Application Note

SX68200M Series: Motor Drivers with Sensorless Vector Control

A Quick Start Guide to Demo Board Evaluation

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.

Contents

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. For more details, refer to the SX68200M series data sheet. For more details on how to adjust parameters with the GUI, refer to the following application note: A Guide to Demo Board Evaluation and Parameter Adjustment (AN0009).

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^2C 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

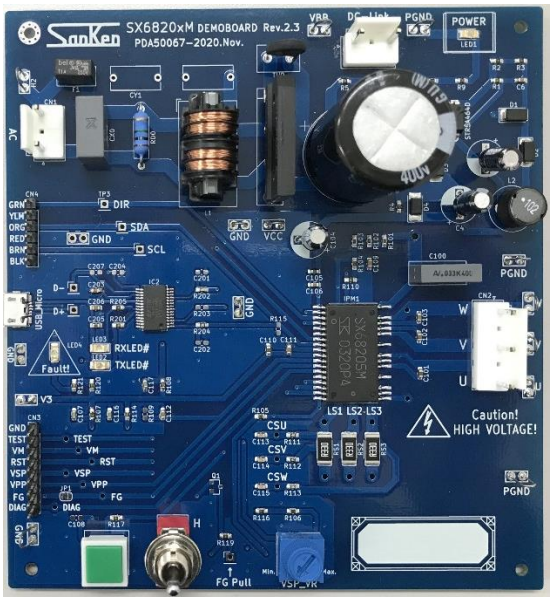
- Fan Motor for Air Conditioner
- Fan Motor for Air Purifier and Electric Fan

SX68200M Series Package

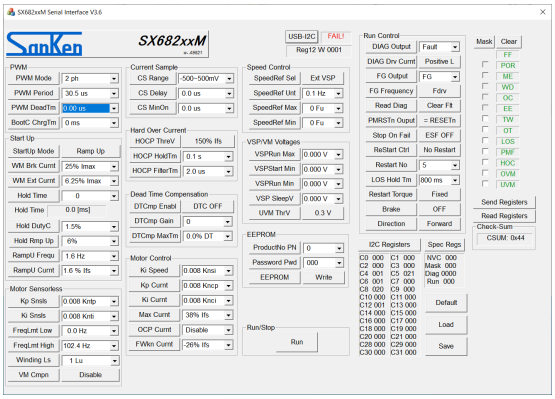
SOP36

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

Table 1-1. Demo Board Specifications

No.	On-board IC (V_{DSS}, I_O)	Motor Type	Input Supply Voltage	Rectified Voltage	VCCx Pin Voltage
Demo Board 1	SX68201M (250 V, 2.0 A)	100 V system	100 VAC	141 VDC	15 V
Demo Board 2	SX68203M (600 V, 1.5 A)	100 V system / 200 V system	100 VAC / 200 VAC	141 VDC / 282 VDC	
Demo Board 3	SX68205M (600 V, 2.0 A)	100 V system / 200 V system	100 VAC / 200 VAC	141 VDC / 282 VDC	

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

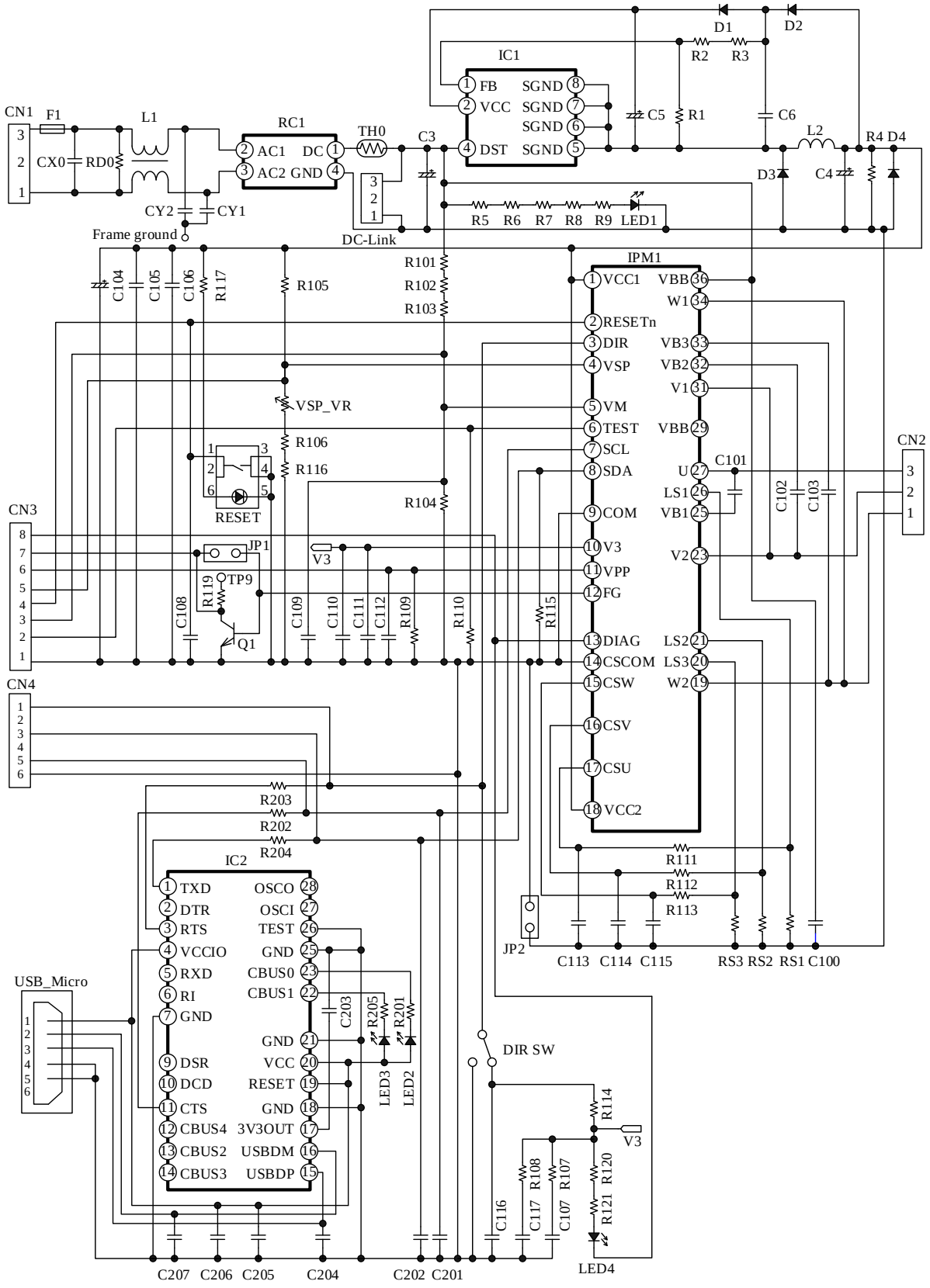


Figure 1-1. Circuit Diagram of Demo Board

- **Bill of Materials**

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
R5	General	33 kΩ, 0.25 W	USB_Micro	Micro USB Type-b connector	ZX62-B-5PA
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
R103	Metal plate	1 MΩ, 0.25 W	Q1	NPN transistor	Open
R104	Metal plate	10 kΩ, 0.25 W	IPM1	IC	SX68200M series
R105	General	47 kΩ, 0.25 W	IC1	IC	STR5A464D
R106	General	5.6 kΩ, 0.25 W	IC2	IC	FT232RL
R107	General	10 kΩ, 0.25 W	JP1	Jumper	Short
R108	General	10 kΩ, 0.25 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 you rotate a testing motor for the first time with your demo board.

2.1. Calculating Winding L_S

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.

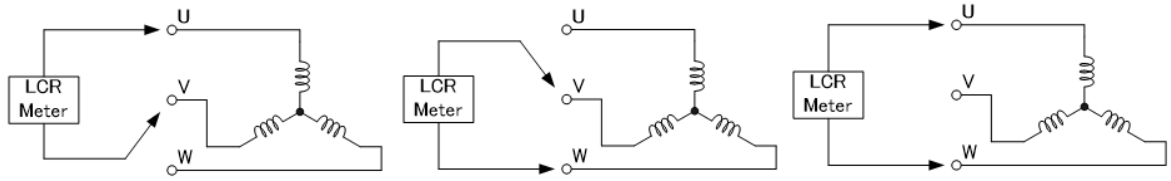


Figure 2-1. Line Inductance Measurement

Table 2-1. Example Results of Line Inductance Measurement

Motor	Number of Measurements	Line Inductance, L_{IJ} (mH)		
		L_{UV}	L_{VW}	L_{UW}
No. 1	First	81	80	79
	Second	82	82	81
	Third	80	82	81
No. 2	First	81	80	81
	Second	82	82	82
	Third	81	80	82
Average (L_{AVG})		81.1		

Secondly, calculate a value of the Winding L_S. We 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

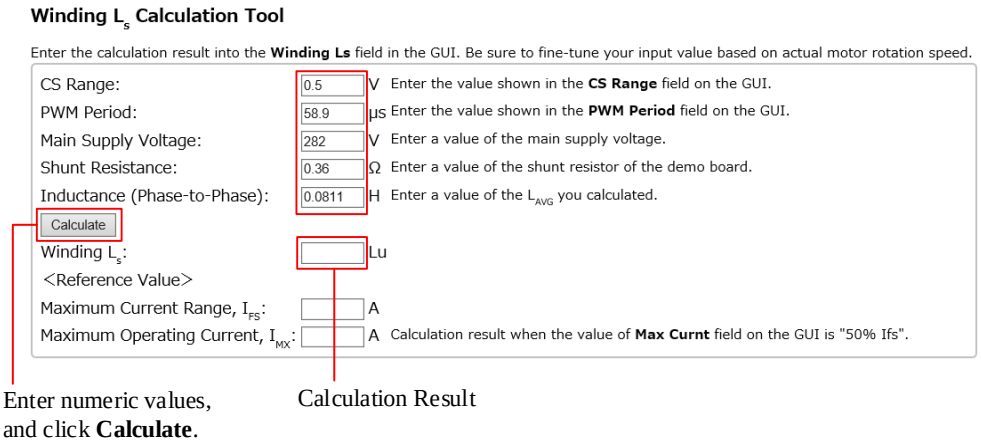


Figure 2-2. Winding L_S Calculation Tool

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, PWM period = 58.9 µs. For more details on the GUI and calculation methods, refer to the following application note: A Guide to Demo Board Evaluation and Parameter Adjustment (AN0009).

Section 2.4 describes how to enter a calculated value into the GUI.

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.

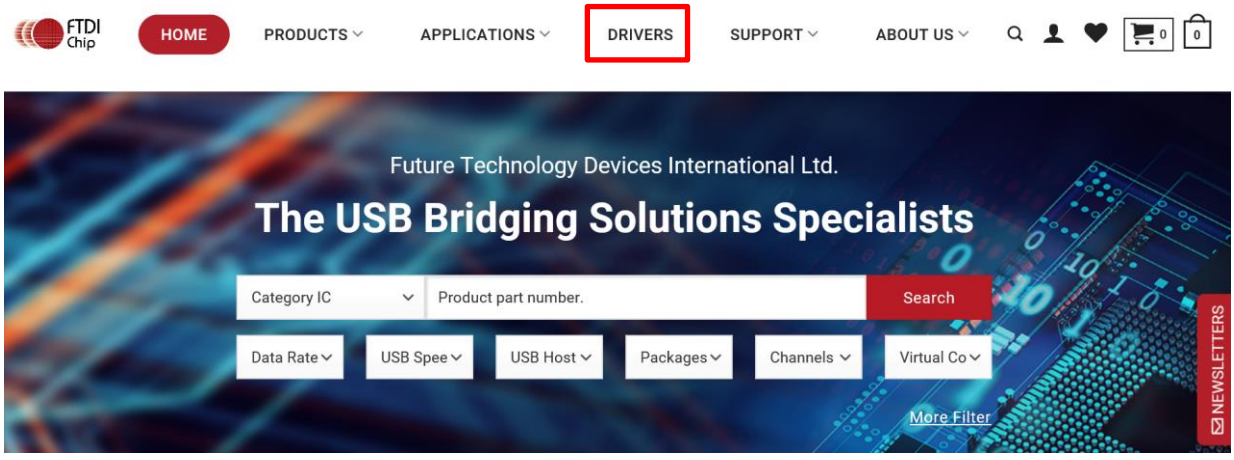
Table 2-2. Required Devices

Device	Description	Remarks
AC Power Supply	Constant voltage power supply or SLIDAC	Required
USB Cable	USB A－USB micro B cable	Required
USB Isolator	Model name: 114991949 Manufacturer: Seeed Studio URL: https://www.mouser.jp/ProductDetail/Seeed-Studio/114991949?qs=P1JMDcb91o6Z7ld6yCt%2FVQ==	Required (The items at left are examples; you can use any USB isolator.)
	Model name: USB Isolator USB-ISO Manufacturer: OLIMEX URL: https://strawberry-linux.com/catalog/items?code=15043	
Motor		Required
Control PC	OS: Windows 7 or later	Required
Oscilloscope		Required

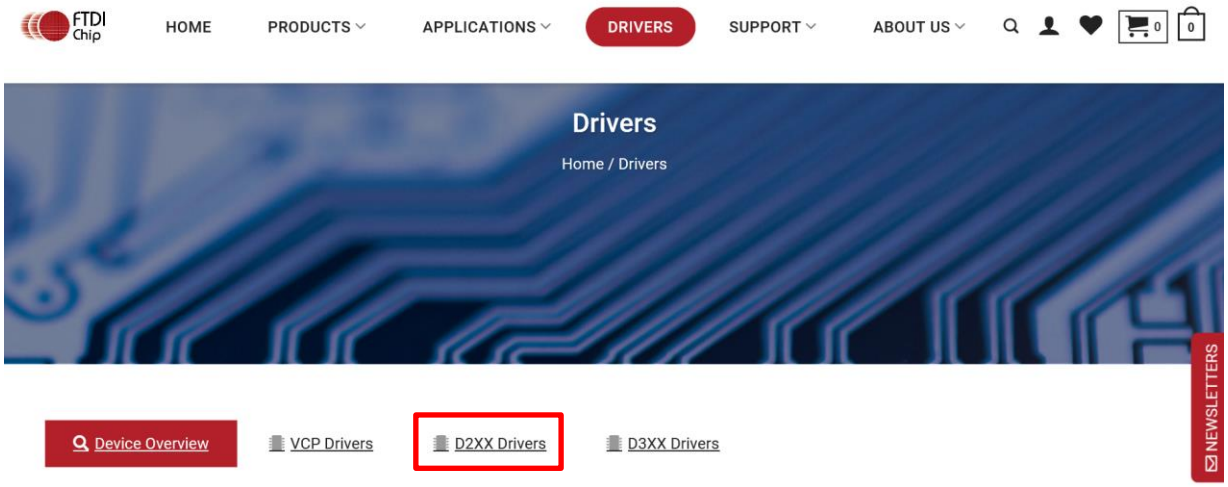
- **GUI Executable File**
  The GUI for setting parameters is available.
  From the URL below, download the **SX682xxM_Serial_Interface_V3p6.exe** file.
  URL: https://www.semicon.sanken-ele.co.jp/en/support/documentsfordesign/hvmdtools/sx68200m.html#tool

- **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® 64-bit operating systems.

1) Go to the FTDI's website.
   URL: https://ftdichip.com/
2) Click **DRIVERS**.



3) Click **D2XX Drivers**.



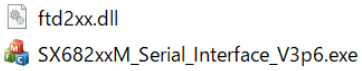
4) Click **2.12.28**.

Currently Supported D2XX Drivers:

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

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

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.



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.

1) 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.

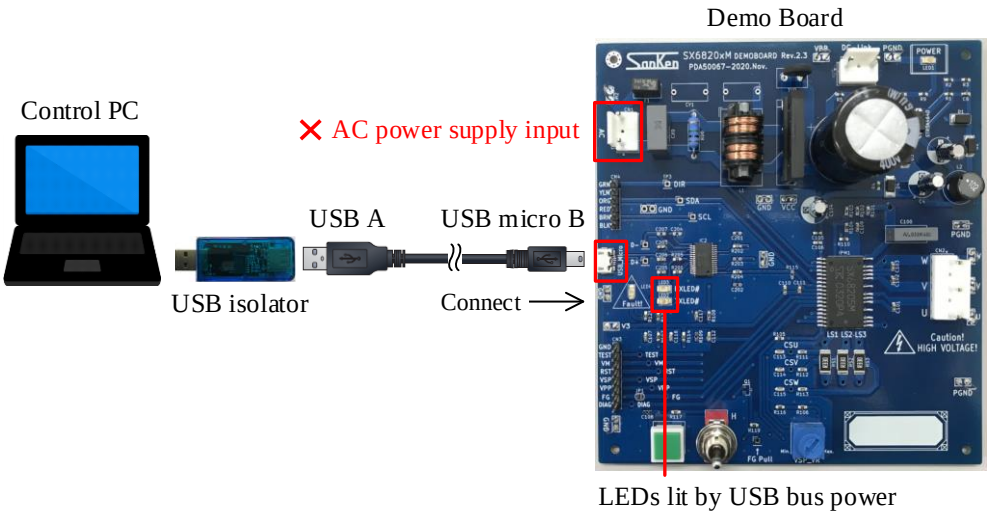
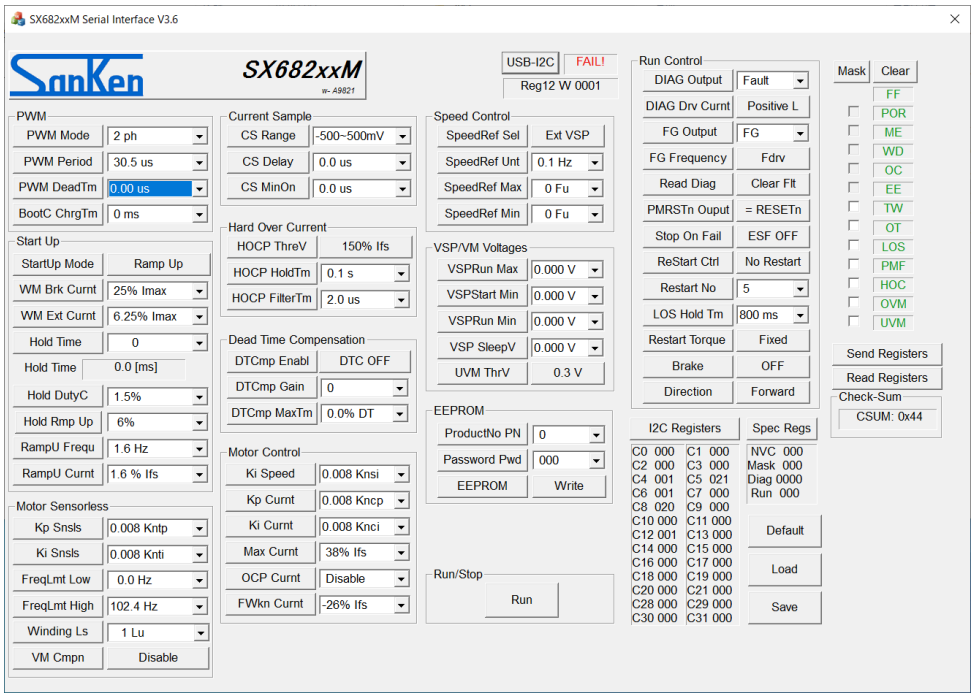
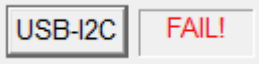
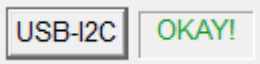


Figure 2-3. Connection by USB Cable

3) 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 Disabled	Communications Enabled
	

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

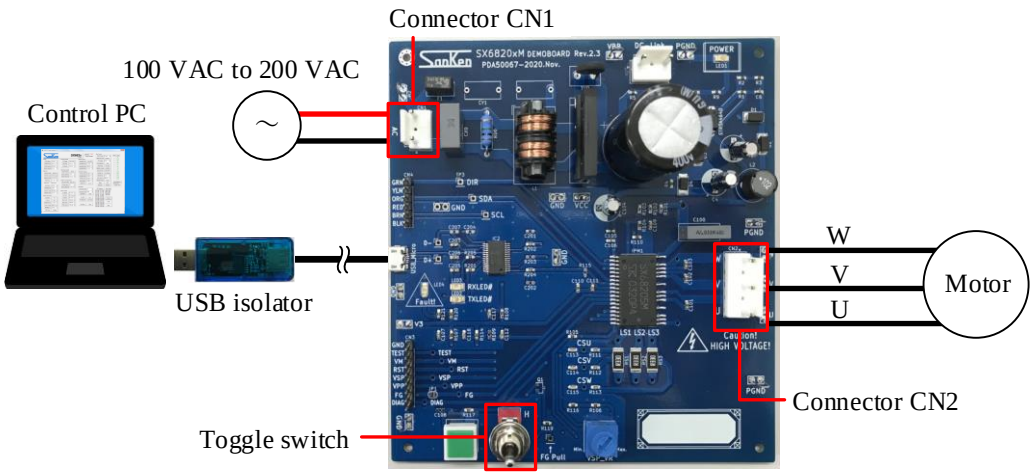
- The FT232 driver, an essential interface between the control PC and the IC, have not been downloaded.
- The .dll file and the **SX682xxM_Serial_Interface_V3p6.exe** file are not placed in the same hierarchy.

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.

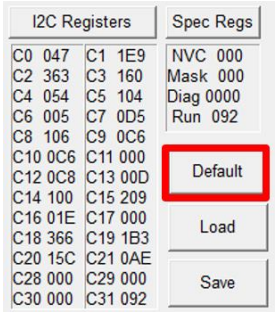
2.4. Setting Up the Motor

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

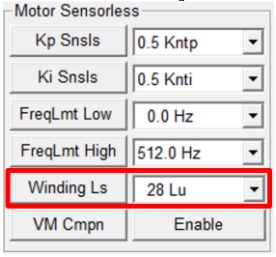
1) Connect the motor to the connector CN2.
2) Connect the AC power supply to the connector CN1.
3) Flip the toggle switch to “L” (i.e., push the switch lever toward the demo board edge).



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.
   To measure the DIAG waveform, connect the voltage probe to the DIAG pin of the connector CN3.
5) To initialize the GUI, click the **Default** button.

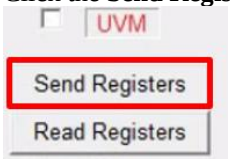


6) In the **Motor Sensorless** group box, select a value from the **Winding Ls** list.
   Select the value you obtained by the calculations in Section 2.1.



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.

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.
10) 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 start 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. 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.

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