Programmer activity log



12) In the Address (hex) group box, change the checksum settings.



#### Writing Parameters to the IC

13) Insert the IC into the adaptor.

When inserting the IC, use the pickup tool enclosed in the adaptor package.



14) Click the **Program** button on the toolbar.



Then the window below opens.

😥 Program?	×			
Sanken Electric SX68203M [SOIC36]				
Device operation options				
Device operation	options			
Buffer start:	Addresses 0000000000 h ;			
Ins	ertion test and/or ID check			
Insertion test:	Enable 🔻			
Command execution				
Verify after reading:	Enable 👻			
Verify:	Once •			
	Yes 💊 No			

15) Click Yes in the Program? dialog box.

Stepson Program?				
Sanken Electric SX68203M [SOIC36]				
Device operation options				
Device operation options				
Addresses				
Buffer start: 0000000000 h ;				
Insertion test and/or ID check				
Insertion test: Enable 👻				
Command execution				
Verify after reading: Enable 💌				
Verify: Once				
Yes 🛇 No				

Then, a parameter writing process starts. Once the writing process starts, in the **Programmer** pane on the **Info** window, the status indicator **BUSY** lights up. When the writing process completes, the **BUSY** indicator stops lighting and then the **GOOD** indicator lights up. When the writing process fails, the **ERROR** indicator lights up.

🚺 Info	×		🚺 Info		23
Programming device			Prog	ramming device - O.K	•
Progress	Programmer		Progress		Programmer
Device pointer: 000000000 Buffer pointer: 000000019 File pointer: 000000000	BUSY GOOD ERROR	$\rightarrow$	Device pointer: Buffer pointer: File pointer:		BUSY GOOD ERROR
0%	Cancel		1	00%	Cancel
Sanken Electric SX68203M [SOIC36]			Sanken Elec	tric SX68203M [S	OIC36]
		l (I			

After the writing process completes, the **Repeat?** dialog box appears.

ſ	Repeat?		
	2	Press "YES!" button or "Y" key to repeat last activity or press <esc> key to exit</esc>	
		Yes No >>	

16) Remove the IC that underwent the writing process from the adaptor. If you want to repeat a writing process to another IC, go to Step 17). If not, click **No** in the **Repeat?** dialog box.

Repeat?			
2	Press "YESI" button or "Y" key to repeat last activity or press <esc> key to exit</esc>		
	Yes No >>		

- 17) Insert another IC to the adaptor.
- 18) Click Yes in the Repeat? dialog box. Repeat? Press "YES!" button or "Y" key to repeat last activity or press <Esc> key to exit

Then, a parameter writing process starts. You can repeat Steps 16) to 18).

Yes <u>N</u>o

>>

### 4.5. Reading Parameters

There are two ways to read the parameters written to the EEPROM: automatic or manual reading.

### 4.5.1. Automatic Parameter Reading

To perform an automatic parameter reading process, follow the steps below:

- 1) Connect the demo boad and the control PC. See Steps 1) to 2) in Section 2.3.
- Twist the VSP pin voltage-adjusting resistor, VSP\_VR, fully counterclockwise.
   With this setting, applying a 1.5 V voltage to the VCCx pin allows a 1.5 V voltage to be applied to the VSP pin as well. For more details, see Table 3-20.
- 3) In the VSP/VM Voltages group box, set the VSP SleepV and VSPRun Min parameters. Be sure to set the parameters to fall within the range below (see Section 3.6): VSP SleepV < VSP pin voltage (1.5 V) < VSPRun Min.</p>
- 4) Apply 15 V to the VCCx pin.
- Voltages are applied respectively as follows: VCC = 15 V,  $V_{SP} = 1.5 V$ .
- 5) To launch the GUI, double-click the **SX682xxM\_Serial\_Interface\_V3p6.exe** file.

A parameter reading process then automatically starts to read the EEPROM-stored parameters. DO NOT operate the GUI until the reading process ends. As in the image below, the status indicator right under the **USB-I2C** indicator starts to display the registers currently being read, one after another. As a sign of completion, the status indicator stops switching and changes the letter in its display from "R" to "W".



The corresponding parameters on the GUI are also updated. In case any writing error has occurred, the NVC counter value (i.e., the number of writes) is decremented after the parameter reading process completed. The GUI displays an NVC counter value of the latest writing process which has been completed successfully.

### 4.5.2. Manual Parameter Reading

To perform a manual parameter reading process, follow the steps below:

- 1) Establish communications between the control PC and IC (see Steps 1) to 3) in Section 2.3).
- 2) Click the **Read Registers** button.

A parameter reading process then starts. DO NOT operate the GUI until the reading process ends. As in the image below, the status indicator right under the **USB-I2C** indicator starts to display the registers currently being read, one after another. As a sign of completion, the status indicator stops switching and changes the letter in its display from "R" to "W".



The corresponding parameters on the GUI are also updated. In case any writing error has occurred, the NVC counter value (i.e., the number of writes) is decremented after the parameter reading process completed. The GUI displays an NVC counter value of the latest writing process which has been completed successfully.

In case you have done either of the following operations after power-on, the individual setting values on the GUI are stored into the RAM even without clicking the **Send Registers** button:

- If you have clicked the **Default** button
- If you have imported a parameter file by clicking the Load button

If so, the GUI does not read the EERPOM-stored parameters after you clicked the **Read Registers** button. Instead, the GUI starts to read the RAM-stored parameters.

### 4.6. Setting the Checksum

The Elnec's programmer offers the checksum options as a verify function. The GUI employs the checksum "Word SUM Little Endian (x16)". When you set the programmer checksum to the Word SUM Little Endian (x16), both values displayed in the following fields are matched: the **CheckSum** field of the programmer and the **Check-Sum** field of the GUI.

Programmer	GUI
CheckSum: 00001768h x16 LE-S [0h31h] Serialization: None Split: None	Check-Sum CSUM: 0x1768

This checksum setting helps you check if the GUI-adjusted parameter values have been successfully written to the IC. For more details on the programmer setting, see Step 12) in Section 4.4.2.

The default checksum value displayed on the GUI is "0x1768". For each default parameter value, see Figure 4-2.

# 5. FAQ

Question	Answer
Why the GUI does not launch?	The operating system your control PC uses may NOT our required operating environment. Please check your current operating environment and use a PC with Windows 7 or later.
I tried to run the motor for the first time, but it didn't rotate properly. What should I do?	If you have connected the AC power supply to the connector CN1, please try a DC power supply. Here is how to run the motor with a DC power supply: First, connect the DC power supply to the DC-Link connector. Next, check the motor operation by applying a voltage of 40 V. Then, increase the voltage gradually while monitoring the motor operation.
Why does the GUI display the status indicator <b>POR</b> in red after motor startup?	When the IC restarts operating, the GUI displays the status indicator <b>POR</b> in red to alarm a possible error such as an instantaneous power failure. This is because ground potential fluctuations due to an inrush current at motor startup may have induced the V3 pin voltage to cause a decrease. Therefore, please try the following measures to protect the V3 pin from having a voltage drop:
	<ul><li>Remove superimposed noise to the V3 pin.</li><li>Suppress inrush current.</li></ul>
What are "open loop" and "closed loop"?	An open loop is a control loop where a rotor position is not estimated. When commutation current is forced to flow through a stator, a rotating magnetic field is generated, which drives a rotor to follow in a synchronous manner. A closed loop is a feedback-controlled loop where a rotor position is estimated. The rotor position is estimated from the motor's back EMF (BEMF: Back Electromotive Force).
Why does the GUI display the status indicator <b>LOS</b> in red at open-to-closed loop frequency control changeover?	When a loss-of-synchronization condition is detected, the GUI displays the status indicator <b>LOS</b> in red. This means that the IC cannot detect a back EMF condition properly. The faster the motor rotation, the larger the back EMF. In the <b>Start Up</b> group box, adjust the <b>RampU Frequ</b> and <b>RampU Curnt</b> setting values so that the IC can detect a back EMF condition with a faster rotation speed in the open-loop control.
What should I do when a data writing process is unstable?	Please initialize all the registers by writing "0x0000", and then write your desired parameter values to the IC. If no improvement is seen even after troubleshooting, please replace the IC with another one.
Why can't I perform a data reading process?	The password-locked mode may have been enabled. The Config[11] is the register for setting a password to the EEPROM. If you have set a value other than "0" to the Config[11], any data reading process cannot be performed. Please perform a reading process via the serial communications (SCL or SDA) that you have established, and then disable the password-locked mode (see Section 4.2.2).
How do I check the number of writing processes?	You can check the number of EEPROM writes by reading data from the Register 28 Read. Note that the programmer cannot perform such data reading. Please perform a reading process via the serial communications (SCL or SDA) that you have established.

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