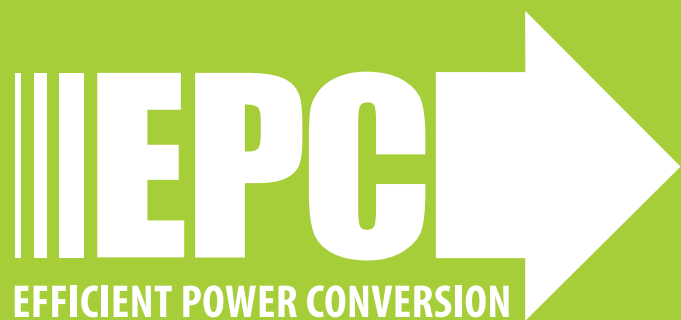


Evaluation Board EPC91122 Datasheet

*3-phase Inverter for Humanoid Robot Joints featuring
the EPC33110 3-phase ePower™ Stage Module*

May 19, 2026

Board EPC91122 Revision 1.1
Document Revision 1.0



DESCRIPTION

The EPC91122 evaluation board is a 3-phase BLDC motor drive inverter intended for humanoid robot joints motors. The board features EPC33110 which is a three-phase co-packaged module that integrates three monolithic gallium nitride (GaN) half-bridges, each featuring integrated gate drivers, bootstrap circuits, and level shifters. The EPC33110 has $11.7 + 13 \text{ m}\Omega R_{DS(on)}$ and 100 V absolute maximum input voltage.

The EPC91122 can deliver up to 21 Apk (15 A_{RMS}) steady-state output current and up to 28 Apk (20 A_{RMS}) pulsed output while inserted inside the motor chassis.

The EPC91122 is intended for driving humanoid robot joints and contains all the necessary critical function circuits to support a complete motor drive inverter, including a microcontroller, motor shaft angular sensor, housekeeping power supplies, accurate voltage and current sense, JTAG/SWD connector and RS485 interface. The various functional blocks are shown in Figure 1.

REGULATORY INFORMATION

This evaluation board is for evaluation purposes only. It is not a full-featured power converter and cannot be used in final products. No EMI test was conducted. It is not FCC approved.

KEY FEATURES OF THE EPC91122 EVALUATION BOARD

- 3-phase inverter based on EPC33110 three half-bridges co-packaged with wide input DC voltage ranging from 15 V to 65 V
- Housekeeping power supply
- Dimensions: 32 mm diameter inverter, 55 mm diameter external frame
- Phase current sense gain: 44 mV/A
- DC bus voltage sense gain: 44.89 mV/V
- Encoder default resolution: 1024 PPR (Pulses Per Revolution) with Z index
- RS485 communication interface

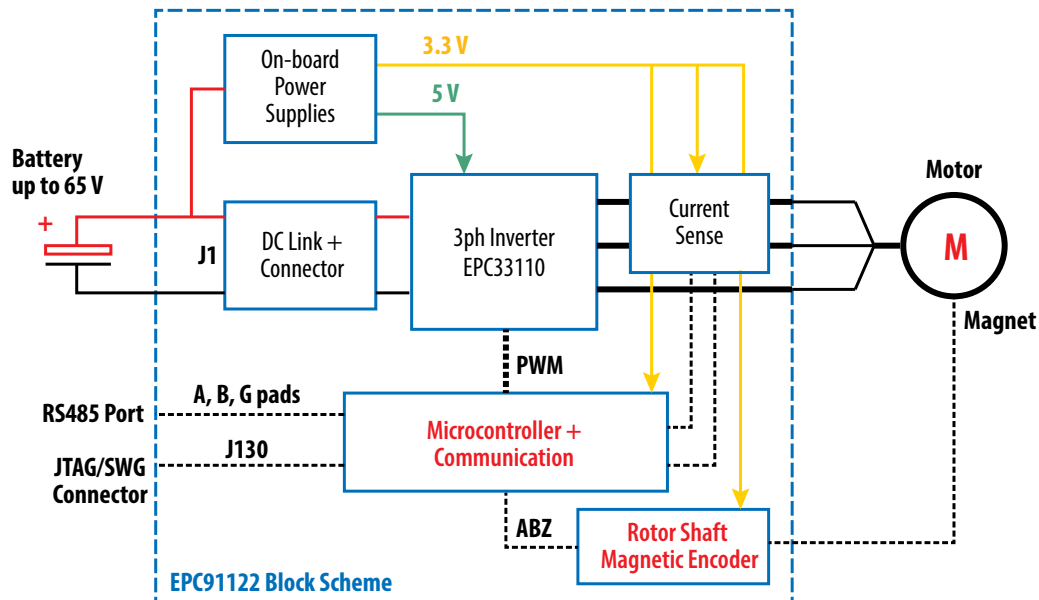
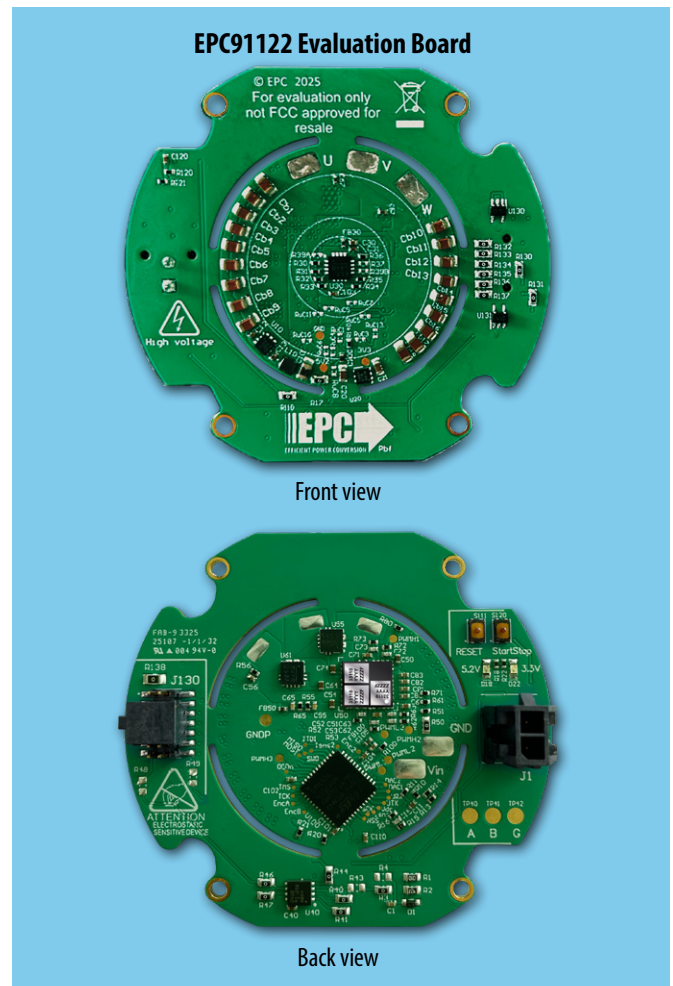


Figure 1: Block diagram overview of the EPC91122 evaluation board

FEATURED 3-Phase ePower™ Stage IC

The EPC91122 evaluation board features the EPC33110 3-Phase ePower™ Stage IC, which is a 100 V maximum voltage three-phase integrated power module shown in figure 2.

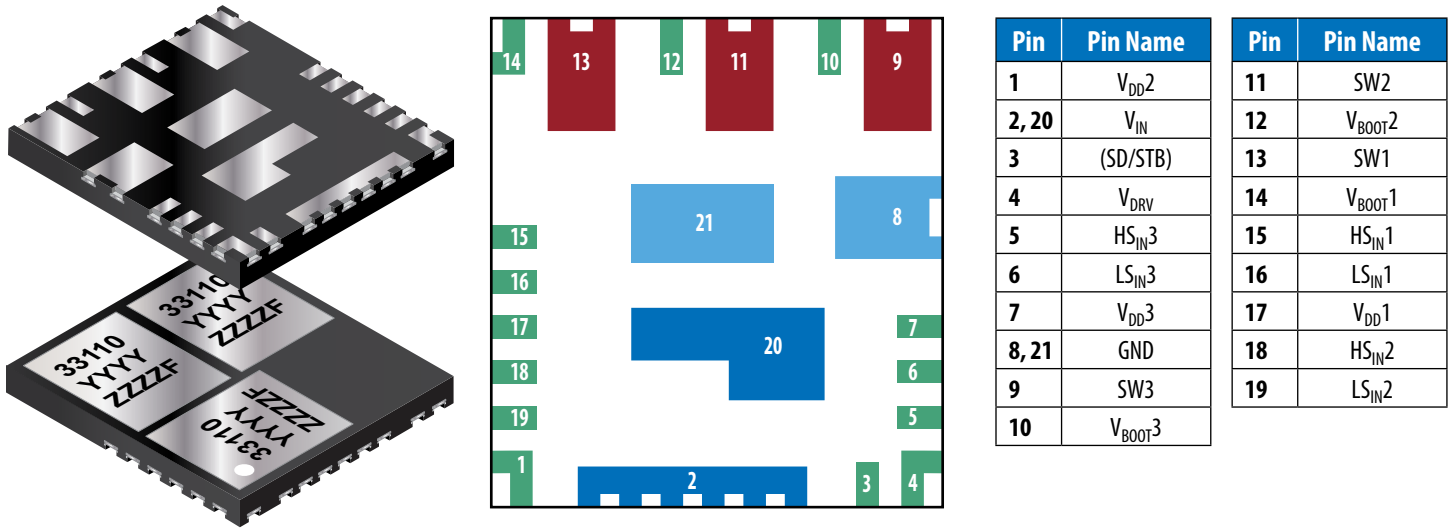


Figure 2: Pin assignments of the EPC33110

For additional details, refer to the [EPC33110 datasheet available at www.epc-co.com](http://www.epc-co.com). The datasheet should be read in conjunction with this quick start guide.

OVERVIEW OF THE EPC91122 EVALUATION BOARD

Figure 3 shows an image of both sides of the EPC91122 evaluation board with the location of the various functional blocks highlighted.

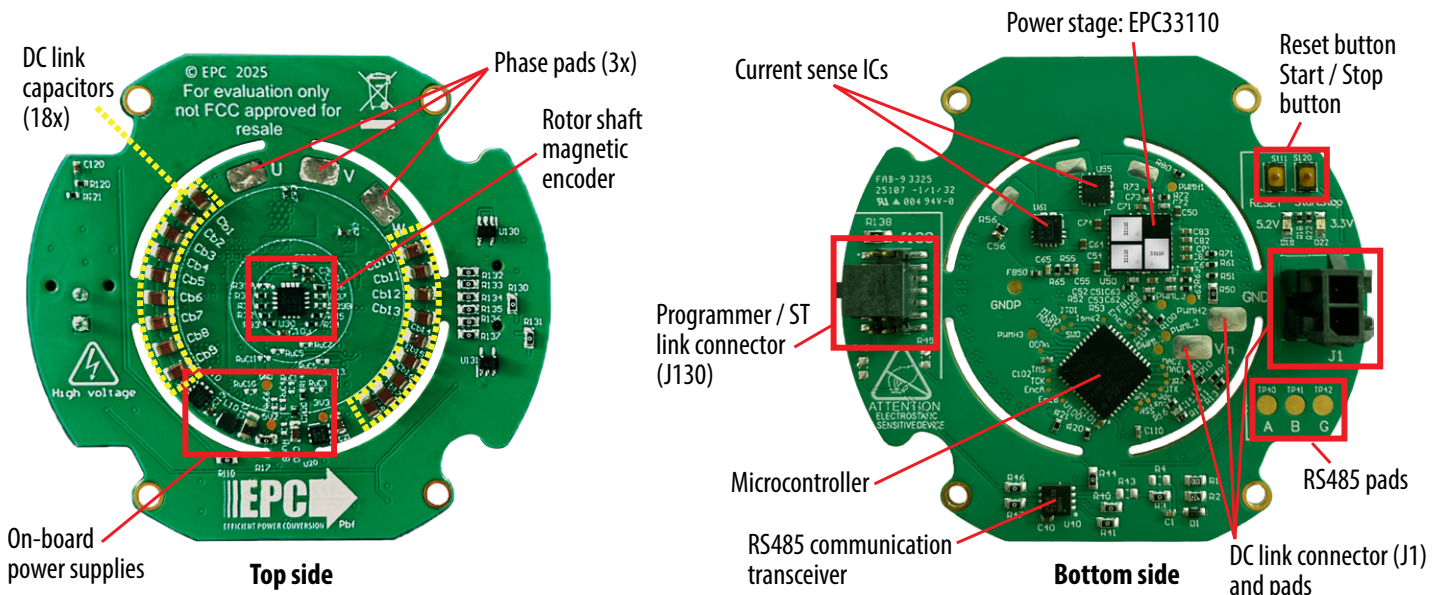


Figure 3: Top and bottom views of EPC91122

MECHANICAL OVERVIEW

Figure 4 shows the inverter located in a 32 mm diameter circle. The external frame is meant for mechanical reasons to install the board into a specific humanoid joint motor and to place the connectors J130 and J1 meant for debugging the firmware and to do lab tests.

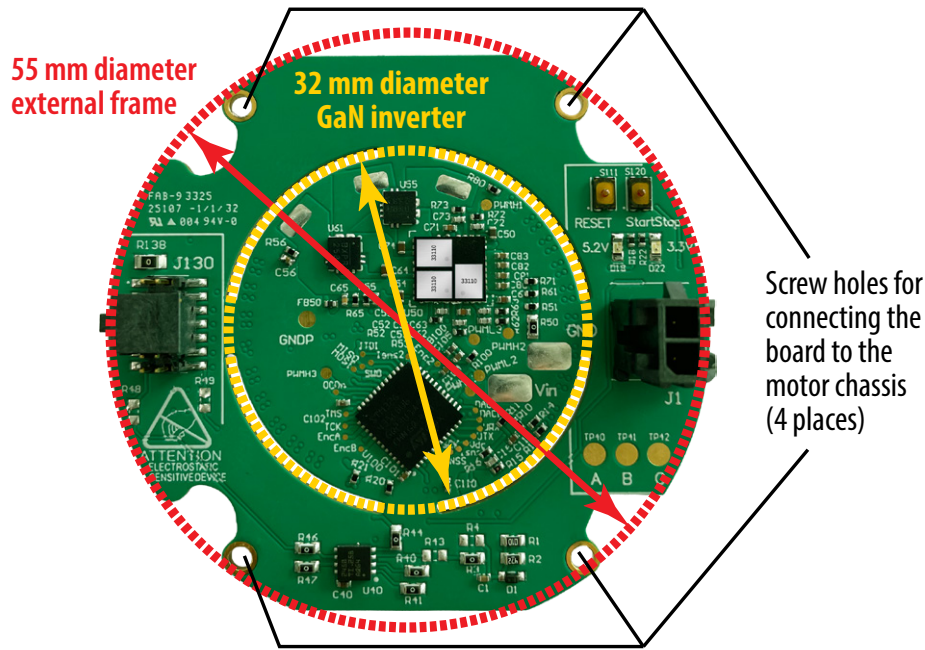


Figure 4: Mechanical details of EPC91122

The EPC91122 board was shaped a specific humanoid joint motor. The whole inverter is disposed in the 32 mm inner circle, while the external frame can be adjusted to fit in different motors. The design files are available on request from EPC website. Figure 5 shows the EPC91122 inverter board mounted inside the stator of the motor.

The EPC91122 is preprogrammed to operate the motor at 100 kHz, 50 ns, running at 50 rpm on the outer rotor, but different speed conditions can be set either by connecting to the real time GUI through the JTAG connector or by programming the microcontroller to communicate through the RS485 port.



Figure 5. Mechanical details of EPC91122

HIGHLIGHTED PARTS OF THE EPC91122 CIRCUIT

Power Stage

The EPC91122 features the 3-phase module EPC33110. For more information on the EPC33110 please refer to the [datasheet available from EPC at www.epc-co.com](https://www.epc-co.com). The datasheet of EPC33110 should be read in conjunction with this document.

Onboard Power Supply

The EPC91122 board includes house-keeping power supplies that are powered from the main input supply voltage to the inverter board. The 5 V supply is generated by a small DC-DC converter to supply the GaN FET ICs and LDO, which generates a 3.3 V that supplies the microcontroller, the current sensors, the magnetic encoder and RS485 interface chip.

A green LED is powered by the 5 V supply, while a yellow LED is powered by the 3.3 V supply.

Current and Voltage Sense

The EPC91122 inverter is equipped with current sense for phases U and V and voltage sense for the DC input.

The output current of phases U and V is measured using the current sense IC MCS1823-330BRN, that has a sensitivity of 44 mV/A. The two sensors also feature an overcurrent detection circuit that are pulled up and connected to the microcontroller in a wired-OR configuration.

The main input DC supply voltage and each phase voltage are measured using a resistor divider network that yields a total gain of 44.89 mV/V.

DC Link Capacitors

The entire DC link is made of MLCC capacitors and are dimensioned on the maximum RMS phase current that can be delivered by the board.

Rotor Shaft Magnetic Encoder

An encoder located in the center of the board detects the position of the magnet placed at the end of the rotor shaft. The encoder has a resolution of 1024 PRR (Pulses PER Revolution) and the Z index pin. The sensor can also communicate through the SPI port the absolute position of the rotor (currently not supported).

Microcontroller

The microcontroller provided on the board is the small 7x7 mm QFN STM32G431C8U6. For deeper information on its complete functions, please visit ST microelectronics website. (www.st.com).

SWD/JTAG Connector

The board doesn't include on-board programmer, for this reason an external programmer is needed available at these links:

- [STLINK-V3SET | Tool - STMicroelectronics](#)
- [STLINK-V3MINIE | Tool - STMicroelectronics](#)

The programmer can be connected to 14-pin connector on the board and can be programmed both SWD and JTAG (SWD default). A serial communication is included on the connector. Via the STLINKV3 which acts as a USB-UART bridge, this communication is used to interface with the Motor Pilot software.

RS485 Interface

The inverter is equipped with an RS485 port to meet the typical communication interface of humanoid robot motors. By default, JTAG communication is set, to use the RS485 interface is needed to remove resistors R131 and R137 and mount resistors R41 and R44.

RECOMMENDED OPERATING CONDITIONS

Electrical Specifications

Table 1: Electrical specifications

Symbol	Parameter	Conditions	Min	Nom	Max	Units
V_{IN}	Input supply voltage		10	24	65	V
V_{IN_uvlo}	Input under voltage lockout voltage			6		
I_s	Standby current		23	33	46	mA
I_{Phase}	EPC91122 RMS phase current ⁽¹⁾				20	A_{RMS}
f_{sw}	Switching frequency		50	100	150	kHz
V_{Isns_range}	Phase current sense voltage dynamic range	-Imax to Imax	0		3.3	V
I_{sns_range}	Phase current sense dynamic range	Current sense IC gain: 44 mV/A	-37.5		37.5	A
I_{ovc}	Positive over-current threshold	Over-current circuits detects both positive and negative OVC		30		
V_{Isns_offset}	Amplified current sense signal offset voltage			1.65		V
G_{Isns}	Amplified current sense gain	Current sense IC MCS1823GQTE-330BRN		44		mV/A
G_{Vsns}	Phase and DC voltage sense gain ⁽²⁾			44.89		mV/V
SD_{Pull}	SDn pin Internal pull-up resistance ⁽³⁾	Pulled-up to V_{DRV}		50		k Ω
OCD_{Pull}	Current sensor overcurrent signal ⁽⁴⁾ OCDn pull-up resistance	External pull-up resistance to 3.3 V		100		
ENC_res	Encoder default resolution			1024		PRR

⁽¹⁾ Maximum current depends on die temperature – actual maximum current is affected by switching frequency, bus voltage and thermal cooling. Refer to thermal performance section in this guide and to EPC33110 data sheet for details.

⁽²⁾ **Maximum dynamic voltage range is 0 V to 73.5 V which exceeds maximum recommended supply voltage for the EPC33110 eGaN IC and maximum input voltage of 5 V housekeeping power supply**

⁽³⁾ SD signal is Active Low

⁽⁴⁾ OCD signal is Active Low

Controller Pin Assignment

Table 2: EPC91122 controller pin map

Pin #	Function Name	Pin Name	Description	Type	Input/Output
1	3V3	VBAT	3V3	Power	Input
2	StartStop	PC13	Start and stop input	Digital	Input
3	NC	PC14	GPIO pin		
4	NC	PC15	GPIO pin		
5	SPI2_NSS	PF0-OSC_IN	SPI Chip Select	Digital	Output
6	SPI2_SCK	PF1-OSC_OUT	SPI Clock	Digital	Output
7	nRST	PG10-NRST	Reset button	Digital	Input
8	Isns1	PA0	Phase U Current sense signal	Analog	input
9	Vdc/RS485_DE*	PA1	Vdc sense/RS485 enable*	Analog/Digital	Input/Output
10	VCP/UART_TX	PA2	UART TX	Digital	Output
11	VCP/UART_RX	PA3	UART RX	Digital	Input
12	DAC_CH1	PA4	DAC Channel 1	Analog	Output
13	DAC_CH2	PA5	DAC Channel 2	Analog	Output
14	Vdc	PA6	Vdc sense signal	Analog	Input
15	PWML1	PA7	Phase U Low PWM signal	Digital	Output
16	NC	PC4	GPIO pin		
17	PWML2	PB0	Phase V Low PWM signal	Digital	Output
18	PWML3	PB1	Phase W Low PWM signal	Digital	Output
19	NC	PB2	GPIO pin		
20,21	3V3A	VREF+, VDDA	Input reference voltage for ADCs and DACs	Power	Input
22	Enc_z	PB10	Encoder Z signal	Digital	Input
23	3V3	VDD_1	VDD	Power	
24	Isn2	PB11	Phase V Current sense signal	Analog	Input
25	JTDI	PB12	SWD/JTAG Data Input	Digital	Input
26	SWO	PB13	Serial Wire Output	Digital	Input
27	SPI2_MISO	PB14	SPI Master Input Slave Output	Digital	Input
28	SPI2_MOSI	PB15	SPI Master Output Slave Input	Digital	Output
29	NC	PC6	GPIO pin		
30	PWMH1	PA8	Phase U High PWM signal	Digital	Output
31	PWMH2	PA9	Phase V High PWM signal	Digital	Output
32	PWMH3	PA10	Phase W High PWM signal	Digital	Output
33	OCDn	PA11	Overcurrent signal	Digital	Input
34	NC	PA12	GPIO pin		
35	3V3	VDD_2	VDD	Power	Input
36	SWDIO/TMS	PA13	Serial Wire Debug Input Output/JTAG TMS	Digital	Input/Output
37	SWCLK/TCK	PA14	SWD clock/JTAG clock	Digital	Output
38	Enc_A	PA15	Encoder A signal	Digital	Input
39,40	NC	PC10, PC11	GPIO pins		
41	Enc_B	PA15	Encoder B signal	Digital	Input
42-45	NC	PB4-PB7	GPIO pins		
46	Boot0	PB8-BOOT0	Boot Function		
47	NC	PB9	GPIO pins		
48	3V3	VDD_3	3V3	Power	Input
49	GNDP	EP	Ground	Power	

* If PA1 is connected to RS485 enable pin, the V_{DC} should be connected to PA6 pin

Connection Information

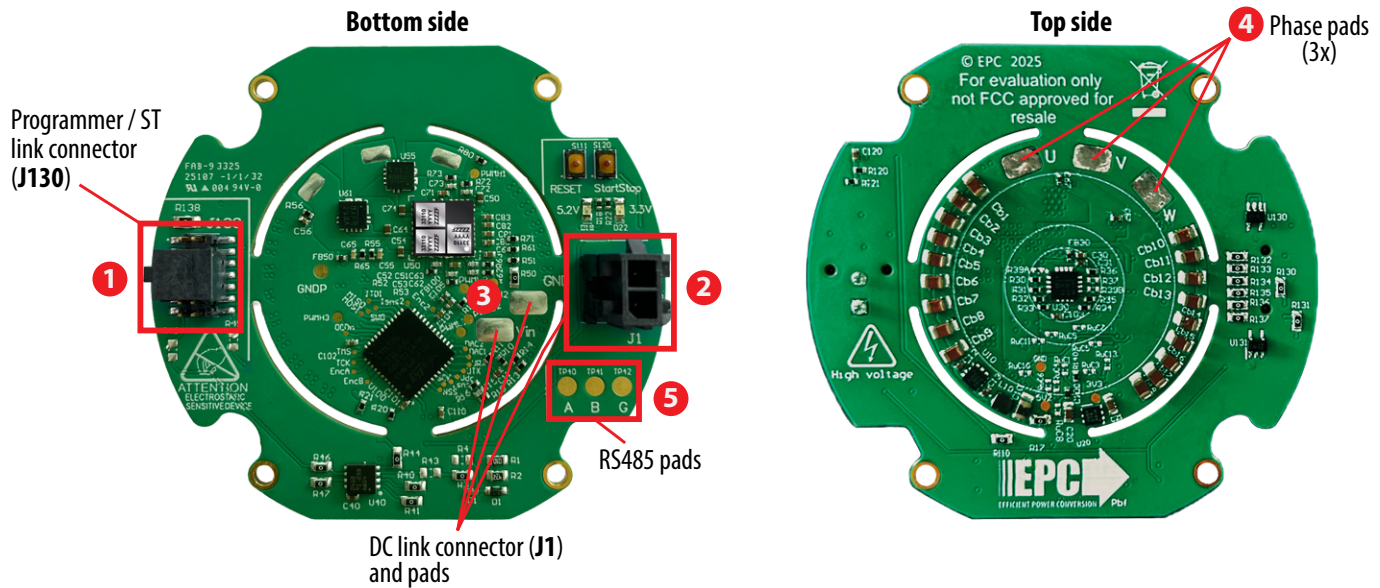


Figure 6: Connectors overview of EPC91122

1 JTAG/SWD connector

J130 is a 14-pin connector of SAMTEC (PN: FTSH-107-01-L-DV-K-A-P) to interface STLINK programmer to program the microcontroller.

2 DC input connector

The DC link connector J1 is a Molex 2 position header connector through hole (PN: 0430450228). This connector is polarized and can be interfaced with female Molex cable PN:2147561021.

3 DC input Pads

The DC link can be interfaced through V_{IN} and **GND** pads directly soldering the wires for the DC input.

4 Phase Pads

The phase connections are made of **U, V, W** pads on the board where can be soldered the connections for the motor windings.

5 RS485 Pads

The RS485 is interfaced through **A, B, G** pads. **To use RS485 communication interface remove R131 and R137 and mount R41 and R44**

PERFORMANCE

The EPC91122 motor drive inverter was tested in two different conditions. Firstly, a steady state analysis was performed to outline the thermal performance of the board at different RMS phase currents delivered. These tests were carried out using a 48 V_{DC} supply voltage while switching at 50 kHz, 100 kHz, 50 ns dead-time setting and powering a 5 kW servo motor at 30 rpm. Subsequently, the EPC91122 board was operated from a 24 V_{DC} supply voltage while switching at 100 kHz, 50 ns dead-time, powering the humanoid joint motor on a dynamometric bench setting a defined pulse torque at different pulse time.

Steady State Thermal Performance

The steady state thermal performance summary of the EPC91122 board is shown in Figure 6 and Figure 7. When operated on a motor bench at ambient temperature of 26°C, 100 kHz and 50 kHz PWM, 48 V_{DC} supply and natural convection cooling, the EPC91122 can deliver 7 A_{RMS} per phase without a heatsink with temperature increase below 80°C from eGaN IC case to ambient. At the same condition EPC91122 can deliver 15 A_{RMS} per phase with the humanoid joint motor casing acting as a heatsink (see Figure 5), in which the ICs were covered using a 1 mm-thick electrically non-conductive thermal interface material (PN: TG-A1780-20-20-1.0), keeping the temperature rise below 70°C from eGaN IC case to ambient.

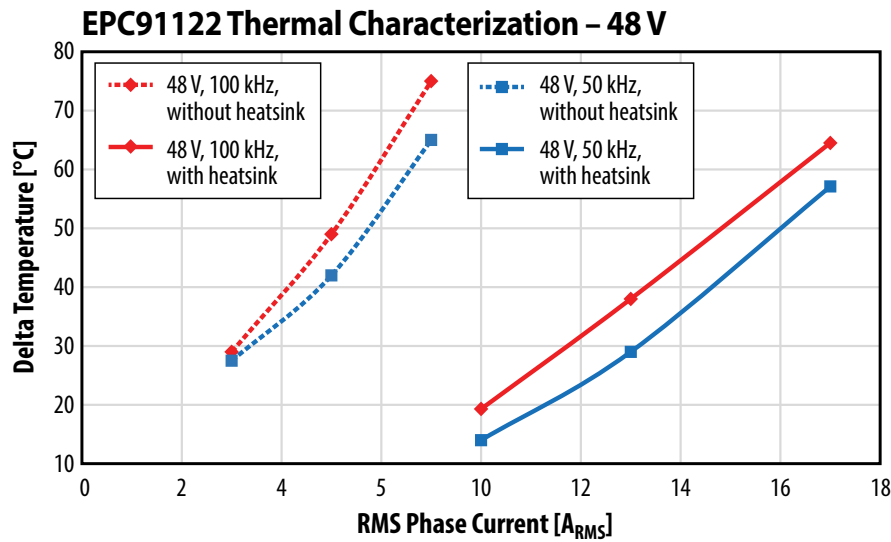


Figure 7: 48 V_{DC} EPC91122 eGaN IC temperature increase vs. the ambient temperature (27°C)

When operated on a motor bench at ambient temperature of 26°C, 100 kHz and 50 kHz PWM, 24 V_{DC} supply and natural convection cooling, the EPC91122 can deliver 7 A_{RMS} per phase without a heatsink with temperature increase below 70°C from eGaN IC case to ambient. At the same conditions EPC91122 can deliver 15 A_{RMS} per phase with the humanoid joint motor casing acting as a heatsink (see Figure 5), in which the ICs were covered using a 1 mm-thick electrically non-conductive thermal interface material (PN: TG-A1780-20-20-1.0), keeping the temperature rise to 60°C from eGaN IC case to ambient.

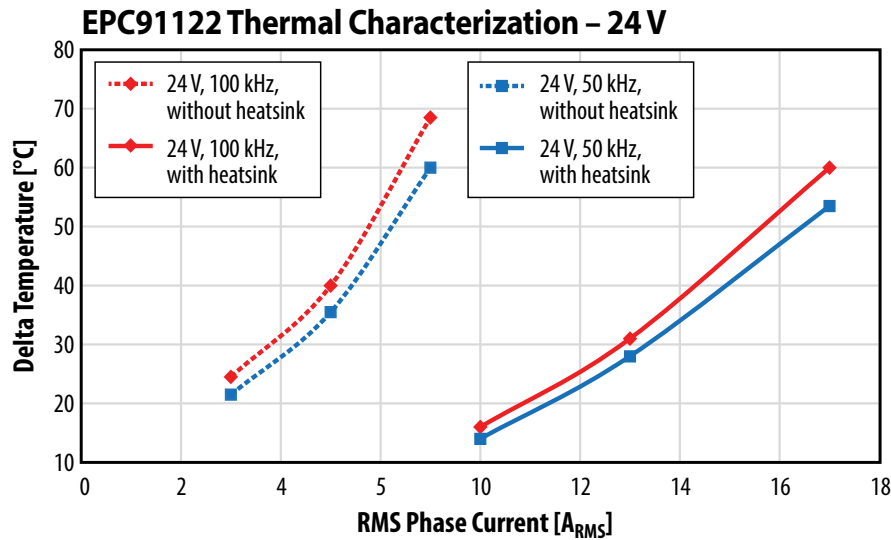


Figure 8: 24 V_{DC} EPC91122 eGaN IC temperature increase vs. the ambient temperature (26°C)

When operated on a motor bench at ambient temperature of 26°C, 100 kHz and 50 kHz PWM, 12 V_{DC} supply and natural convection cooling, the EPC91122 can deliver 7 A_{RMS} per phase without a heatsink with temperature increase below 60 °C from eGaN IC case to ambient. At the same conditions EPC91122 can deliver 15 A_{RMS} per phase with the humanoid joint motor casing acting as a heatsink ((see Figure 5), in which the ICs were covered using a 1 mm-thick electrically non-conductive thermal interface material (PN: TG-A1780-20-20-1.0), keeping the temperature rise below 55°C from eGaN IC case to ambient.

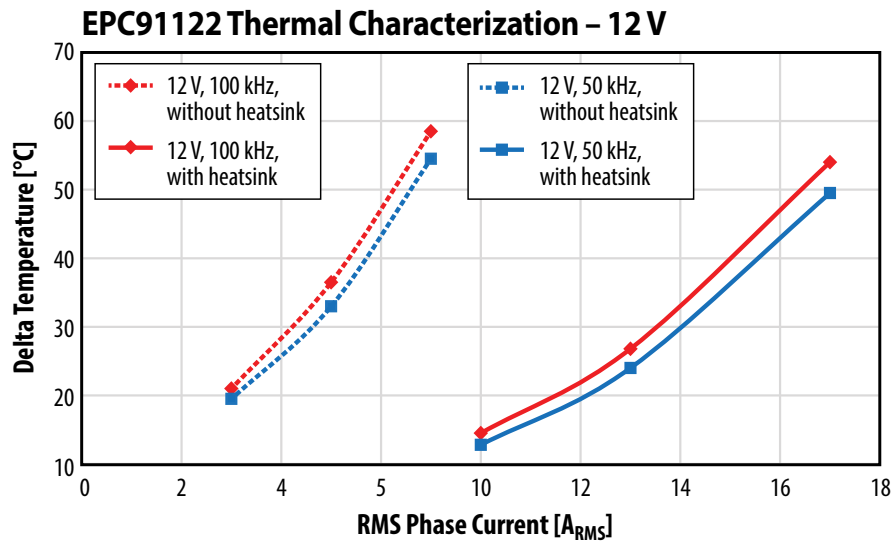


Figure 9: 24 V_{DC} EPC91122 eGaN IC temperature increase vs. the ambient temperature (26°C)

Pulsed torque operation

The pulsed torque tests were performed to emulate the performance of EPC91122 in applications subject to a dynamic operation. The tests were done connecting the humanoid motor to a controlled hysteresis brake. In Figure 9, the peak capabilities of the board are reported: the braking generates load pulses of 20 Nm peak; the used humanoid motor required a 20 A_{RMS} phase current to generate such torque. The tests were executed with a 24 V_{DC} supply, 100 kHz PWM frequency, and 50 ns dead time at 24°C ambient temperature with the EPC91122 board installed inside the humanoid robot motor joint.

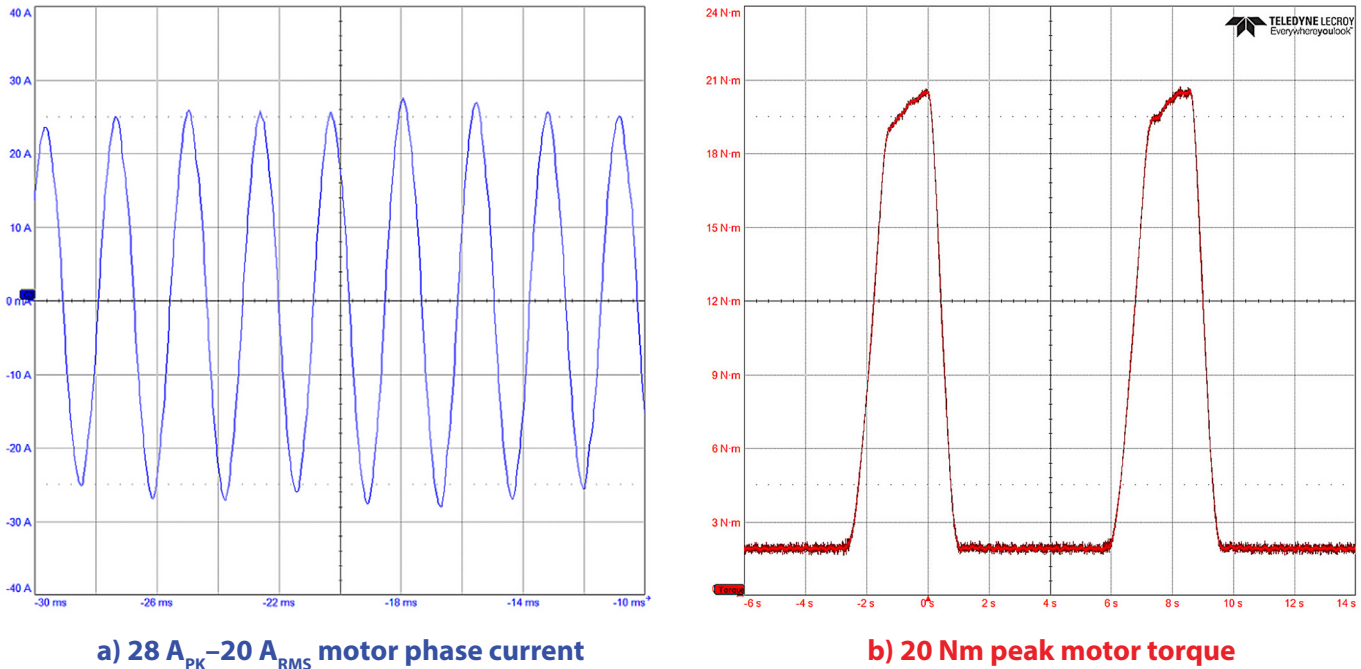


Figure 10: a) Maximum peak current of 20 A_{RMS} (28 A_{pk}) [10 A/div] [2 ms/div]; b) Load pulse overview from 2 Nm of break off mode torque to 20 Nm of break on mode torque [3 Nm/div] [2 s/div].

For support files including schematic, Bill of Materials (BOM), and Gerber files please visit the EPC91122 landing page at: <https://epc-co.com/epc/products/demo-boards/EPC91122>

Change Log

STATUS	VERSION	DATE	REMARK
1.0	Production	2 March 2026	Production release

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