Development Board EPC9147C Quick Start Guide

Motor Drive Controller Interface Board – STMicroelectronics STM32 Nucleo

Revision 2.2



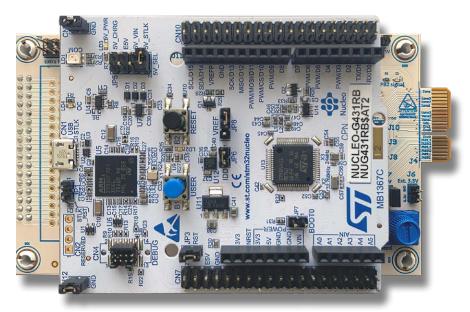
QUICK START GUIDE

EPC9147C Motor Drive Controller Interface Board

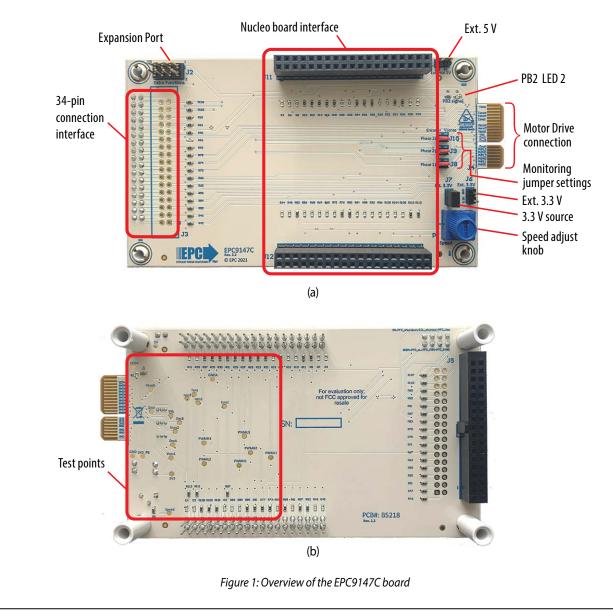
DESCRIPTION

The EPC9147C board is an interface board that accepts the STMicroelectronics STM32 NUCLEO-G431RB motor drive development board, that is fitted with the STM32G431RBT6 ARM Digital Controller, and interfaces to a 3-phase eGaN® FET/IC motor drive inverter board. This interface board allows users to utilize the existing STMicroelectronics Integrated Development Environment resources to program the controller board that controls a motor powered by an eGaN FET/IC 3-phase inverter using sensor-less field oriented control with space vector pulse width modulation.

Figure 1 shows an overview of the EPC9147C board detailing connections and various human interfaces that measures 120 mm x 71 mm (L x W).



EPC9147C development board



The EPC9147C includes a standard STMicroelectronics STM32 NUCLEO-G431RB motor drive development board compatible connector (J11 & J12) that interfaces the PWM, analog feedback signal, errors states and 3.3 V power to the motor drive inverter board as shown in figure 2.

Communications



Figure 2: Application overview of the EPC9147C control interface board

HUMAN INTERFACE CONTROLS AND INDICATORS

The EPC9147C has a human interface controls and indicators as shown in figure 1.

To operate the motor the following controls are available:

- Black button on ST Nucleo board press this button once after the power supply is set to prepare for motor run.
- Blue button on ST Nucleo board press this button once to start the motor and press it again to stop the motor.
- Speed potentiometer on EPC9147C This knob can be used to change the motor speed. By default, the potentiometer is not interfaced in original ST firmware, so it is up to the customer to modify the ST firmware to interface the potentiometer to use it as target speed setting analog interface.

There are LED indicators that provide information on the status of the controller:

On Nucleo board:

- Power LED (green) The Nucleo board has power. Power is provided by the motor drive inverter, through the EPC9147C board.
- Status LED (red) when it is flashing, the Nucleo board is ready for operation. After power up, press the black button at least once. The blue button is
 used for starting and stopping the motor.

On EPC9147C board

• PB2 signal status (red). This LED is not used by the official ST firmware. The user may re-program and customize the Nucleo board firmware and provide driving for this LED.

Warning: The human interface controls and knob, as well as the entire EPC9147C, and the ST Nucleo board are not isolated. The EPC9147C is referenced to Power Ground and extreme caution must be observed when operating the board at high voltage.

QUICK START GUIDE

Test Points

Several test-points are available for measurement of various analog, error and PWM signals. Analog signals include voltage and current readings, input DC voltage to the drive, and current sense amplifier voltage reference. The operator is encouraged to read the motor drive inverter drive QSG carefully to determine the correct scaling factors. The locations of the test points are shown in figure 1(b).

Monitoring Jumper Settings

The EPC9147C is provided with a set of jumpers that can be used to change the monitoring connections. Table 1 provides a detailed list of the settings mapping and figure 3 shows this graphically.

Table 1: Monitoring jumper settings mapping

Jumper	Phase	Position 1-2 (default)	Position 2-3
J8	1	Shaft Encoder A	Motor Phase Voltage 1
J9	2	Shaft Encoder B	Motor Phase Voltage 2
J10	3	Shaft Encoder Index	Motor Phase Voltage 3

Any combination of valid position settings may be selected.

Internal/External 3.3 V Power Jumper Setting

The EPC9147C is provided with a jumper (J7) that, when it is mounted (by default), allows the 3.3 V power supply to be fed by the Power Board. If Jumper J7 is not mounted, the EPC9147C 3.3 V (and the ST Nucleo 3.3V) power must be supplied by an external 3.3 V power supply connected to the connector J6.

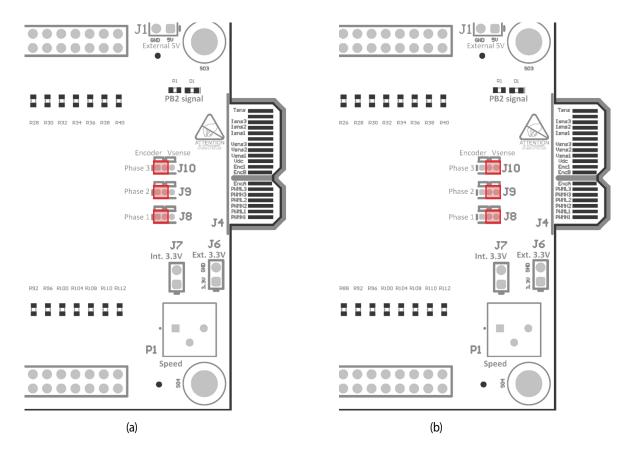


Figure 3: Monitoring jumper settings (a) shaft encoder (default), (b) phases voltage

Compatible Motor Drive Inverters

A list of motor drive inverter power boards compatible to the EPC9147C is given in table 2.

Table 2: Compatible eGaN FET/IC motor driver inverters to the EPC9147C

Motor Drive Inverter Board Number	Basic Specifications	Web Link
EPC9146 Rev. 2.1	400 W, 3-phase BLDC Inverter using EPC2152	EPC9146 – 400 W Motor drive demo board
EPC9145 Rev. 1.1	1000 W, 3-phase BLDC Inverter using EPC2206	EPC9145 – 1000 W Motor drive demo board

EPC9147C Electrical Specifications

Table 3: Electrical Specifications ($T_{A} = 25^{\circ}C$) EPC9147C

Symbol	Parameter	Conditions	Min	Nominal	Мах	Units
V _{3.3EXT}	External 3.3 V Operating voltage	J7 is not mounted	3.1	3.3	3.5	V
V _{5VEXT}	External 5 V straight to ST board connector		4.9	5.0	5.1	V

CONNECTION DETAILS

Inverter

A 40 pin connector is used to interface power, PWM signals and analog feedback signals between the interface board and the motor drive inverter. Table 4 gives the map (J2) for each signal

Table 4: Motor interface connection (J2) pin allocation map

Pin N PWMH1 PWML1	ame GND GND	Pin # 1
PWML1		1
	GND	
		3
PWMH2	GND	5
PWML2	GND	7
PWMH3	3V3	9
PWML3	3V3	11
EncA	3V3	13
Inde	x	
EncB	GND	17
Encl	GND	19
Vin	GND	21
V1	GND	23
V2	GND	25
V3	GND	27
lin	GND	29
11	GND	31
12	GND	33
13	GND	35
EN/Pgood	LEDerr	37
Tsns	LEDact	39
	PWML2 PWMH3 PWML3 EncA EncB Encl CVin V1 V1 V2 V3 V3 Iin 11 12 I3 EN/Pgood	PWML2GNDPWMH33V3PWML33V3EncA3V3EncA3V3EncBGNDEncIGNDVinGNDV1GNDV2GNDV3GND11GND12GND13GNDEN/PgoodLEDerr

PROGRAMMING

The ST Nucleo board that is connected to the EPC9147C board provides a full programmer and debugger onboard. The user can program the ST Nucleo board by using a USB cable connected to connector CN1 to the ST Nucleo board and by using official ST integrated development environment.

More details on the ST environment can be found at this page: https://www.st.com/ content/st_com/en/ecosystems/stm32-motorcontrol-ecosystem.html

The flow, as described by ST, can be depicted in Figure 4.

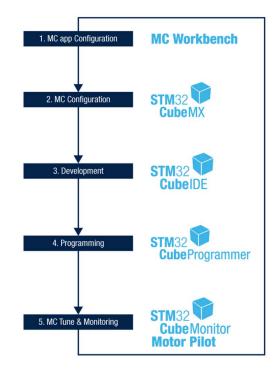


Figure 4 - ST motor control development programs

PROGRAMMING WITH .elf FILE

The ST Nucleo board comes with an onboard programmer debugger. Connect the CN1 connector to a USB port of your computer and use the STM32 CubeProgrammer software. The CN1 connector requires a Micro B USB male cable. The STM32CubeProgrammer software can be downloaded from ST's' website, after registration, at this link: https://www.st.com/en/development-tools/stm32cubeprog.html

Verify that the jumpers CN11 and CN12 in ST Nucleo board are mounted and that the selector on the 5V_SEL is set on 5V_STLK position. Start the STM32CubeProgrammer, click on **Connect** button by making sure that the ST-LINK option is chosen.

Pro STM	32CubeProgrammer		- 🗆 X
STM32 Cube	Programmer (19)	F 🕒 🕚	* * 57
	Memory & File edition		Not connected
	Device memory Open file +	ST-LINK	Connect
.	Address 🔹 Size Data width 32-bit 👻 Find Data Ox Read 👻	Serial number	No ST-L 🔻 💋
OB		Port Frequency (kHz)	swd 🔹
-			· · · · · ·

Figure 5: STM32CubeProgrammer

Once connected, click on the **Open File tab** and choose the proper .elf file to be programmed on the board. The original demo .elf file can be downloaded from EPC website on the EPC9147C web page.

STM32CubeProgrammer								- 🗆 ×
STM32 CubeProgrammer						(19)	F 🕒	y 🛧 🖅
Memory & Fi	le edition							Connected
Device memory	Open file +						ST-LINK	Disconnect
Address 0x08	000000 - Size	0x400	Data width	32-bit 💌	Find Data 0x	Read 💌	ST-L Serial number	INK configuration
Address	0	4	8	с	ASC	1	Port	SWD
OB 0×08000000	20008000	08000511	08000561	08002860)am(Constant of the local division of the local
0x08000010	08000561	08000561	08000561	00000000	aaa		Frequency (kHz	24000 👻
CPU 0x08000020	00000000	00000000	00000000	08000561	a		Mode	

Figure 6: Open file tab

Click on the **filename tab** to bring it in front, so that it is fully visible. *Right-click* on the **filename tab** and choose the **Download** option. This will program the ST Nucleo flash memory. Once programming is done, it is possible to verify the Flash memory content if needed.

pe Program		1100.000								fi 🖸 🖇	
Memo	ory & File	edition	<u>k</u>								Connecter
Device	e memory			mmyNema34_5	0k_100n.	Save As	Ctrl+S		_	ST-LINK	Disconne
Addres	s 0x8000	• 000	Size	0x9258	Data		Ctrl+V	x Download	1 *	ST-LIN Serial number	K configuration
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0×08	000030	08000	561	00000000	0800	Address 0x8000000		aŮ(Access port	Contractor -
0x080	000040	08000	561	08000561	0800	Close tab		aa			0
0x080	000050	08000	561	08000561	0800	Close other tabs		aa		Reset mode	Software reset
0x080	000060	08000	561	08000561	0800	Option bytes	Ctrl+B	aa		Shared	Desibled 1
0x080	000070	08000	561	08000561	0800	Fill memory	Ctrl+M	aa		Debug in Low Pow	Contraction of the local division of the loc
0x080	080000	08000	561	00000000	080	Blank check		'a		External loader	
0x080	000090	08000	561	08000561	0800		Ctrl+L	aa		Target voltage Firmware version	3.28 V V3J8M3
0×08	0A0000	08002	7C9	080027B1	0800	Compare memory with fil	e Ctrl+T	aa			
0x080	000080	08000	561	08000561	0800	Compare two files	Ctrl+F		×		

Figure 7: Open .elf file and download it to the flash memory

EXTRA FUNCTION PORT

The EPC9147C is provided with an extra function port (J2) that can be used to expand functionality to the board. Table 6 provides the pin allocation map for the expansion port. The usage of the expansion port depends on official ST firmware. In the demo provided by EPC, these functions are not used.

Table 6: Extra Function port (J2) pin allocation map

Pin #	Connector
1	5 V
2	GND
3	PFC shutdown
4	PFC iL
5	ICL shutout
6	PFC PWM
7	PFC Vac
8	PFC Synce

QUICK START PROCEDURE

Please check EPC's EPC9147C product page for updates on compatible eGaN FET/IC inverters with reference settings for specific motors:

https://epc-co.com/epc/Products/DemoBoards/EPC9147c.aspx

The demo program is set to drive a specific motor: Teknic M-3411P-LN-08D. If a different motor needs to be used, please follow these steps:

- 1. Verify that the ST Nucleo G431RB is properly mounted on the EPC9147C as shown in Figure 2.
- Verify that on ST Nucleo board, CN11, CN12, JP6, and JP3 jumpers are mounted. JP8 <u>must</u> be in position 2-3, 5V_SEL <u>must</u> be in 5V_STLK position, and JP1 and JP7 are not mounted.
- 3. Connect the motor Teknic M-3411P-LN-08D to the power board. Only the three phase wires of the motor are needed, because the firmware is sensor-less.
- 4. Connect 48 V 3.0 A power supply to the power board connected to the EPC9147C.
- 5. Power up the 48 V power supply.
- 6. Press the **black** button once.
- 7. Press the **blue** button once. Motor start spinning at a fixed speed.
- 8. Press the **blue** button once again. Motor Stops.

Warning: The human interface controls and knob, as well as the entire EPC9147C, and the ST Nucleo board are not isolated. The EPC9147C is referenced to Power Ground and extreme caution must be observed when operating the board at high voltage.

MOTOR COMMISSIONING PROCEDURE

To commission a new motor, the user *must* install the entire development suite from ST website after registration.

Download and install the following programs:

ST Motor Control Workbench:

https://www.st.com/content/st_com/en/products/embeddedsoftware/mcu-mpu-embedded-software/stm32-embedded-software/ stm32cube-expansion-packages/x-cube-mcsdk.html

STM32CubeMX

https://www.st.com/en/development-tools/stm32cubemx.html

STM32CubeIDE

https://www.st.com/en/development-tools/stm32cubeide.html

For your reference, the page about the ST Nucleo G431RB is at this link:

https://www.st.com/en/evaluation-tools/nucleo-g431rb.html#tools-software

Once the software is properly installed, the user <u>must</u> follow this procedure:

- 1. Use the Motor Control Workbench with specific EPC project relevant to the specific EPC power board being used
- 2. Modify the motor parameters to adapt the system to the desired motor
- 3. Generate the code
- 4. Use STM32CubeIDE to compile, link, and flash the generated .elf file to the ST Nucleo board

ST MOTOR CONTROL WORKBENCH

Download from EPC power board web page the proper .zip archive that contains the ST Motor Control Workbench project. Unzip the archive by placing the .stmcx file and the contained directory in a folder in your computer. E.g., for EPC9145 power board, the project file name is G431-EPC9145-DummyNema34_50k_100n.zip, and it contains a file G431-EPC9145-DummyNema34_50k_100n.stmcx and a directory named G431-EPC9145-DummyNema34_50k_100n.Save these in a specific location folder in your computer, then start the ST Motor Control Workbench program. Click on Load Project button (Figure 8) and choose the G431-EPC9145-DummyNema34_50k_100n.stmcx file. The architecture will be then shown in the program as in Figure 9.



Figure 8: ST Motor Control Workbench Load Project button

Double click on the **motor symbol**.

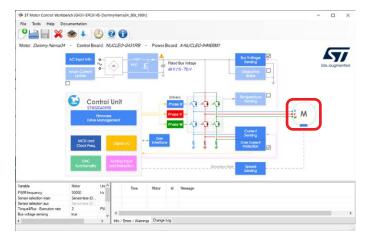


Figure 9: ST Motor Control Workbench

On the Motor tab, fill in the Electrical parameters and click the Done button:

Magnetic structure	Surface Mounted PMSM $$				
lectrical parameters					
Pole Pairs	4	-			
Max. Application Speed	3000	-	rpm		
Nominal Current	6.00	-	Apk		
Nominal DC Voltage	48.0	-	v		
Rs	0.40	-	Ohm		
Ls	0.466	\$	mH		
B-Emf constant	10.2	-	Vms/krpm		

Next, click on the Generation arrow button:

ST Motor Control Workbench [G431-EPC9145-DummyNema34_50k_100n]

		Documentation		
9	🖹 🗐 🖇	🖌 🌧 🚺 🕘 🕘 🚺		
Motor	r. Dummy Nem	na34 - Control Board: NUCLEO-G431R	в -	Power Board:

Figure 11: ST Motor Control Workbench Generate Code button

Project generation dialog box will appear. Verify it matches Figure 12's settings and then click Generate.

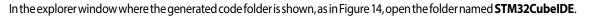
Project generation			13	_ 🗆 ×
SETTINGS	🛃 GENERATIC	DN		
STM32CubeMX				
6.2.0 💌				
Target Toolchain ST STM32CubeIDE				
Firmware Package Version STM32 FW V1.3.0 (Recommended)				
'Latest' will require internet connection				
Orive Type HAL - Hardware Abstraction Layer				
O LL - Low Level				
	UPDATE		GEN	IERATE

Figure 12: STM32CubeMX Code Generation dialog box

Once the Generation is complete, click **Open Folder** button and then click the **Close** button.

Project generation		11	_ 0 ×
STM32CubeMX 6.2.0	\Inc\mc_mathrm \Src\mc_interface.c \Inc\mc_interface.h \Inc\parameters_conversion_f4xx.h \Inc\parameters_conversion_g4xx.h \Inc\parameters.h		
Target Toolchain ST STM32CubeIDE	\Inc\power_stage_parameters.h \Src\stm32g4xx_mc_it.c \Inc\mc_parameters.h \Src\mc_parameters.c \Src\ui task.c		
Firmware Package Version STM32 FW V1.3.0 (Recommended)	\Inc\ui_task.h \Src\user_interface.c \Inc\user_interface.h \Src\dac_ui.c \Src\dac_ui.c		
Selecting `not installed` firmware or `Latest` will require internet connection	\Inc\stm32q4xx_it.h \Src\stm32q4xx_hal_msp.c \Inc\stm32q4xx_hal_conf.h \Inc\main.h		
Drive Type HAL - Hardware Abstraction Layer LL - Low Level 	Completed OPEN FOLDER RUN STM32Ct	ubeMX	LOSE

Figure 13: STM32CubeMX Code successfully generated



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Pictures	^	Name		C	Date modified	Туре	Size
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PowerAppsExar	nple	Inc		2	1-Oct-21 11:05 AM	File fold	der
📜 ti		MCSDK_V	/5.4.5	C	1-Oct-21 6:21 PM	File fold	der
This PC		Src Src		2	1-Oct-21 11:05 AM	File fold	der
3D Objects		📕 STM32Cu	beIDE	C	1-Oct-21 6:25 PM	File fold	der
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Desktop		.mxprojed	ct	2	1-Oct-21 11:05 AM	MXPRO	JECT File 21 KB
Documents		MX G431-EPC	29145-DummyNe	ema34_50k_100 2	1-Oct-21 11:05 AM	STM320	CubeMX 50 KB
Downloads		G431-EPC	29145-DummyNe	ema34_50k_100 0	11-Oct-21 6:21 PM	BAK File	e 50 KB
b Music			09145-DummyNe	ema34_50k_100 2	1-Oct-21 11:04 AM	WB File	87 KB
Pictures		G431-EPC	C9145-DummyNe	ema34_50k_100 2	1-Oct-21 11:07 AM	Text Do	ocument 131 KB
Videos			29145-DummyNe		1-Oct-21 11:04 AM	SETTING	
Windows-SSD ((C:)	G431-EPC	C9145-DummyNe	ema34_50k_100 2	1-Oct-21 11:03 AM	WB_DE	F File 27 KB

Figure 14: Generated code folder

Inside the STM32CubeIDE folder, double click the **.project** file.

File Home Share View					^
in to Quick Copy access Copy Paste	Move Copy to to t	New item •	Properties	Select all Select none Invert selection	
Clipboard	Organize	New	Open	Select	
← → ✓ ↑ 📜 « G43 > STM32	🗸 ひ 🔎 Sear	ch STM32CubeIDE			
Pictures	Name	Date	modified	уре	Size
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PowerAppsExample	Application			ile folder	
📕 ti	Debug	01-00	t-21 6:25 PM	File folder	
🗢 This PC	Drivers	01-Oc		File folder	
3D Objects	Middlewares	01-Oc		ile folder	
Desktop	.cproject	21-Oc	t-21 11:05 AM	PROJECT File	27 KB
	.project	01-Oc	t-21 6:21 PM	PROJECT File	14 KB
Documents	STM32G431RBTX_FLASH.	ld 21-00	t-21 11:05 AM	D File	5 KB
Downloads					
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Figure 15: STM32CubeIDE project directory

QUICK START GUIDE

If this is the first time that the STM32CubeIDE project file is opened, an **Operation completed** dialog box will appear once the installation is completed. Click **OK**. Note: If the project was already imported the following dialog will not appear and the program will open.

IDE Oper	ation completed	×
1	Successfully imported the project 'G431-EPC9145-DummyNema34_50k_100n' into the workspace.	
	ОК	

Figure 16: Import the .project in the STM32CubeIDE Workspace

Connect the USB cable to the ST Nucleo board on the EPC9147C.

Highlight the project (1) in the STM32CubeIDE program and click the **Debug (2)** button as in Figure 17. The entire Compilation, link and flash of the project in the STM32 flash will start (a dialog box may appear, in that case click OK). When the process is finished, the Compiler will enter in Debug mode. Click the **Terminate** button as in Figure 18 and disconnect the USB cable. The STM32CubeIDE program can be closed.

The ST Nucleo Board in the EPC9147C is now ready to run the motor and you can follow the steps described in the quick start procedure paragraph.

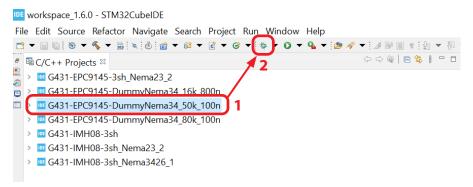


Figure 17: Compile, Build and Flash

workspace_1.6.0 - G431-EPC9145-DummyNema34_50k_100n/Application/User/main.c - STM32CubeIDE

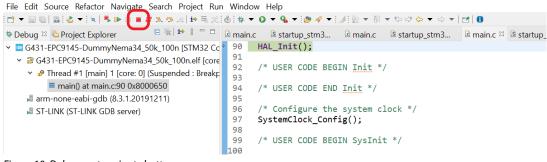


Figure 18: Debugger terminate button

ST Motor Control Workbench – Advanced Use

When the ST Nucleo board is properly programmed and connected via the EPC9147C to the proper power board, it is also possible to use the ST Motor Control Workbench GUI to change the speed and the direction of the motor.

Open the **ST Motor Control Workbench** and load the proper **.stmcx** file that is relevant to the project you are working at (e.g. G431-EPC9145-DummyNema34_50k_100n.stmcx).

Click on the **Open Monitor** button.

ST Motor Control Workbench [G431-EPC9145-DummyNema34_50k_100n]



Figure 19: ST Motor Control Workbench Open Monitor button

Connect the USB cable to the PC and power up the 48 V to the power board.

Click on the **Connect** button.

-	kbench [G431-EPC9145-Dumr Documentation	iyixemas4_sok_toonj			
	s 🏟 👫 🙆 🤇	Port COM5	• 115200		Close Monitor
Status	Basic Advanced Register	s Configuration	Device r	not connected	

Wait for the successful connection message (Figure 21).

💠 ST Motor Control Work	bench [G431-EPC9145-DummyNema34_50k_100n]	
File Tools Help D	ocumentation	
🦻 🔒 🗶	🐟 🖡 🙆 🕑 🕦 Port COM5	◆ 115200 → 🐼 🌲 🚺 🌆 Clos Monitor 🥙
Status	Basic Advanced Registers Configuration	Firmware: ST MC SDK Ver. 5.4.5
Figure 21: Device succ	essfully connected message	

Click Fault Ack (1) button if any fault was detected. Then click Start Motor (2). Motor should spin. It is now possible to move the graphic potentiometer on the GUI to change the speed of the motor and to change the motor direction. Refer to ST user guide manual for more details on how to work with the ST Motor Control Workbench for further customization.



Figure 22: GUI with speed potentiometer. Note the yellow LED "Fault over" (3). Fault Ack (1) must be clicked before starting the motor.

Table 5: Bill of Materials

ltem	Qty	Reference	Part Description	Manufacturer	Part #			
1	1	C1	CAP CER 0.1 μF 16 V X7R 0603		0603YC104KAT2A			
2	3	C2, C3, C4	CAP CER 0.1 μF 16 V X7R 0603	AVX	0603YC104KAT2A			
3	1	D1	LED RED CLEAR CHIP SMD	Lite-On	LTST-C193KRKT-5A			
4	3	J1, J6, J7		TE	4-103185-0-02			
5	1	J2		TE	87227-4			
6	1	J3		Sullins	SBH11-PBPC-D17-ST-BK			
7	1	J5		Sullins	SFH11-PBPC-D17-ST-BK			
8	2	J11, J12	Header Male&Female 100 mil 2 row, 19 pos. thru Vert. Polarized	Samtec	ESQ-119-24-T-D			
9	1	P1	TRIMMER 1 k Ω 0.5 W Horz TOP	Vishay	M63P103KB30T607			
10	1	R1	RES SMD 1 K Ω 0.1% 1/10W 0603	Yageo	RT0603BRD071KL			
11	38	R2, R3, R4, R6, R7, R8, R13, R15, R19, R20, R22, R30, R32, R38, R39, R40, R41, R44, R45, R48, R49, R56, R60, R61, R64, R68, R69, R72, R84, R86, R88, R89, R92, R93, R96, R100, R104, R108	RES 20 K Ω 0.1% 1/10 W 0603, RES SMD 0 Ω JUMPER 1/10 W 0603	Stackpole, Panasonic	RNCF0603BTE20K0, ERJ-3GEY0R00V			
12	74	R5, R9, R10, R11, R12, R14, R16, R17, R18, R21, R23, R24, R25, R26, R27, R28, R29, R31, R33, R34, R35, R36, R37, R42, R43, R46, R47, R50, R51, R52, R53, R54, R55, R57, R58, R59, R62, R63, R65, R66, R67, R70, R71, R73, R74, R75, R76, R77, R78, R79, R80, R81, R82, R83, R85, R87, R90, R91, R94, R95, R97, R98, R99, R101, R102, R103, R105, R106, R107, R109, R110, R111, R112, R113	RES SMD 0 Ω JUMPER 1/10 W 0603	Panasonic	ERJ-3GEY0R00V			
13	4	SO1, SO2, SO3, SO4	8834 Nylon Standoff	Keystone	8834			

Table 6: Optional Components

ltem	Qty	Reference	Part Description	Manufacturer	Part #
1	3	J8, J9, J10	Jumper 2 pin 50 mil	Harwin	M50-203005

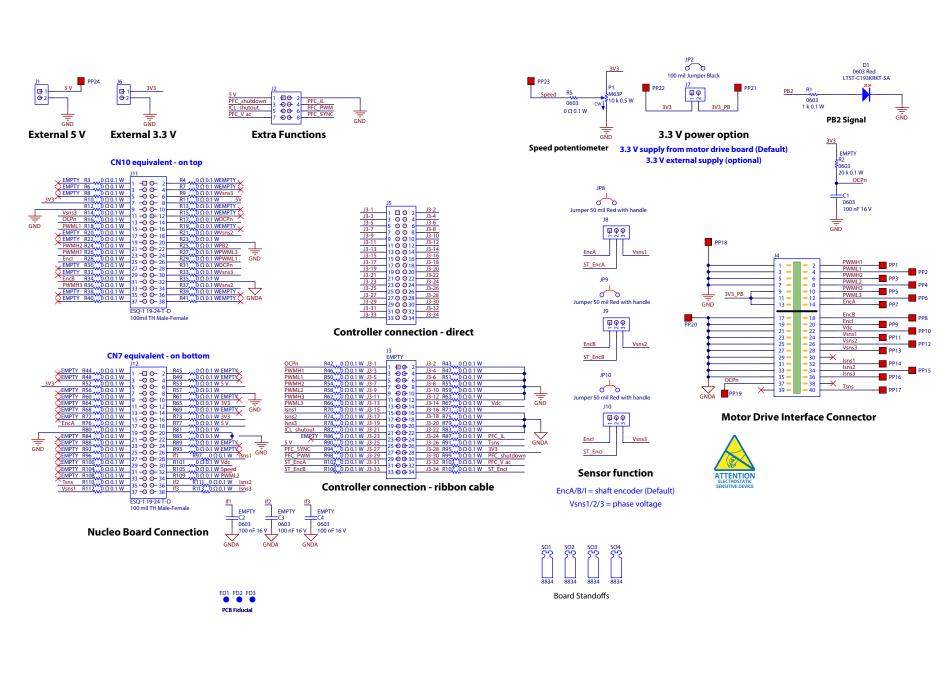


Figure 23: EPC9147C Main schematic

QUICK START GUIDE

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