EVAL-IKA15N65ET6 User Guide

About this document

Scope and purpose

This user guide provides an overview of the evaluation board EVAL-IKA15N65ET6 including its main features, key data, pin assignments and mechanical dimensions.

The evaluation board EVAL-IKA15N65ET6 was developed to support customers during their first steps designing applications for permanent magnet synchronous motors (PMSM) or brushless DC machines used e.g. for pumps, fans, washing machines, general purposes drives and power tools up to 1.2 kW.

The evaluation board is equipped with the latest components from the iMOTION™, TRENCHSTOP™ and CoolSET™ product series (see also Chapter 4).

1. The iMOTION™ IMD112T-6F040 smart driver is used for the motor control. It is a highly integrated IC for controlling three-phase motors, and includes a power factor correction (PFC).
2. The TRENCHSTOP™ IGBT IKWH30N65WR6 and the power silicon diode IDW30E65D1 perform the boost PFC. The TRENCHSTOP™ 5 WR6 family of discrete devices offers lowest losses, and enables a more reliable system design with increased creepage and clearance distances.
3. The TRENCHSTOP™ IGBT6 IKA15N65ET6 is implemented in a three-phase, two-level inverter.

   The TRENCHSTOP™ IGBT6 portfolio targets MHA (major home appliances) drives application from low-power to higher- power appliances.
4. The CooSET™ TLI4971 Hall sensor is used for PFC and inverter current sensing.

The auxiliary power supply uses the ICE5GR4780AG controller and creates the supplementary voltages for the internal circuits.

Intended audience

This user guide is intended for all technical specialists who have a good understand of motor control and high-power electronic converters. The board is intended for use under laboratory conditions.

Evaluation board

The board is to be used during the design-in process, for evaluating and measuring characteristic curves, and for checking datasheet specifications.

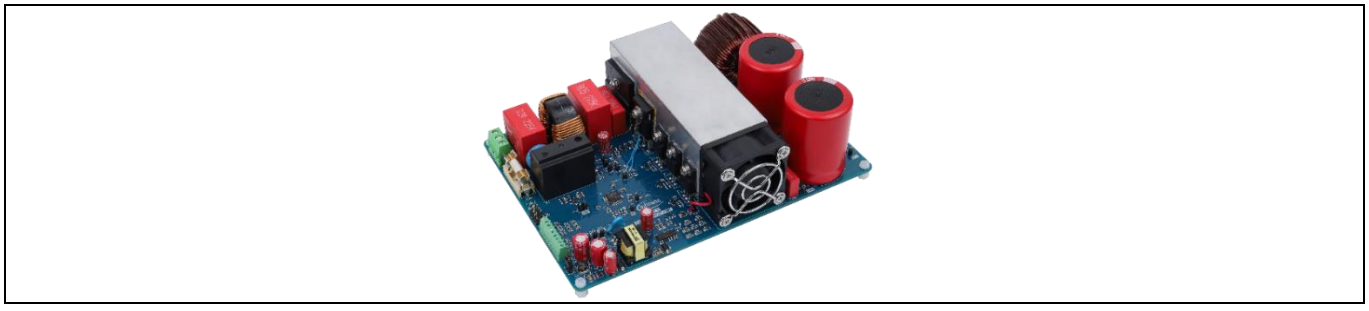

Figure 1 EVAL-IKA15N65ET6

The board at a glance

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“Evaluation Boards and Reference Boards” shall mean products embedded on a printed circuit board (PCB) for demonstration and/or evaluation purposes, which include, without limitation, demonstration, reference and evaluation boards, kits and design (collectively referred to as “Reference Board”).

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Safety precautions

Note: Please note the following warnings regarding the hazards associated with development systems.

Table 1 Safety precautions

	**Warning:** *The DC link potential of this board is up to 1000 VDC. When measuring voltage waveforms by oscilloscope, high voltage differential probes must be used. Failure to do so may result in personal injury or death.*
	**Warning**: *The evaluation or reference board contains DC bus capacitors which take time to discharge after removal of the main supply. Before working on the drive system, wait five minutes for capacitors to discharge to safe voltage levels. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *The evaluation or reference board is connected to the grid input during testing. Hence, high-voltage differential probes must be used when measuring voltage waveforms by oscilloscope. Failure to do so may result in personal injury or death. Darkened display LEDs are not an indication that capacitors have discharged to safe voltage levels.*
	**Warning:** *Remove or disconnect power from the drive before you disconnect or reconnect wires, or perform maintenance work. Wait five minutes after removing power to discharge the bus capacitors. Do not attempt to service the drive until the bus capacitors have discharged to zero. Failure to do so may result in personal injury or death.*
	**Caution:** *The heat sink and device surfaces of the evaluation or reference board may become hot during testing. Hence, necessary precautions are required while handling the board. Failure to comply may cause injury.*
	**Caution:** *Only personnel familiar with the drive, power electronics and associated machinery should plan, install, commission and subsequently service the system. Failure to comply may result in personal injury and/or equipment damage.*
	**Caution:** *The evaluation or reference board contains parts and assemblies sensitive to electrostatic discharge (ESD). Electrostatic control precautions are required when installing, testing, servicing or repairing the assembly. Component damage may result if ESD control procedures are not followed. If you are not familiar with electrostatic control procedures, refer to the applicable ESD protection handbooks and guidelines.*
	**Caution:** *A drive that is incorrectly applied or installed can lead to component damage or reduction in product lifetime. Wiring or application errors such as undersizing the motor, supplying an incorrect or inadequate AC supply, or excessive ambient temperatures may result in system malfunction.*
	**Caution:** *The evaluation or reference board is shipped with packing materials that need to be removed prior to installation. Failure to remove all packing materials that are unnecessary for system installation may result in overheating or abnormal operating conditions.*

Table of contents

1 The board at a glance

The evaluation board EVAL-IKA15N65ET6 is intended to control three-phase motors, plus power factor correction (PFC). The board is equipped with all assembly groups for sensorless field-oriented control (FOC). It includes an EMI filter and soft power-up circuit, an 8-pin iMOTION™ interface connector, the motor controller, a PFC gate drive circuit, an auxiliary power supply, discrete modules, and a three-phase output for connecting the motor.

The board described here can be operated directly without the need for additional hardware components. A set of PC software tools is required to set-up the system, as well as to control and fine-tune its performance to match users' needs (see Chapter 3).

The evaluation board is available through regular Infineon distribution partners and on Infineon's website. The features of this board are described in the "Main features" section (Chapter 2) of this document (UG-2021-42). The remaining chapters provide information on how to copy, modify and qualify the design for production according to customers' specific requirements.

Environmental conditions were considered in the design, but the board is not qualified in terms of safety requirements, manufacturing and operation over the entire operating-temperature range or lifetime. The boards provided by Infineon are subject to functional testing only.

The evaluation boards are not subject to the same procedures as regular products regarding returned material analysis (RMA), process change notification (PCN) and product discontinuation (PD). Evaluation boards are intended to be used under laboratory conditions by technical specialists only.

1.1 Scope of supply

The scope of supply includes the complete EVAL-IKA15N65ET6 evaluation board.

Figure 2 highlights the functional groups on the top side of board.

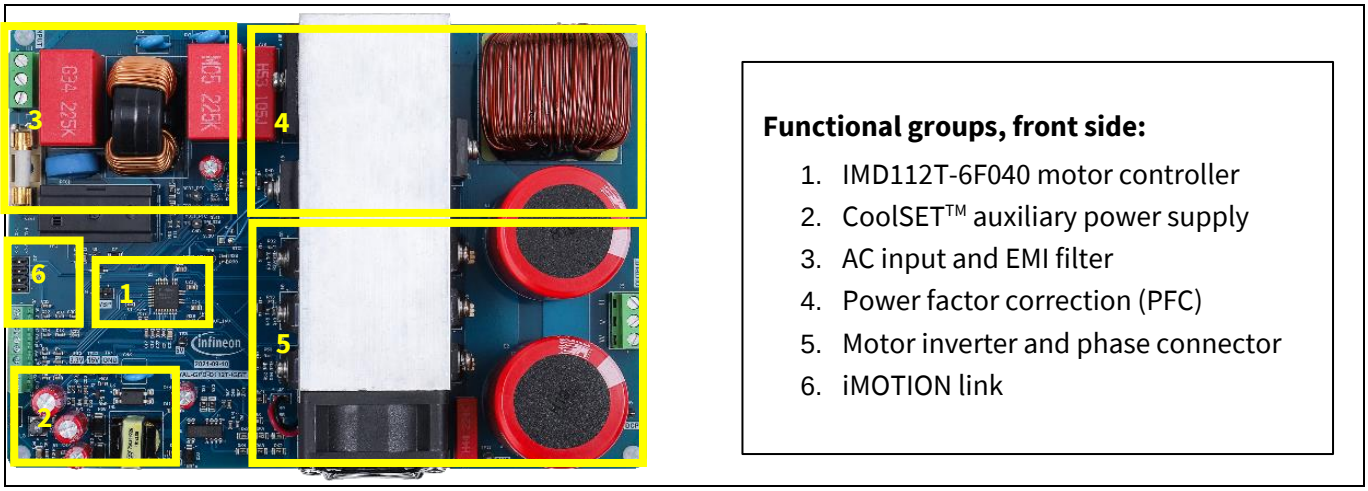


Figure 2 Functional groups of the EVAL-IKA15N65ET6 evaluation board, top side

Figure 3 illustrates the functional groups on the bottom side of the board.

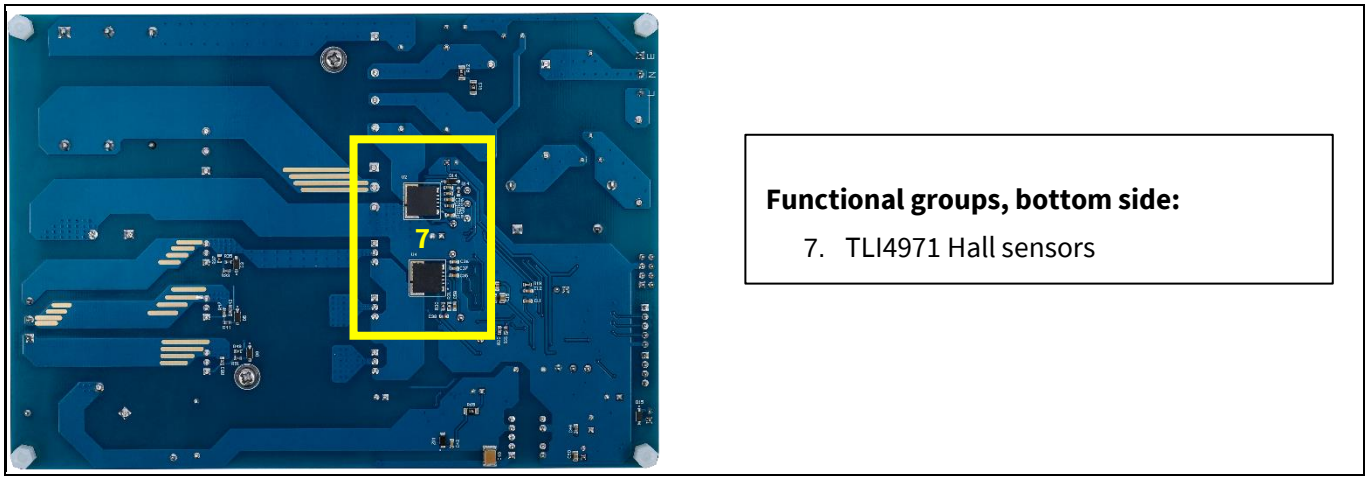


Figure 3 Functional groups of the EVAL-IKA15N65ET6 evaluation board, bottom side

1.2 Block diagram

The block diagram of the EVAL-IKA15N65ET6 is depicted in Figure 4.

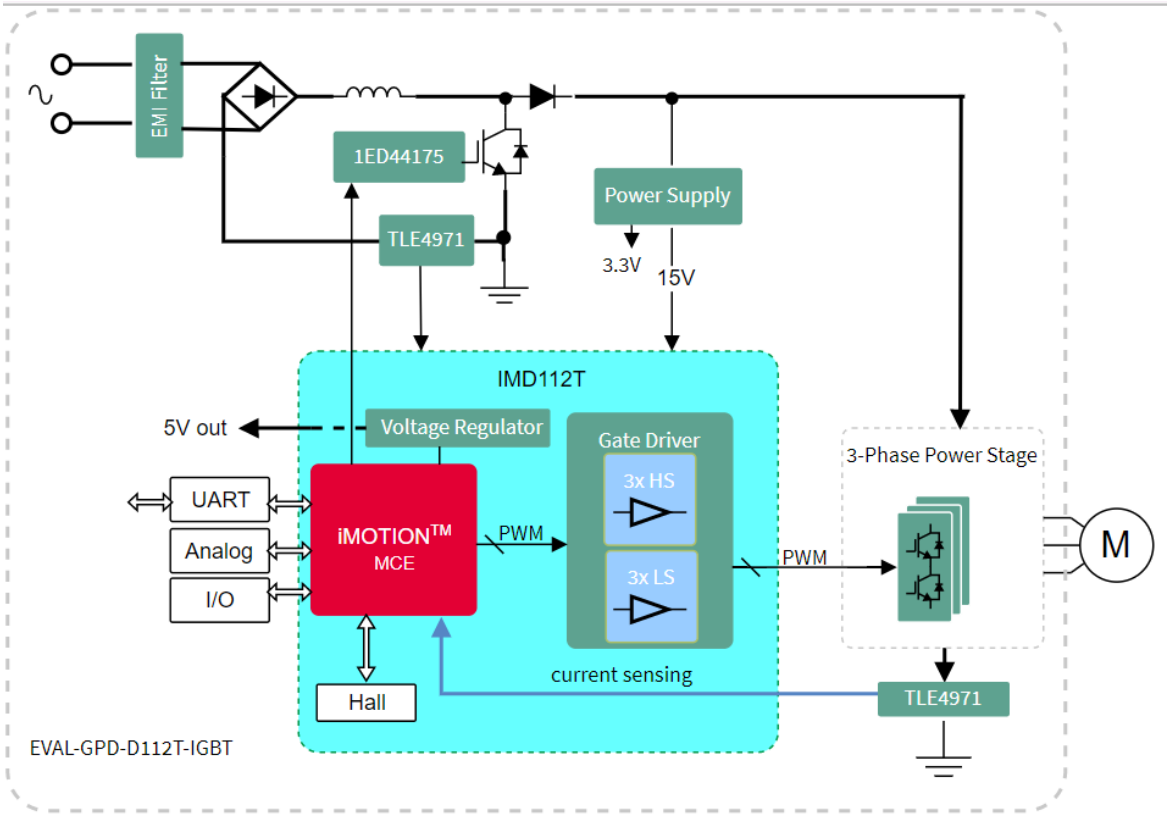


Figure 4 Block diagram of the EVAL-IKA15N65ET6

2 Main features

The EVAL-IKA15N65ET6 evaluation board provides the following main features:

- Power factor correction (PFC) control stage with Rapid 1 IDW30E65D1 and TRENCHSTOP™ 5 IGBT IKWH30N65WR6 in a wide creepage and clearance TO247 package
- 3-phase, 2-level inverter with TRENCHSTOP™ IGBT6 IKA15N65ET6 in TO220FP, 15 A, 650 V
- Sensorless or Hall sensor operation using the TLI4971
- IMD112T-6F040 controller for PFC and inverter operation

2.1 EVAL-IKA15N65ET6 board specifications

Table 1 depicts the key specifications of the evaluation board EVAL-IKA15N65ET6.

Table 1 EVAL-IKA15N65ET6 board specifications

Parameters	Values	Conditions/comments
Input		
Voltage	165~265 V_{ac}	• V_{in} = USA grid voltage rectified w/o PFC; 120 V_{nom} • Typical Pulse width modulation setup for 40 kHz PFC and 6 kHz motor PWM, 3-phase-only mode, motor speed: max.2500 rpm for GK6063 motor • PFC control parameters: KpI = 2800, KxI = 9000, KpV = 1000, KxV = 50
Current	3.64 A_{rms}	Input 165 V_{AC} (enable PFC function), Pin = 593 W, f_{PWM} = 6 kHz, f_{PFC} = 40 kHz, T_a = 22.1°C, motor speed = 2500 rpm
	7.36 A_{rms}	Input 165 V_{AC} (enable PFC function), Pin = 1215 W, f_{PWM} = 6 kHz, f_{PFC} = 40 kHz, T_a = 22.3°C, motor speed = 2500 rpm
	2.84 A_{rms}	Input 220 V_{AC} (enable PFC function), Pin = 597 W, f_{PWM} = 6 kHz, f_{PFC} = 40 kHz, T_a = 19.3°C, motor speed = 2500 rpm
	5.56 A_{rms}	Input 220 V_{AC} (enable PFC function), Pin = 1202 W, f_{PWM} = 6 kHz, f_{PFC} = 40 kHz, T_a = 19.8°C, motor speed = 2500 rpm
	2.36 A_{rms}	Input 265 V_{AC} (enable PFC function), Pin = 588 W, f_{PWM} = 6

		kHz, f_{PFC} = 40 kHz, T_a = 21.6°C, motor speed = 2500 rpm
	4.70 A_{rms}	Input 265 V_{AC} (enable PFC function), Pin = 588 W, f_{PWM} = 6 kHz, f_{PFC} = 40 kHz, T_a = 22.6°C, motor speed = 2500 rpm
Output		
Power (3 phases)	1200 W	165 V_{AC} ≤ input ≤ 265 V_{AC} (enable PFC function), f_{PWM} = 6 kHz, f_{PFC} = 40 kHz, motor speed = 2500 rpm
Current per leg	5 A_{rms}	Input = 165 AC (enable PFC function), P_{out} = 1200 W, f_{PWM} = 6 kHz, f_{PFC} = 40 kHz, motor speed = 2500 rpm
DC bus voltage		
Recommended DC bus voltage	375 V	
Switching frequency		
PFC switching frequency f_{PFC}	40 kHz	
Inverter switching frequency f_{PWM}	6 kHz	
Protections		
Inverter short-circuit protection/OCP	Via iMOTION	
PFC OCP	Via TLI4971	
On board power supply		
15 V	15 V ± 1 V	
3.3 V	3.3 V ± 5%	
5 V	5 V ± 5%	
PCB characteristics		
Material	FR4	
Dimension	178 mm x 125 mm	
System environment		
Ambient temperature	25°C	Tested at ambient temperature

2.2 Pin assignment

The EVAL-DP-D112T-IGBT evaluation board provides an AC input connector and a three-phase output for connecting the motor.

Table 2 includes the details of the AC input connector J1.

Table 2 J1- AC line connector

o.	Pin	Details
1	Line	AC line input
2	Neutral	AC neutral input

3	Earth	Earth ground

Table 3 provides the details of the motor side connector J2.

Table 3 J2- Motor side connector

No.	Pin	Details
1	W	Connected to motor phase W
2	V	Connected to motor phase V
3	U	Connected to motor phase U

3 Getting started

In order to run the motor system with the EVAL-IKA15N65ET6 evaluation board, the iMOTION™ PC software tools, MCEDesigner and MCEWizard, are required to set up the system and to control and fine-tune the system's performance to meet users' needs. This chapter provides more details on setting up the system and getting started with the EVAL-IKA15N65ET6 evaluation board.

Note: *The Hall sensor TLI4971 is used for PFC and inverter current sensing. On delivery of the evaluation board EVAL-IKA15N65ET6, the Hall sensors are programmed with a pre-configured range of 25 A current in a single-ended mode. These settings are described in detail in the according datasheet of the current sensor. The evaluation board was tested with both the firmware and the MCEDesigner (version V1.03.03). All features described here are based on the iMOTION™ software version.*

3.1 Setting up the system

After downloading and installing the iMOTION™ PC tools MCEWizard and MCEDesigner, the following steps must be taken to run the motor. Refer to Chapters 3.2.1 and 3.2.2 and to the MCEWizard and MCEDesigner user guide for more information.

Figure 5 shows the system connections using EVAL-IKA15N65ET6.

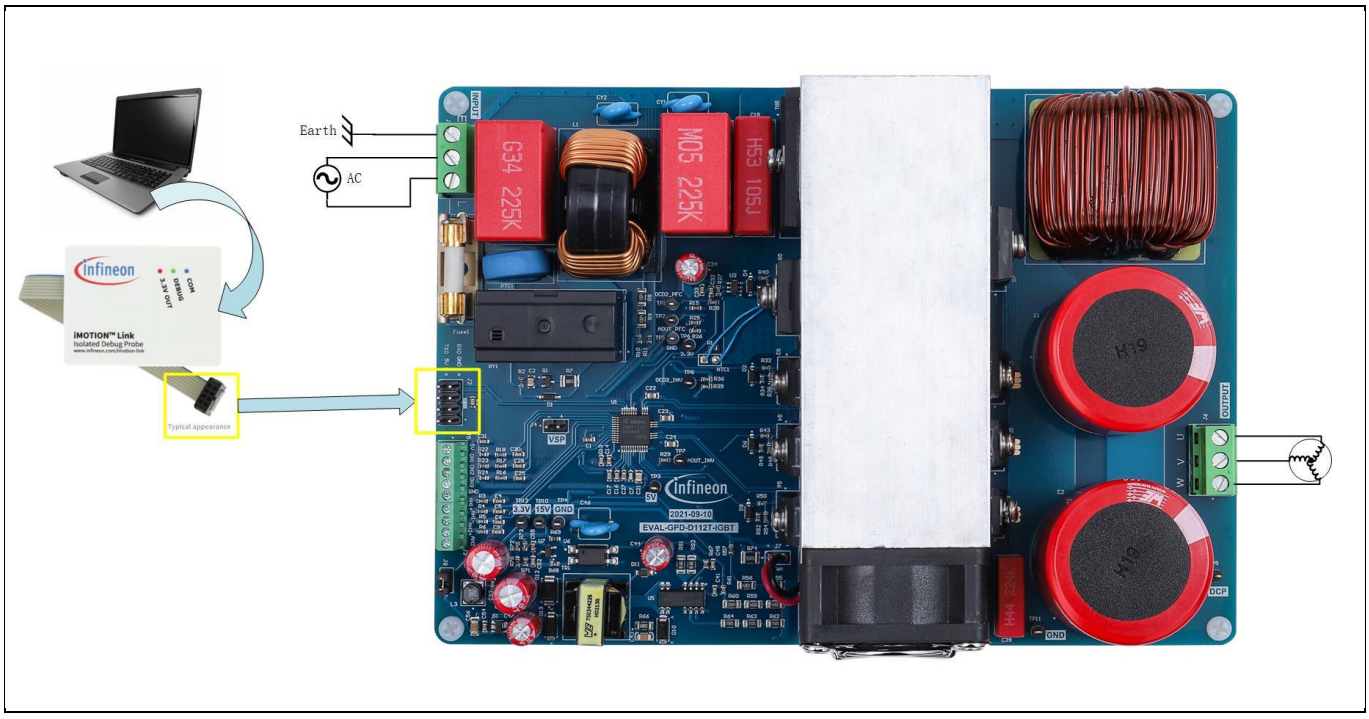


Figure 5 System connections using EVAL-IKA15N65ET6

1. Obtain the "IMD112T Software Package" V1.03.03 version available on the www.infineon.com/imotion-software website.
2. Connect PC and evaluation board via USB cable or iMOTION™ link.
3. Connect the AC source and target motor.
4. Use MCEWizard to calculate and create a parameter text file. See the section on MCEWizard setup in Chapter 3.2.1 for more details.

5. Power-on the system and start the MCEDesigner tool to open the MCEDesigner default configuration file (.irc) for IMD112T smart driver.
6. Program the calculated parameters into the flash. See Chapter 3.2.2 for an overview of the MCEDesigner setup for more details. The firmware V1.03.03 has been programmed into the flash of IMD112T. The firmware .ldf file can also be re-programmed together with the calculated .txt file for the own motor.
7. After successful programming, click on the hammer icon to clear the fault signals if there is a red light at the bottom of MCEDesigner. When the system is ready, start the motor by clicking on the green traffic light. Clicking on the red traffic light stops the motor.

3.2 iMOTION™ development tools and software

The iMOTION™development tools for MCEDesigner and MCEWizard are available for download via Infineon iMOTION™ website (http://www.infineon.com/imotion-software). All available tools and software versions are listed there.

The iMOTION™ link is mandatory for tuning, and is not included in the scope of delivery. Users should order the link if they do not already have one. Ordering information can be found here IMOTION-LINK.

Note: *Please note that the iMOTION™ development tools described here are based on version V2.3.0.1. Some features may vary according to the different versions. Please refer to the relevant version of the MCEWizard or MCEDesigner user guides.*

3.2.1 MCEWizard setup overview

MCEWizard defines the control gains, limits and fault levels based on real number inputs, and converts the gains and levels to parameter counts based on hardware and control limit settings. MCEWizard also exports parameters and variable scale factors to the MCEDesigner.

To open the setup overview, double-click the MCEWizard shortcut on the Windows desktop. The MCEWizard welcome page is shown in Figure 6.

If users have the evaluation design kit “MCEWizard configuration file,” they need only to click on the “Open System Configuration File” button and change the user’s motor parameters under test.

If users do not have the above-mentioned configuration file, they need to follow these steps:

1. Click on the button “File” and select “Create System Configuration File”
2. Select the IMD112T device in the pop-up window
3. Click OK and return to the welcome page
4. Select “Customized Design for Expert User”
5. Click on the “Next” button to answer questions concerning hardware design and user test motor specifications

Figure 6 Welcome page of MCEWizard

The iMOTION™ PC software tools enable users to easily test their motors. Users should be familiar with the system-level parameters that are related to the motor used. There is a limited number of parameters that are specific to the control board or power board hardware. Table 4 provides the MCEWizard setup overview for hardware-related parameters.

Table 4 MCEWizard setup overview table

Page	Parameter	Value	Comment
Welcome Page	Control device selecting	IMD112T	
Options Page	Motor 1 shunt configuration	Single shunt	
Question 2	Motor rated current	7.5 A_{rms}	GK6063-6AC31-FE
Question 3	Motor poles	6	GK6063-6AC31-FE
Question 4	Motor stator resistance	0.6 Ω/phase	GK6063-6AC31-FE
Question 5	Motor L_q inductance	4 mH	GK6063-6AC31-FE
Question 6	Motor L_q inductance	4 mH	GK6063-6AC31-FE
Question 7	Motor back electro-motive-force constant (Ke)	45 V (In-rms)/krpm	GK6063-6AC31-FE
Question 8	Motor maximum rpm	2500 rpm	GK6063-6AC31-FE
Question 16	Target DC bus voltage initialization	380 V	
Question 24	Controller supply voltage	15 V	
Question 46	Maximum DC bus voltage	500 V	

Question 50	DC bus sensing high resistor	2000 kΩ	Depends on the board
Question 51	DC bus sensing low resistor	20 kΩ	Depends on the board
Question 78	Inverter dead time	~1 us	Programmable
Question 80	GateSense low-side devices	High is true	
Question 81	GateSense high-side devices	High is true	
Question 83	Current feedback and sample timing	48 mV/A	Depends on the TLI4971 setting
Question 84	Internal ADC gain	1	Programmable
Question 93	Overcurrent trip level for internal GateKill comparator	15.5 A	For EVAL-IKA15N65ET6 only
Question 107	PFC topology	Boost PFC	
Question 104	PFC inductance	0.5 mH	For EVAL-IKA15N65ET6 only
Question 110	PFC current measurement input scaling	348 mV/A	Depends on the TLI4971 setting
Question 114	AC voltage sensing high resistor	2000 kΩ	Power board parts
Question 115	AC voltage sensing low resistor	20 kΩ	
Question 117	PFC gate driver polarity low side	High is active	
Question 118	PFC current sample delay time	1.5 µs	Depends on SNR & switching noise

When all MCEWizard questions have been answered, the “Verify & Save Page” will be shown as in Figure 7.

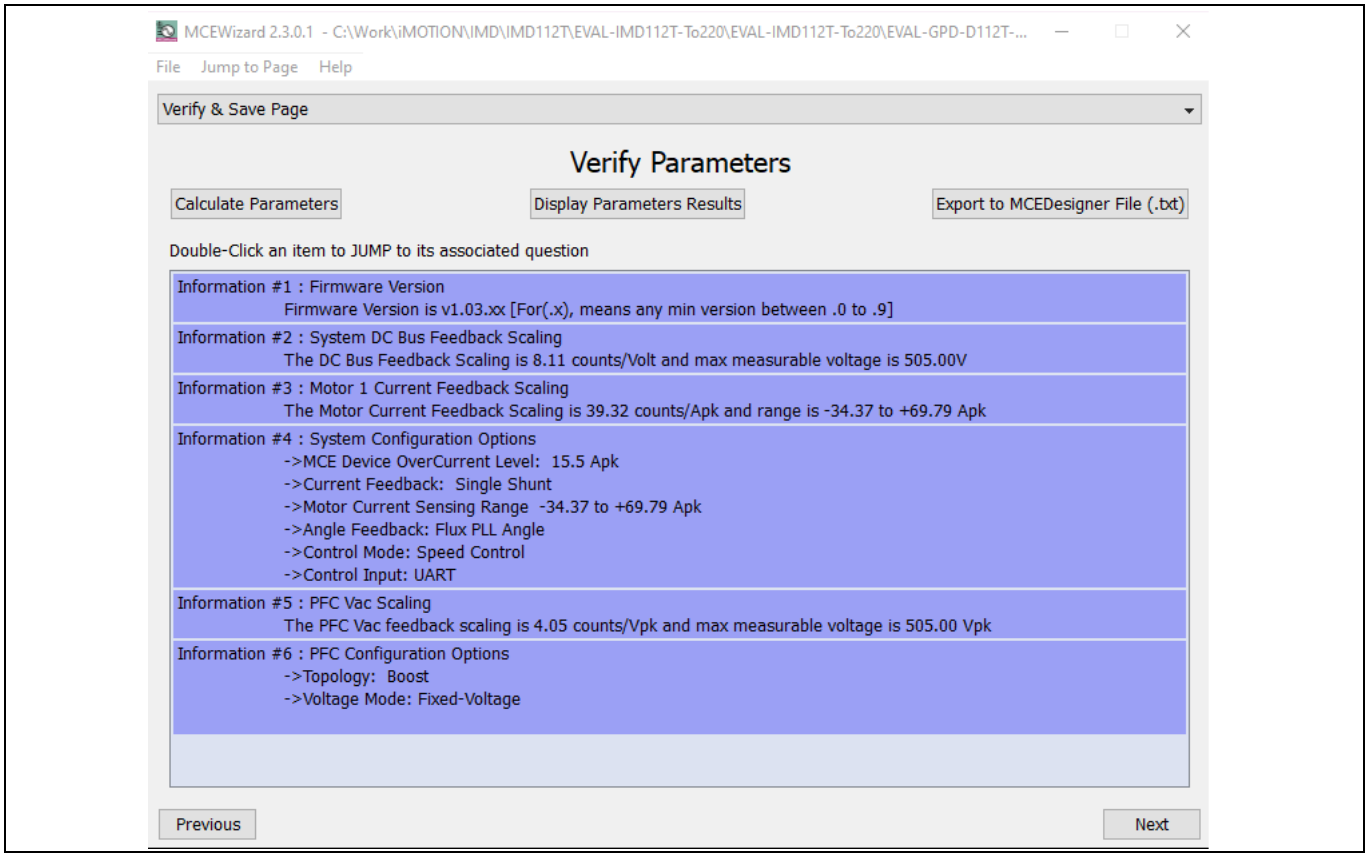


Figure 7 Verify and save page for MCEWizard

Click the “Calculate” button and “Export to Designer File (.txt)” button to save the parameter file, which will be used by the MCEDesigner in the next steps.

3.2.2 MCEDesigner setup overview

MCEDesigner is a tool used for programming code and tuning the evaluation board. It is able to read from 16-bit MCE variable registers, and to read/write from and to MCE parameter registers. MCEDesigner displays both real and “count” values for all variable registers, and selects parameter registers. The count value is the conversion of the real value to a digital number. The register value format can be selected from the “Performance > Tuning Value Format” pop-up window.

After installing the MCEDesigner installer, a shortcut button appears on the Windows desktop for quick-starting the MCEDesigner, as follows:

1. Double-click on the shortcut to open MCEDesigner.
2. Open the MCEDesigner default configuration file (.irc) for IMD112T smart driver (IMD112T_V1.03.03.irc included in the firmware zip folder downloaded from the Infineon website)
3. Select the available COM port in “Performance > Connection” pop-up window

The MCEDesigner window appears, as shown in Figure 8.

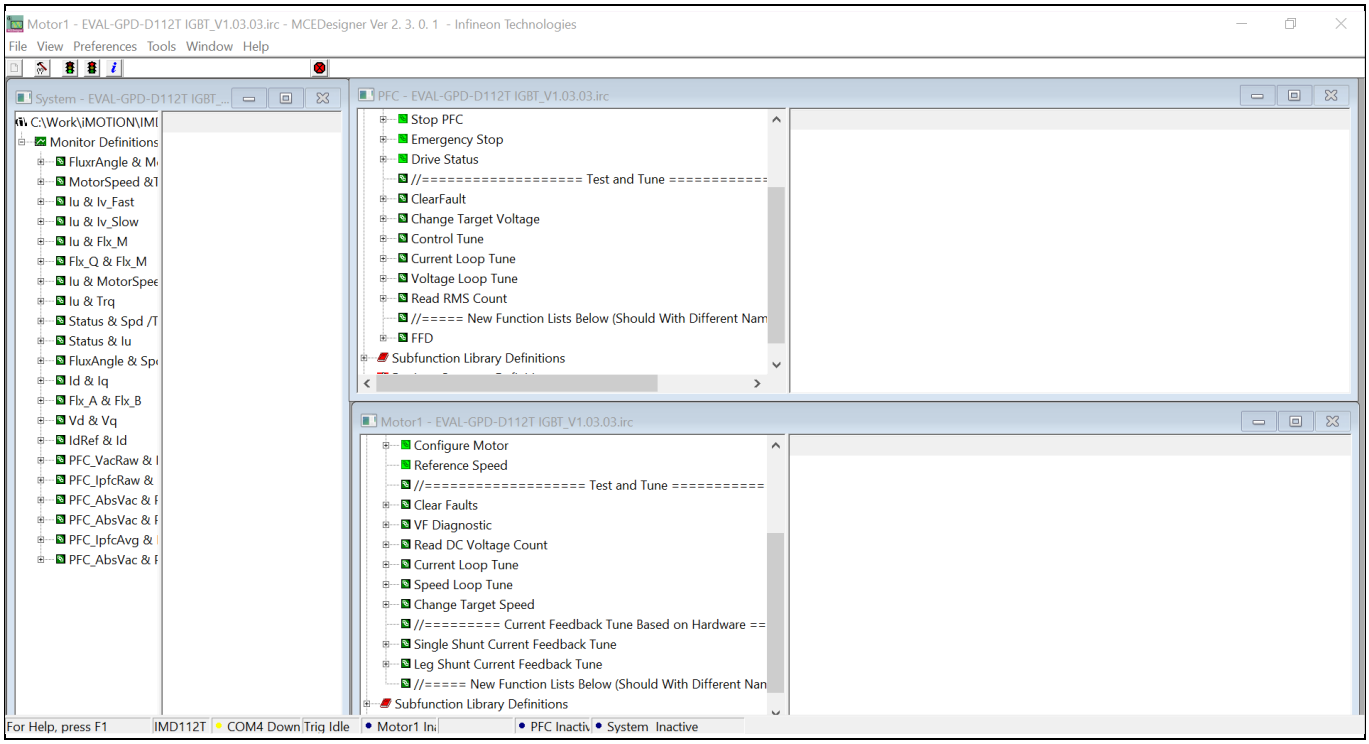


Figure 8 MCEDesigner's main display for IMD112T

For the next step, you need to program the firmware (.ldf file) and parameters (.txt file) into flash. The firmware programming is not necessary if you do not want to change the .ldf file version that has been already programmed for the evaluation board manufacturing test of the IMD112T.

1. Click on the "Tools" menu in the "System" window and select "Programmer" from the pull-down list.
2. Choose the relevant .ldf file and text file.
3. Click the Start button to program the .ldf and .txt files.

The .ldf file can be downloaded from the Infineon website. The .txt file was created by the MCEWizard as described in Chapter 3.2.1. The programming window is shown in Figure 9.

After firmware and parameters are programmed, the system will be ready to run the motor. Users can click the green traffic light to start the motor or click the red traffic light to stop the motor. Users can now check the waveform of phase current, Flx_M, motor speed, and other register values when they double-click the monitor items in the system window.

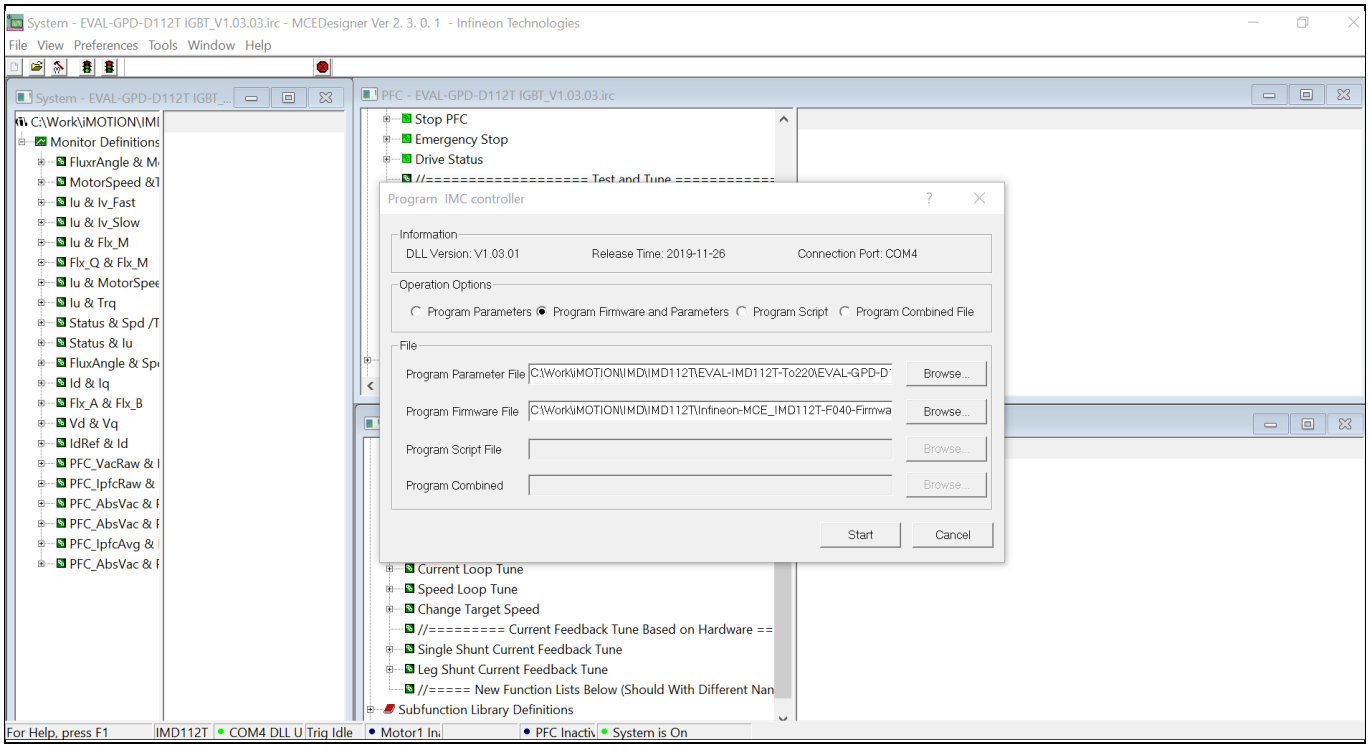


Figure 9 “Program IMD112T controller” pop-up window

3.2.3 Firmware version update

When the board test starts, a pop-up window may appear in the MCEDesigner tool, as shown in Figure 10. This message indicates that the firmware and register map version are incompatible. To solve this issue, users only have to close the pop-up window and re-program the firmware they want to use. If users want to test the board with the latest firmware, they can download the latest version from the Infineon website. Then they can open the newest download MCEDesigner .irc file and re-program the latest firmware (.ldf file).

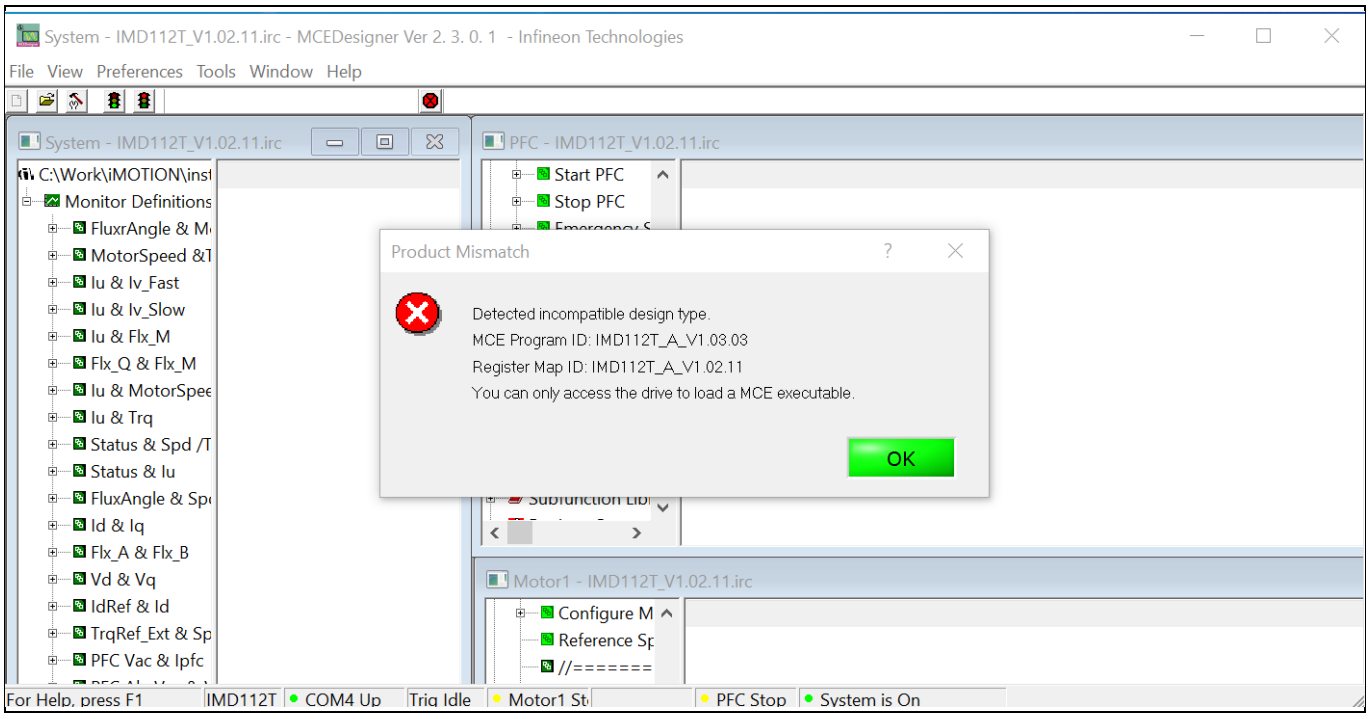


Figure 10 Incompatible map version window

All the latest firmware files and iMOTION™ tools can be found on the Infineon website (http://www.infineon.com/imotion-software).

3.2.4 Hall sensor TLI4971 programming

The evaluation board uses two Hall sensors TLI4971 for current sensing. One sensor is used for PFC current sensing and the other is used for inverter current sensing. These sensors are configured in single-ended mode, and both the current-sensing ranges are +/-25 A. The Hall sensor TLI4971 is a high-precision, coreless current sensor for industrial applications in an 8x8 SMD package. If you want to change the configuration of the Hall sensor, the GUI software can be used for re-programming. The GUI can be downloaded from the Infineon website here. The current-sensing Toolbox Programmer is mandatory for EEPROM programming. Toolbox ordering information can be found at this link, and is also available from local sales representatives. Figure 11 shows the Hall sensor EEPROM programming window. For programming details, please find the application note and datasheet for the programming guide and user manual on the Infineon website: https://www.infineon.com/cms/en/product/sensor/current-sensors/#!documents.

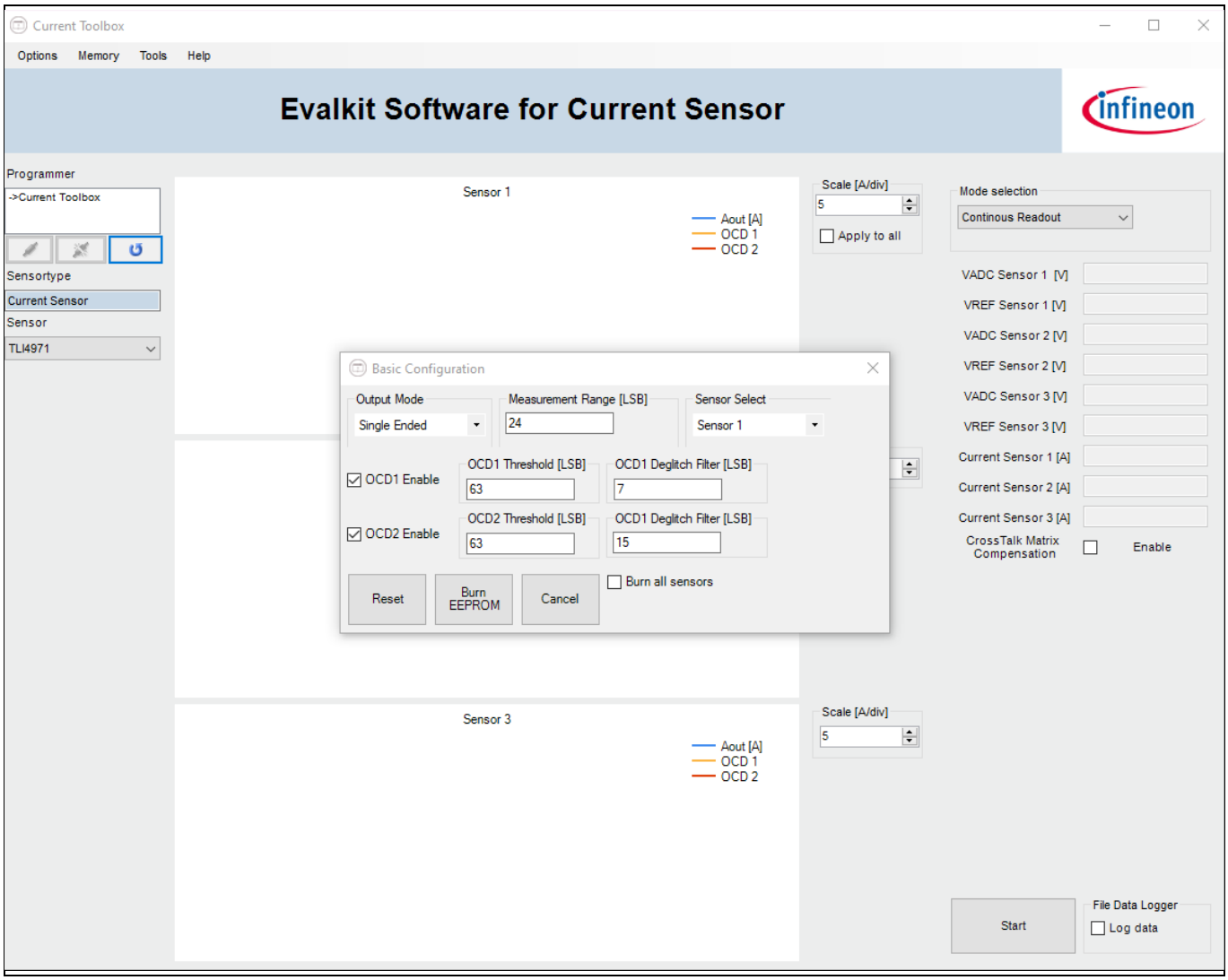


Figure 11 TLI4971 Hall senor programming page

For programming the TLI4971, the toolbox output terminal should be connected with the EVAL-IKA15N65ET6 board, as shown in Figure 12. The toolbox programmer has three channels for connecting three sensors at the same time. For this evaluation board EVAL-IKA15N65ET6, users can use two channels to connect the two Hall sensors, as shown in Figure 12, and then select sensor 1 or sensor 2 to program the two TLI4971 sensors in the programming pop-up window. Of course, only one channel is needed to program the two Hall sensors separately; there is no need to connect the sensors together. For example, when users use channel 1 to program the PFC current sensor, they need only to connect toolbox programmer connector pins 1, 4, 14 and 20 with TP2, TP1, TP5, and TP6, respectively, on the evaluation board. After programming the PFC Hall sensor, users need to keep pin 14 and pin 20 connections for 3.3 V and GND, then move pin 1 and pin 4 connections to TP7 and TP8 on the evaluation board for programming the inverter current sensor.

When programming the Hall sensor, the jumper cap must be unplugged from the connector J8 on the EVAL-IKA15N65ET6 board. After finishing the TLI4971 programming, the jumper cap should be plugged in again for the J8.

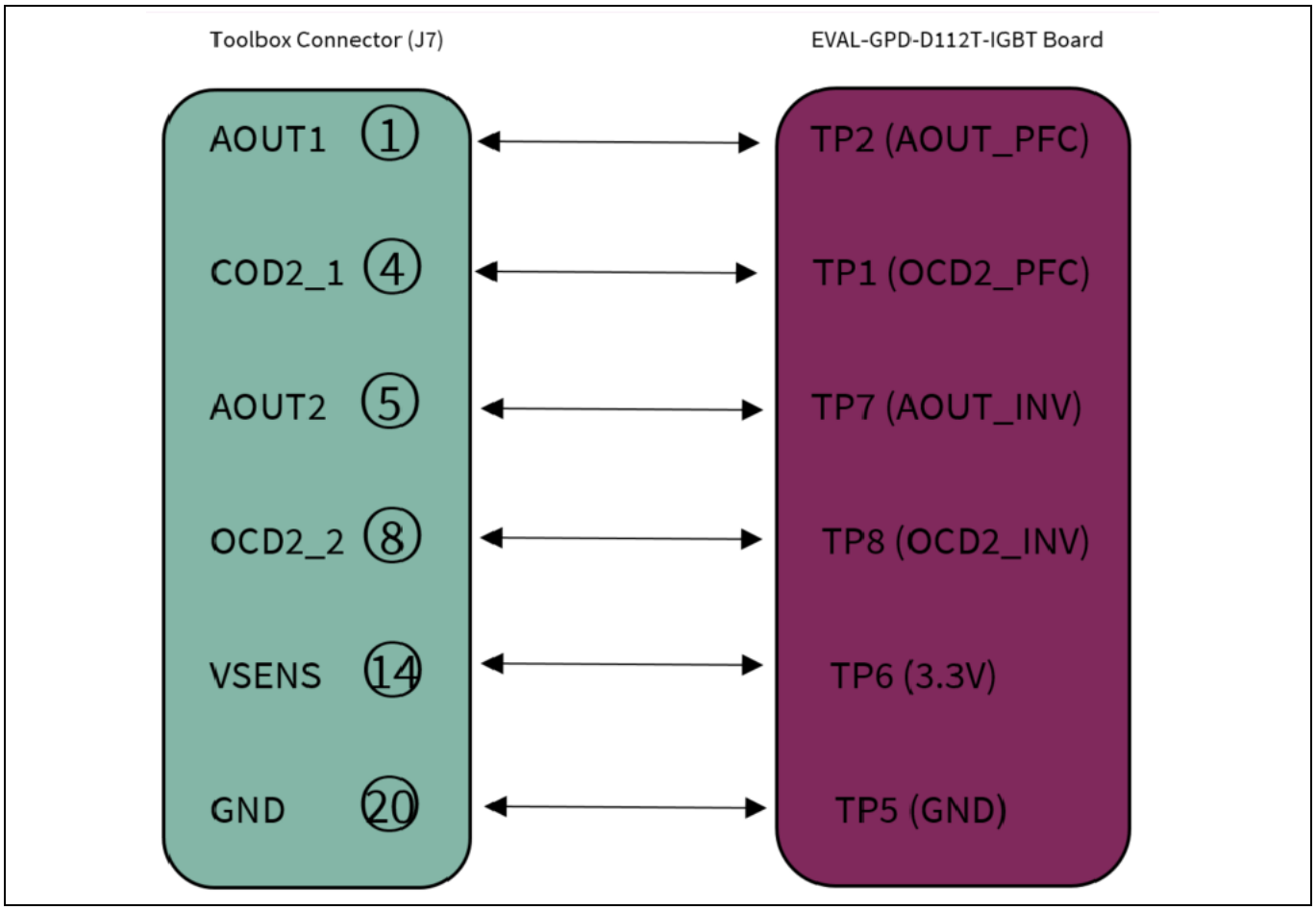


Figure 12 TLI4971 programming connections

4 Hardware description

To meet customer requirements and make the EVAL-IKA15N65ET6 evaluation board a basis for development or modifications, all necessary technical data like schematic diagrams, layouts and components are described in this chapter.

This evaluation board comprises the following functional blocks:

- Motor controller
- Power factor correction
- Three-phase power stage
- Current sensing
- Auxiliary power supply

4.1 Motor controller

The board uses the iMOTION™ IMD112T-6F040 smart driver as motor controller. The IMD112T-6F040 is part of the IM110-6 family of highly integrated ICs for the control of variable speed drives. It integrates the motor controller with a high-voltage, three-phase gate driver and a voltage regulator in a single package.

Controller PWM outputs are internally connected to the gate driver inputs. Two controller digital pins are also connected to the gate driver's enable input and fault output of the gate driver. The integrated voltage regulator generates the controller 5 V supply and can share the same 15 V supply rail as the gate driver.

The motor controller uses the motion control engine (MCE) to create a ready-to-use solution to perform control of a permanent magnet synchronous motor (PMSM), providing the shortest time to market for any motor system at the lowest system and development cost. The integrated script engine allows users application flexibility without interfering with the motor and PFC control algorithm.

4.2 Power factor correction

The EVAL-GDP-D112T-IGBT board contains a boost power factor correction (PFC) to reduce the reactive power.

The PFC function on the evaluation board is performed by the TRENCHSTOP™ 5 WR6 IGBT IKWH30N65WR6 combined with the silicon power diode IDW30E65D1. The TRENCHSTOP™ 5 WR6 IGBT in a high creepage and clearance TO-247-3-HCC package is optimized for PFC topologies. The silicon power rapid diode in a TO-247 package has excellent compatibility with the IGBT.

Power factor correction shapes the input current of the power supply to be synchronized with the mains voltage to maximize the real power drawn from the mains. In a perfect PFC circuit, the input current follows the input voltage as a pure resistor, without any input current harmonics.

The main stage schematic for EVAL-IKA15N65ET6 is illustrated in Figure 13.

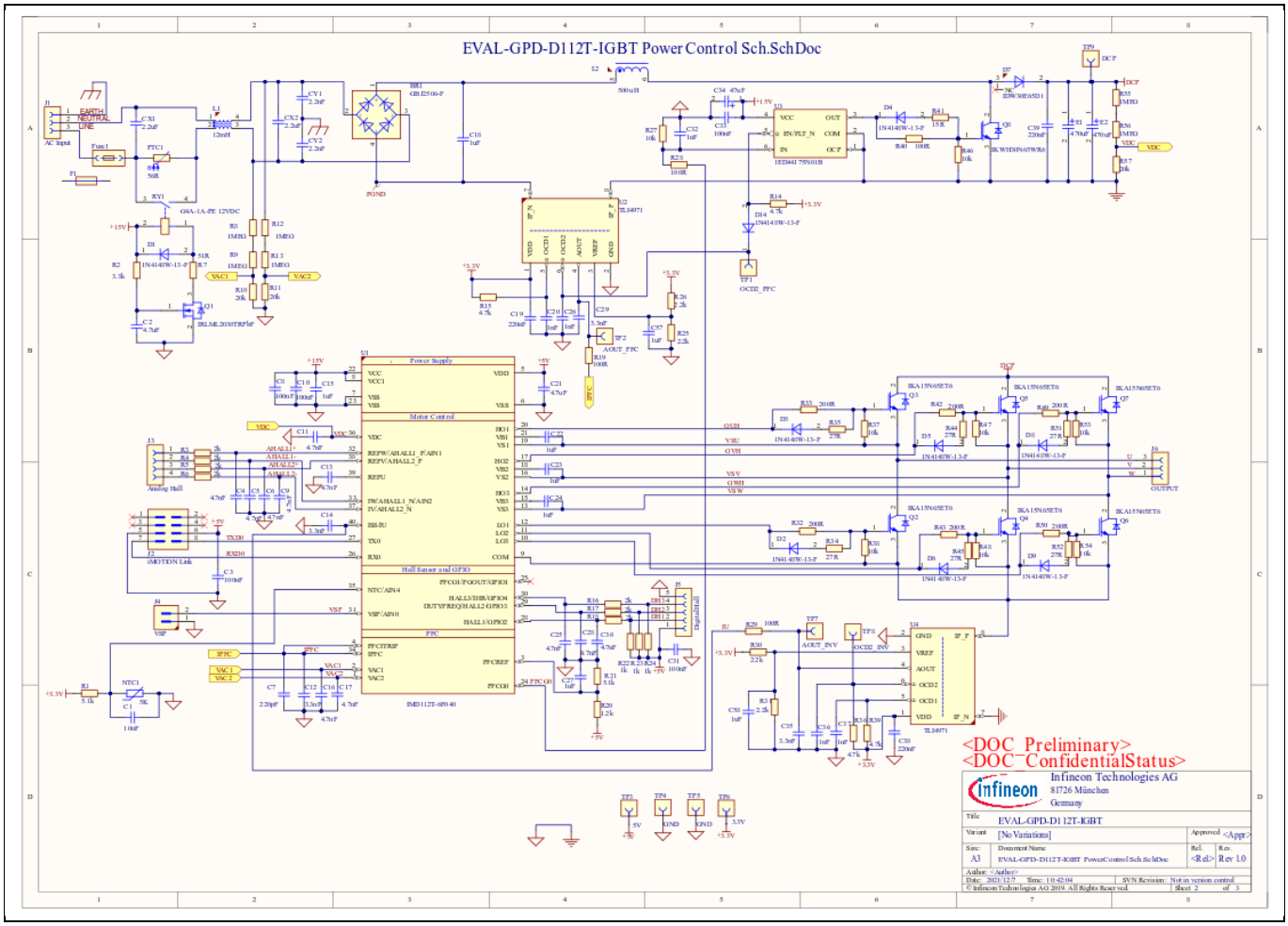


Figure 13 Main stage schematic

4.3 Current sensing

The TLI4971 Hall sensor is used on the evaluation board for PFC and inverter current sensing. It provides non-contact, galvanically isolated testing.

The TLI4971 is a high-precision sensor for AC and DC measurements with analog interface and two fast overcurrent detection outputs. Infineon's well-established and robust monolithic Hall technology enables accurate and highly linear measurement of currents with a full scale up to ±120 A. Negative effects like saturation and hysteresis that are common in open-loop sensors using flux concentration techniques are thus avoided. The sensor is equipped with an internal self-diagnostic feature.

4.4 Power stage

The TRENCHSTOP™ IGBT6 technology provides reduced switching losses, good controllability and an optimized relationship between switching and conduction losses in order to address various motor drive applications having fundamentally different characteristics.

The three-phase, two-level inverter on the board is built by the TRENCHSTOP™ IKA15N65ET6 in. It is mounted on the common heat sink with the PFC stage. The key performance parameters of the IKA15N65ET6 are:

- V_{CE} = 650 V
- I_C = 15 A

- Package PG-TO220-3 FP

4.5 Auxiliary power supply

The auxiliary power supply for the EVAL-GDP-D112T-IGBT board uses the ICE5GR4780AG of the CooSET™ series to generate:

- 15 V, used for motor controller and heat sink fan
- 3.3 V, used for current sensor and discrete driver for PFC

The ICE5GR4780AG is a fifth-generation integrated power IC with fixed frequency from the CoolSET™ series, optimized for off-line switch mode power supply in cascode configuration. The cascode configuration enables a fast startup of the system. The CoolSET™ package has two separate chips, the controller chip and an 800 V CoolMOS™ chip. The frequency-reduction technology with soft gate driving and frequency-jitter operation offers lower EMI and better efficiency between light loads and half loads. The selectable entry and exit standby power enables flexibility and ultra-low power consumption at standby mode with small and controllable output voltage ripple. The product has a wide operating range (10.0 ~ 25.5 V) of IC power supply and lower power consumption. The numerous protection functions with adjustable line overvoltage protection support the power supply system in failure situations.

Figure 14 depicts the schematic diagram of the auxiliary power supply for the EVAL-GDP-D112T-IGBT board. The circuit includes an ICE5GR4780AG that is used to generate 15 V and 6 V through the fixed-frequency flyback topology from the DC bus. The linear voltage regulator IFX1117ME V33 generates 3.3 V from a 6 V power supply. The 3.3 V power supply is used in the PFC overcurrent comparator circuit and overtemperature hardware protection circuit.

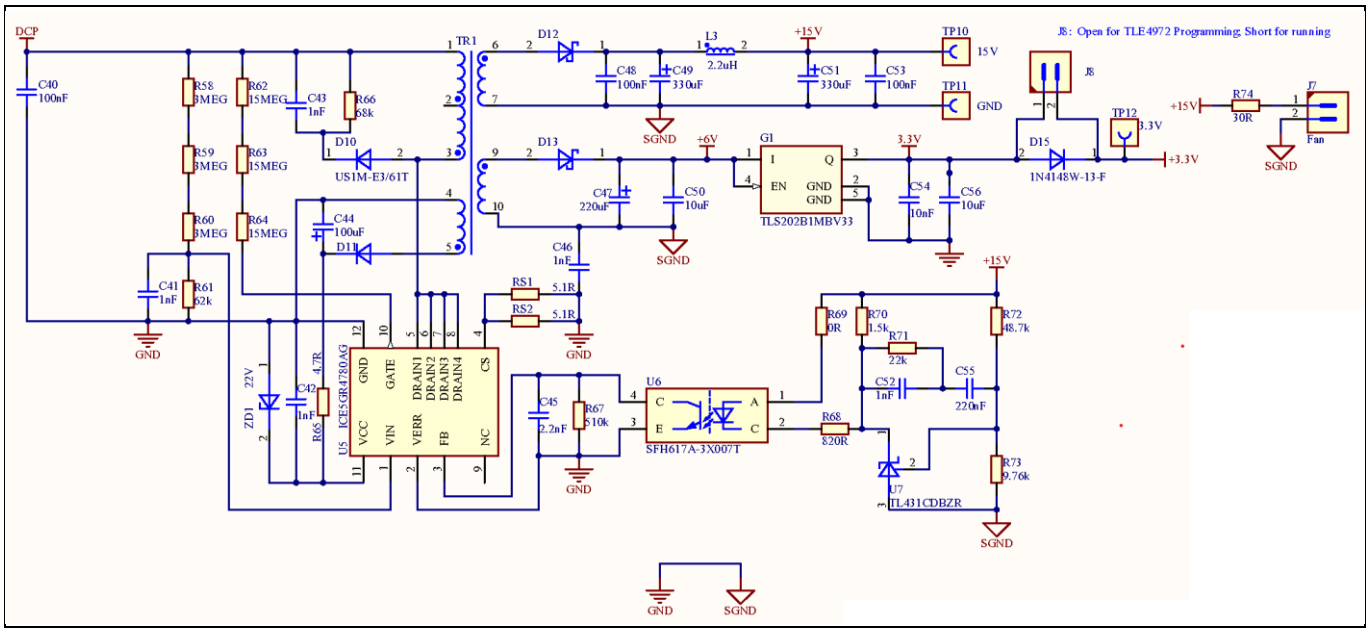


Figure 14 Auxiliary power supply section of the EVAL-IKA15N65ET6 board

4.6 PCB layout for EVAL-IKA15N65ET6

The layout of this board can be used for different voltage or power classes. By default, the PCB has two electrical layers with 35 µm copper, and dimensions of 148 mm × 165 mm. The PCB board thickness is 1.6 mm. You can contact our technical support team for more detailed information and the latest design files.

Figure 15 illustrates the top layer routing of the evaluation board.

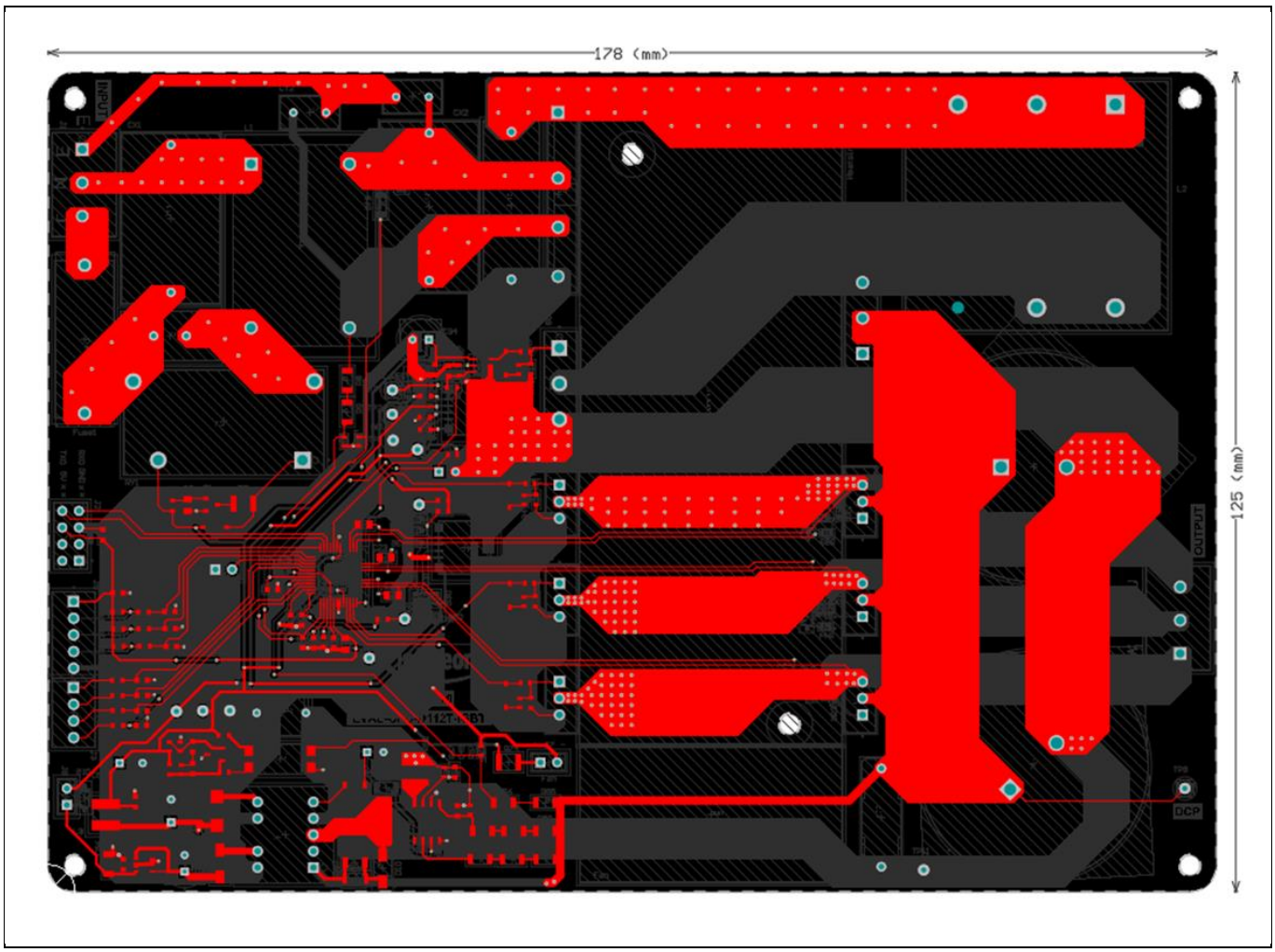


Figure 15 Top layer routing of the EVAL-IKA15N65ET6 evaluation board

Figure 16 depicts the bottom layer routing of the evaluation board.

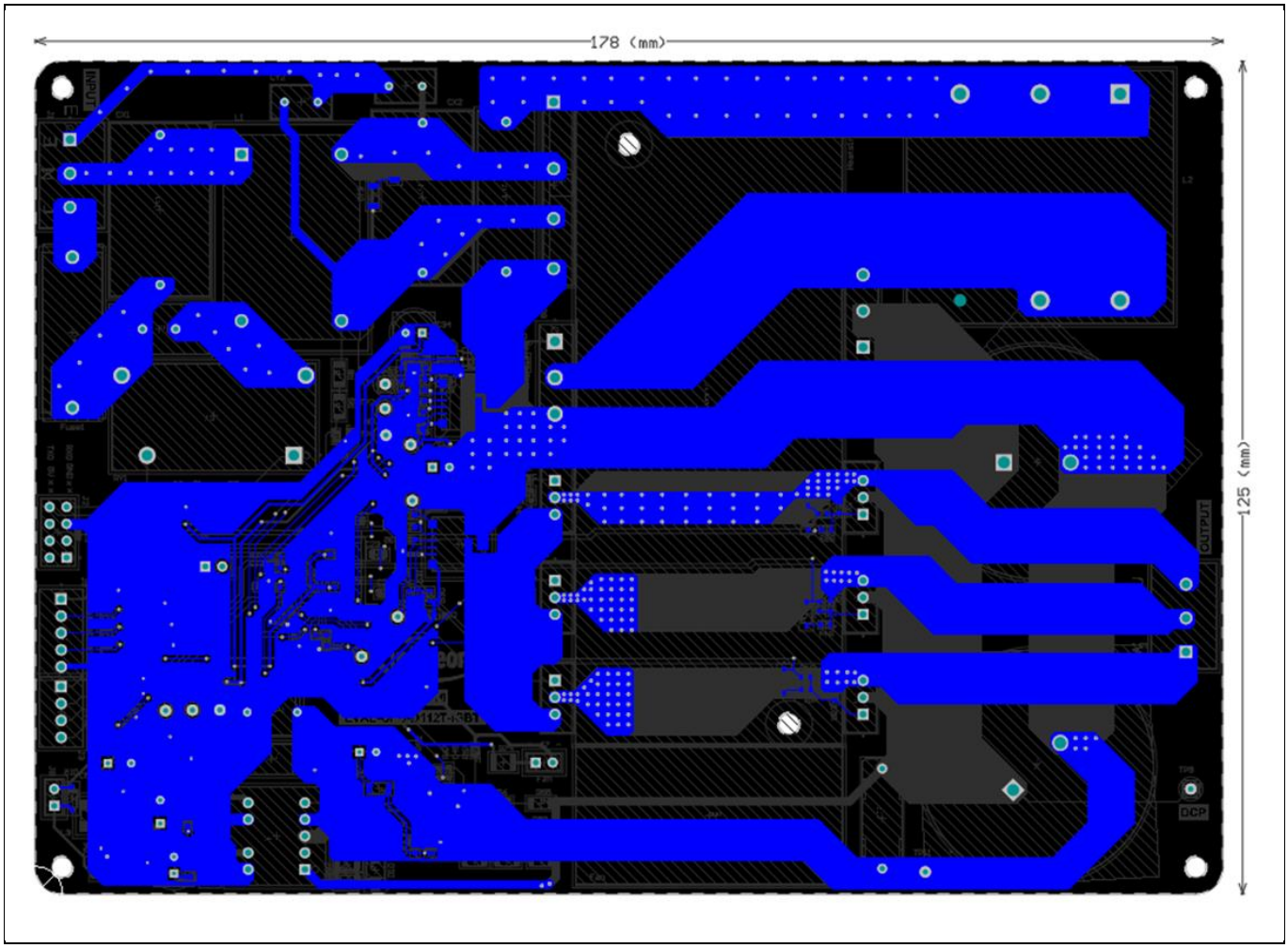


Figure 16 Bottom layer routing of the EVAL-IKA15N65ET6 evaluation board

5 Bill of material

Table 5 provides the complete bill of materials for the EVAL-IKA15N65ET6.

Table 5 Bill of materials

No.	Qty	Part description	Designator	Part number	Manufacturer
1	1	25A GLASS PASSIVATED BRIDGE RECTIFIER	BR1	GBJ2506-F	Diodes Incorporated
2	2	CAP / CERA / 10nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0603 / SMD / -	C1, C54	06035C103K4Z2A	AVX
3	2	CAP / CERA / 4.7uF / 25V / 20% / X5R (EIA) / -55°C to 85°C / 0805 (2012) / SMD / -	C2, C21	885012107018	Wurth Elektronik
4	5	CAP / CERA / 100nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	C3, C8, C10, C31, C33	C0603C104J3RAC	Kemet
5	11	CAP / CERA / 4.7nF / 25V / 1% / C0G (EIA) / NP0 / -55°C to 125°C / 0603 / SMD / -	C4, C5, C6, C9, C11, C13, C16, C17, C25, C28, C30	C0603C472F3GAC	Kemet
6	1	CAP / CERA / 220pF / 25V / 5% / - / -55°C to 125°C / 0603 / SMD / -	C7	885012006040	Wurth Elektronik
7	4	CAP / CERA / 3.3nF / 50V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	C12, C14, C29, C35	GRM1885C1H332JA01	MuRata
8	4	CAP / CERA / 1uF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 0805 / SMD / -	C15, C22, C23, C24	CGA4J3X7R1H105K125AB	TDK Corporation
9	1	CAP / FILM / 1uF / 400V / 5% / MKP (Metallized Polypropylene) / -40°C to 105°C / 22.50mm C X 0.80mm W 26.00mm L X 8.50mm T X 18.00mm H / THT / -	C18	890283326009CS	Wurth Elektronik
10	2	CAP / CERA / 220nF / 25V / 5% / X7R (EIA) / -55°C to 125°C / 603 / SMD / -	C19, C38	C0603X224J3REC7867	Kemet
11	7	CAP / CERA / 1nF / 25V / 5% / C0G (EIA) / NP0 / -55°C to 125°C /	C20, C26, C32, C36,	GRM1885C1E102JA01	MuRata

Bill of material

		0603(1608) / SMD / -, CAP / CERA / 1nF / 25V / 5% / C0G (EIA) / NP0 / -55°C to 125°C / 0603(1608) / SMD / -	C37, C42, C52		
12	3	CAP / CERA / 1uF / 25V / 10% / X5R (EIA) / -55°C to 85°C / 0603(1608) / SMD / -	C27, C57, C58	GRM185R61E105KA12	MuRata
13	1	CAP / ELCO / 47uF / 50V / 20% / Aluminiumelectrolytic / -40°C to 85°C / 2.50mm C X 0.50mm W 6.30mm Dia X 12.50mm H / THT / -	C34	860010673012	Wurth Elektronik
14	1	CAP / FILM / 220nF / 630V / 10% / MKP (Metallized Polypropylene) / -40°C to 105°C / 15.00mm C X 0.80mm W 18.00mm L X 6.00mm T X 12.00mm H / THT / -	C39	890334025027CS	Wurth Elektronik
15	1	CAP / CERA / 100nF / 630V / 10% / X7R (EIA) / -55°C to 125°C / 1812 / SMD / -	C40	885342211006	Wurth Elektronik
16	1	CAP / CERA / 1nF / 16V / 10% / X7R (EIA) / -55°C to 125°C / 0603(1608) / SMD / -	C41	C0603C102K4RACTU	Kemet
17	1	CAP / CERA / 1nF / 630V / 10% / X7R (EIA) / -55°C to 125°C / 1206(3216) / SMD / -	C43	GRM31BR72J102KW01	MuRata
18	1	CAP / ELCO / 100uF / 35V / 20% / Aluminiumelectrolytic / -40°C to 85°C / 2.50mm C X 0.50mm W 6.30mm Dia X 12.50mm H / - / -	C44	860010573007	Wurth Elektronik
19	1	CAP / CERA / 2.2nF / 50V / 10% / X5R (EIA) / -55°C to 85°C / 0603(1608) / SMD / -	C45	GRM188R61H222KA01	MuRata
20	1	CAP / CERA / 1nF / / 20% / E (JIS) / -40°C to 125°C / 7.50mm C X 0.60mm W 7.00mm L X 7.00mm T X 10.00mm H / THT / -	C46	DE6E3KJ102MN3A	MuRata

Bill of material

21	1	CAP / ELCO / 220uF / 16V / 20% / Aluminiumelectrolytic / -40°C to 85°C / 2.50mm C X 0.50mm W 6.30mm Dia X 12.50mm H / THT / -	C47	860010373010	Wurth Elektronik
22	2	CAP / CERA / 100nF / 50V / 10% / X7R (EIA) / -55°C to 125°C / 603(1608) / SMD / -	C48, C53	06035C104K4Z2A	AVX
23	2	CAP / ELCO / 330uF / 25V / 20% / Aluminiumelectrolytic / -40°C to 85°C / 3.50mm C X 0.60mm W 8.00mm Dia X 13.00mm H / THT / -	C49, C51	860010474012	Wurth Elektronik
24	1	CAP / CERA / 10uF / 16V / 10% / X5R (EIA) / -55°C to 85°C / 0805(2012) / SMD / -	C50	GRM219R61C106KA73	MuRata
25	1	CAP / CERA / 220nF / 25V / 10% / X5R (EIA) / -55°C to 85°C / 0603(1608) / SMD / -	C55	GRM188R61E224KA88	MuRata
26	1	CAP / CERA / 10uF / 16V / 5% / X7R (EIA) / -55°C to 125°C / 1206 / SMD / -	C56	C1206C106J4RAC	Kemet
27	2	CAP / FILM / 2.2uF / 630V / 10% / MKT (Metallized Polyester) / -40°C to 105°C / 22.50mm C X 0.80mm W 26.00mm L X 15.00mm T X 25.50mm H / THT / -	CX1, CX2	890324026034CS	Wurth Elektronik
28	2	CAP / CERA / 2.2nF / 1kV / 20% / Y5U (EIA) / -40°C to 125°C / 5.00mm C X 0.60mm W 9.00mm L X 5.00mm T X 13.00mm H / THT / -	CY1, CY2	VY2222M35Y5US6TV5	Vishay
29	10	Surface Mount Fast Switching Diode	D1, D2, D3, D4, D5, D6, D8, D9, D14,D15	1N4148W-13-F	Diodes Incorporated
30	1	Rapid-switching emitter-controlled diode	D7	IDW30E65D1	Infineon Technologies

Bill of material

31	1	Surface Mount Ultrafast Rectifier 1.0A/1000V	D10	US1M-E3/61T	Vishay
32	1	Super Fast Recovery Diode, VR 200 V, IF 1 A	D11	RF071MM2STR	ROHM Semiconductors
33	1	High Voltage Surface-Mount Schottky Rectifier, VRRM 100V	D12	SS2H10-E3/52T	Vishay
34	1	Surface-Mount Schottky Barrier Rectifier, VRRM 45V	D13	BYS10-45-E3/TR3	Vishay
35	2	CAP / ELCO / 470uF / 450V / 20% / Aluminiumelectrolytic / -25°C to 85°C / 10.00mm C X 1.50mm W 35.00mm Dia X 49.00mm H / THT / -	E1, E2	861011486024	Wurth Elektronik
36	1	FUSE CERAMIC 12.5A 250VAC 125VDC,5x20mm	F1	0001.2715.11	Schurter
37	1	Axial DC Fan	Fan	SJ4020HD1BPL	-
38	1	Fuse Holder Block, PCB Clip Cover, 18A, 250VAC	Fuse1	696101000002	Wurth Elektronik
39	1	Fixed Linear Voltage Post Regulator, 3.3V	G1	TLS202B1MBV33	Infineon Technologies
40	1	Standard Heatsink, FL16-023, 40x40x100mm	Heatsink	HS4040-100-U	Fengling
41	2	Horizontal Cable Entry With Rising Cage Clamp - WR-TBL, 3Pins	J1, J6	691216510003S	Wurth Elektronik
42	2	Connector, 2.54mm pitch, 8pins, Board to Board, Through Hole	J2, J8	61300821121	Wurth Elektronik
43	1	Terminal Block 4 Pin	J3	691210910004	Wurth Elektronik
44	2	Header, 2.54mm Pitch, 2 pin, Vertical, Single Row	J4, J7	61300211121	Wurth Elektronik
45	1	Terminal Block 5 Pin	J5	691210910005	Wurth Elektronik
46	1	IND / STD / 12mH / 10A / 50% / -40°C to 125°C / 15mR / THT / Inductor, THT, 4 pin, 23.00 mm L X 34.00 mm W X 33.00 mm H body / THT / -	L1	7448051012	Wurth Elektronik
47	1	IND / STD / - / - / - / - / - / THT / Inductor, THT; 6 pin, 38.00 mm L X 40.00 mm W X 40.00 mm H body / THT / -	L2	PI191035V1	POCO Holding Co., Ltd

Bill of material

48	1	IND / STD / 2.2uH / 2.5A / 20% / -40°C to 125°C / 71mR / SMD / Inductor, SMD; 2-Leads, 4.50 mm L X 4 mm W X 3.50 mm H body / SMD / -	L3	744773022	Wurth Elektronik
49					
50	1	Varistor (Voltage-Sensitive Resistor)	NTC1	B57703M502G40	TDK Corporation
51	1	RES / PTC / 56R / - / 25% / - / -40°C to 125°C / 2 Pin, 15.00 mm L X 7.50 mm W X 19.00 mm H body / - / -	PTC1	B59451C1130B070	TDK Corporation
52	1	HEXFET Power MOSFET VDS 30V	Q1	IRLML2030TRPbF	Infineon Technologies
53	6	TRENCHSTOP IGBT6	Q2, Q3, Q4, Q5, Q6, Q7	IKA15N65ET6	Infineon Technologies
54	1	Reverse-conducting IGBT with monolithic body diode, powerful monolithic diode optimized for ZCS applications	Q8	IKWH30N65WR6	Infineon Technologies
55	1	RES / STD / 5.1k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R1	CRCW06035K10FK	Vishay
56	1	RES / STD / 3.3k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R2	RC0603FR-073K3L	Yageo
57	7	RES / STD / 2k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 603 / SMD / -	R3, R4, R5, R6, R16, R17, R18	AC0603FR-072KL	Yageo
58	1	RES / STD / 51R / 500mW / 1% / 100ppm/K / -55°C to 155°C / 1210 / SMD / -	R7	CRCW121051R0FK	Vishay
59	6	RES / STD / 1MEG / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R8, R9, R12, R13, R55, R56	CRCW12061M00FK	Vishay
60	3	RES / STD / 20k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R10, R11, R57	CRCW060320K0FK	Vishay
61	4	RES / STD / 4.7k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R14, R15, R36, R39	RC0603FR-074K7L	Yageo

Bill of material

62	3	RES / STD / 100R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R19, R28, R29	RC0603FR-07100RL	Yageo
63	1	RES / STD / 1.2k / 100mW / 0.1% / 10ppm/K / -55°C to 155°C / 603 / SMD / -	R20	ERA3ARB122V	Panasonic
64	1	RES / STD / 5.1k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R21	CRCW06035K10FK	Vishay
65	3	RES / STD / 1k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R22, R23, R24	RC0603FR-071KL	Yageo
66	4	RES / STD / 2.2k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R25, R26, R30, R31	RC0603FR-072K2L	Yageo
67	8	RES / STD / 10k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R27, R37, R38, R46, R47, R48, R53, R54	RC0603FR-0710KL	Yageo
68	6	RES / STD / 200R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R32, R33, R42, R43, R49, R50	CRCW0603200RFK	Vishay
69	6	RES / STD / 27R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R34, R35, R44, R45, R51, R52	CRCW060327R0FK	Vishay
70	1	RES / STD / 100R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R40	CRCW0603100R0FK	Vishay
71	1	RES / STD / 15R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R41	CRCW060315R0FK	Vishay
72	3	RES / STD / 3MEG / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R58, R59, R60	CRCW12063M00FK	Vishay
73	1	RES / STD / 62k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R61	CRCW060362K0FK	Vishay
74	3	RES / STD / 15MEG / 250mW / 5% / 200ppm/K / -55°C to 155°C / 1206 / SMD / -	R62, R63, R64	RC1206JR-0715ML	Yageo
75	1	RES / STD / 4.7R / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R65	CRCW12064R70FK	Vishay

76	1	RES / STD / 68k / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	R66	CRCW120668K0FK	Vishay
77	1	RES / STD / 510k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R67	CRCW0603510KFK	Vishay
78	1	RES / STD / 820R / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R68	CRCW0603820RFK	Vishay
79	1	RES / STD / 0R / 100mW / 0R / 0ppm/K / -55°C to 155°C / 0603 / SMD / -	R69	RC0603JR-070RL	Yageo
80	1	RES / STD / 1.5k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R70	RC0603FR-071K5L	Yageo
81	1	RES / STD / 22k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R71	CRCW060322K0FK	Vishay
82	1	RES / STD / 48.7k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R72	CRCW060348K7FK	Vishay
83	1	RES / STD / 9.76k / 100mW / 1% / 100ppm/K / -55°C to 155°C / 0603 / SMD / -	R73	CRCW06039K76FK	Vishay
84	1	RES / STD / 30R / 500mW / 1% / 100ppm/K / -55°C to 155°C / 1210 / SMD / -	R74	CRCW121030R0FK	Vishay
85	2	RES / STD / 5.1R / 250mW / 1% / 100ppm/K / -55°C to 155°C / 1206 / SMD / -	RS1, RS2	CRCW12065R10FK	Vishay
86	1	RELAY GENRAL PURPOSE SPST 20A 12V	RY1	G4A-1A-PE 12VDC	Omron
87	12	Test Point THT, Black	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP10, TP11, TP12	5001	Keystone Electronics Corp.
88	1	Flyback Transformer , Offline aux SMPS for server, PC power applications	TR1	750344226	Wurth Elektronik
89	1	Motor controller with integrated high-voltage gate driver, integrated	U1	IMD112T-6F040	Infineon Technologies

		script engine for application control customization, Thin-film-SOI-technology with negative transient robustness, Built-in temperature sensor			
90	2	High-precision coreless current sensor	U2, U4	TLI4971-A025T5-E0001	Infineon Technologies
91	1	Gate drivers LOW SIDE DRIVERS	U3	1ED44175N01B	Infineon Technologies
92	1	Fixed-frequency 700 V/800 V CoolSET, lowest standby power <100 mW	U5	ICE5GR4780AG	Infineon Technologies
93	1	Optocoupler, Phototransistor Output, High Reliability, 5300 VRMS, 110°C Rated	U6	SFH617A-3X007T	Vishay
94	1	Precision Programmable Reference	U7	TL431CDBZR	Texas Instruments
95	1	Zener Diode with Surge Current Specification	ZD1	BZD27C22P-HE3-08	Vishay

6 System performance evaluation results

The following chapter describes the test bench results for the different functional blocks.

Equipment

- IR camera: FLIR310A
- Scope: Tek3054
- Motor: GK6063-6AC31
- Power meter: Tektronix PA1000

Software

- IRC file: IMD112T_V1.03.03
- Firmware: IMD112T-F040_A_V1.03.03.ldf

6.1 Auxiliary power supply test

Specification

- 15 V ±1 V, 3.3 V ±5%, 5 V ±5%

Table 6 Auxiliary power supply

15 V (V)	3.3 V (V)	5 V (V)
14.89	3.302	4.997

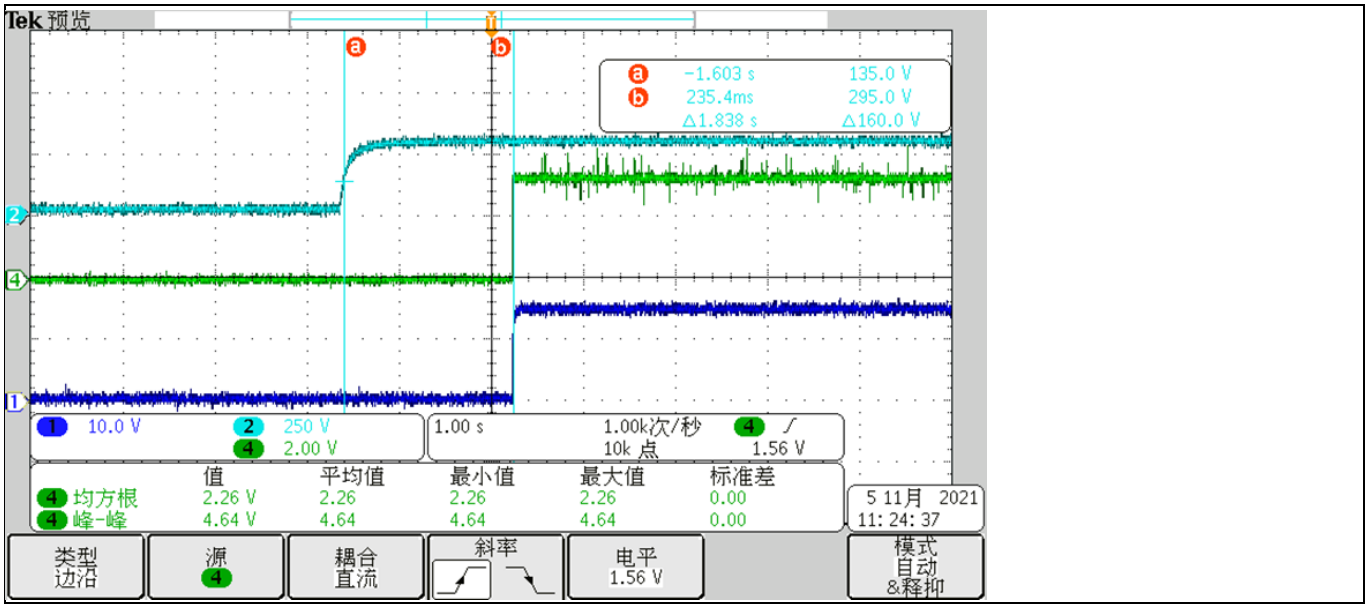


Figure 17 Auxiliary power supply

6.2 PFC test

Specification

- PF >0.9, iTHD <3% @full load, 220 V_{ac} input
- Input voltage range: 165 ~ 265 V_{ac}

System performance evaluation results

- Maximum input power 1200 W

Table 7 PFC test

Input voltage (V_{ac})	Input current (A_{rms})	Input power (W)	DC bus voltage (V)	PF	iTHD (%)	vTHD (%)	Phase current (A_{rms})	Tcase-PFC IGBT (°C)	Tcase-INV IGBT (°C)	Ta (°C)	Picture
165	3.636	593	378.5	0.986	2.167	2.209	3.86	56.7	51	22.1	Figure 18
165	7.356	1215	378.5	0.997	1.7	2.2	5.27	92.7	71.3	22.3	Figure 19
220	2.835	597	378.5	0.956	8.79	1.92	4	47.5	48.1	19.3	Figure 20
220	5.558	1202	378.5	0.988	2.155	1.863	5.11	72.6	61.1	19.8	Figure 21
265	2.362	588	378.5	0.937	14.3	2.45	3.78	45.5	47.9	21.6	Figure 22
265	4.704	1203	378.5	0.974	4.516	2.337	5.05	66.8	62.7	22.6	Figure 23

Legend

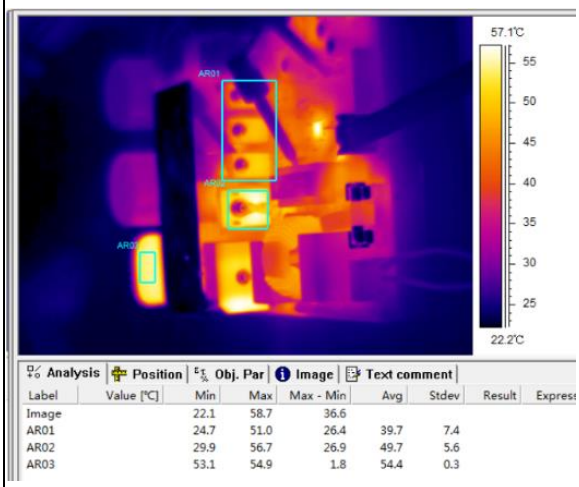
- CH2: DC bus voltage (blue)
- CH3: AC line input (purple)
- CH4: line current (green)

Condition

- Typical PWM setup for: 40 kHz PFC and 6 kHz motor PWM, 3-phase-only mode, motor speed: max. 2500 rpm for GK6063 motor
- PFC control parameters: KpI = 2800, KxI =9000, KpV = 1000, KxV = 50

Results

- PF = 0.988 and iTHD = 2.155% @ 1200 W input power and 220 V_{ac} input



AR01: Inverter IGBT case temperature
AR02: PFC IGBT case temperature
AR03: PFC choke temperature

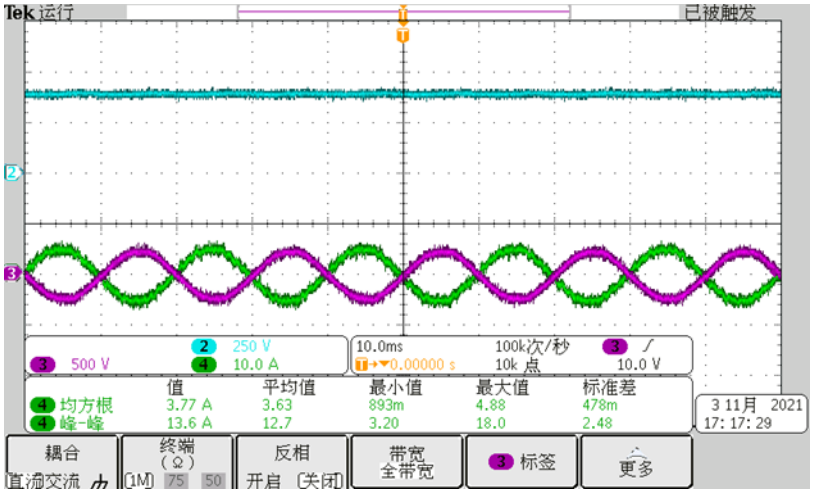


Figure 18 165 V_{ac} input and half-load test

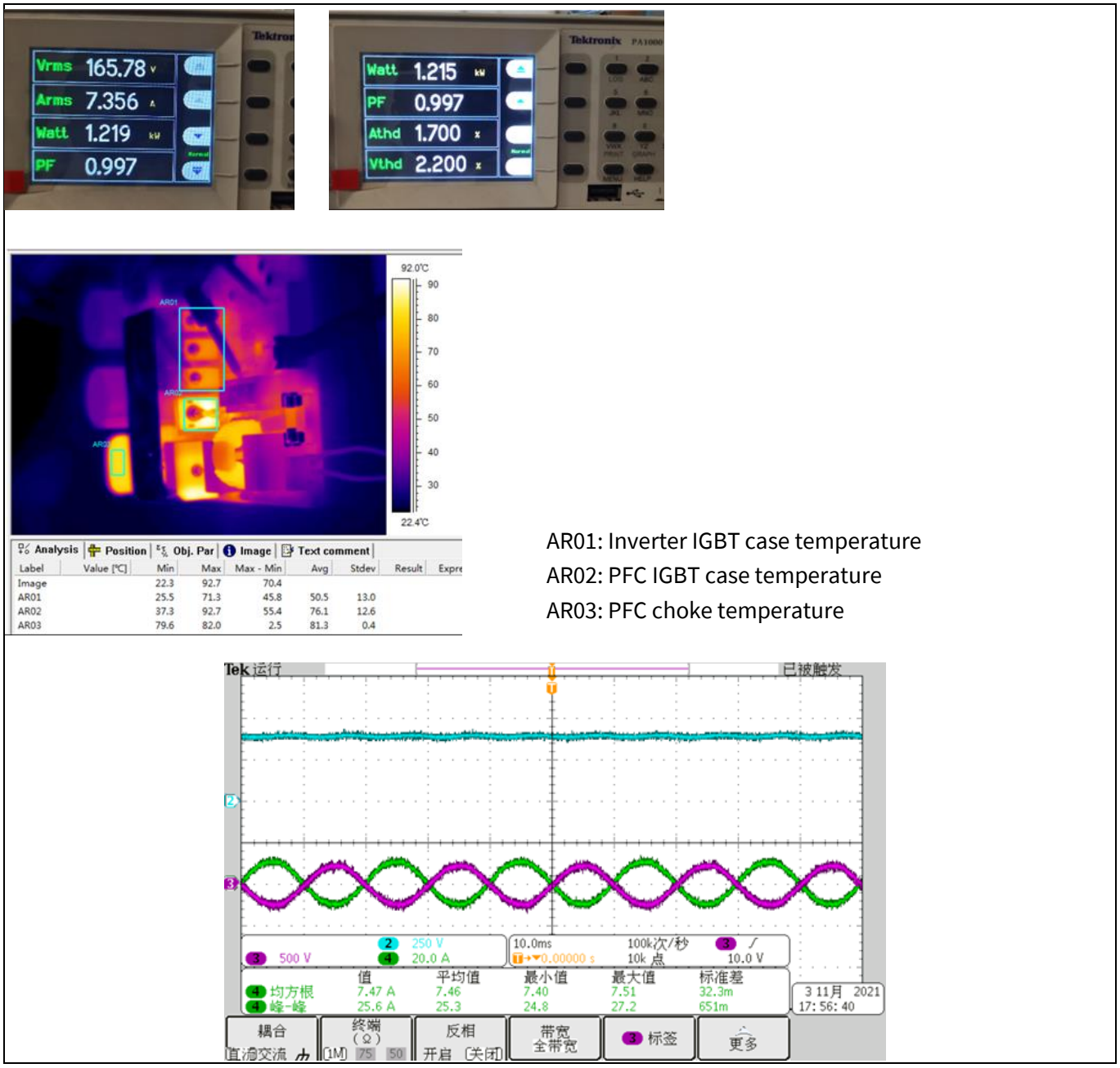


Figure 19 165 V_{ac} input and full-load test

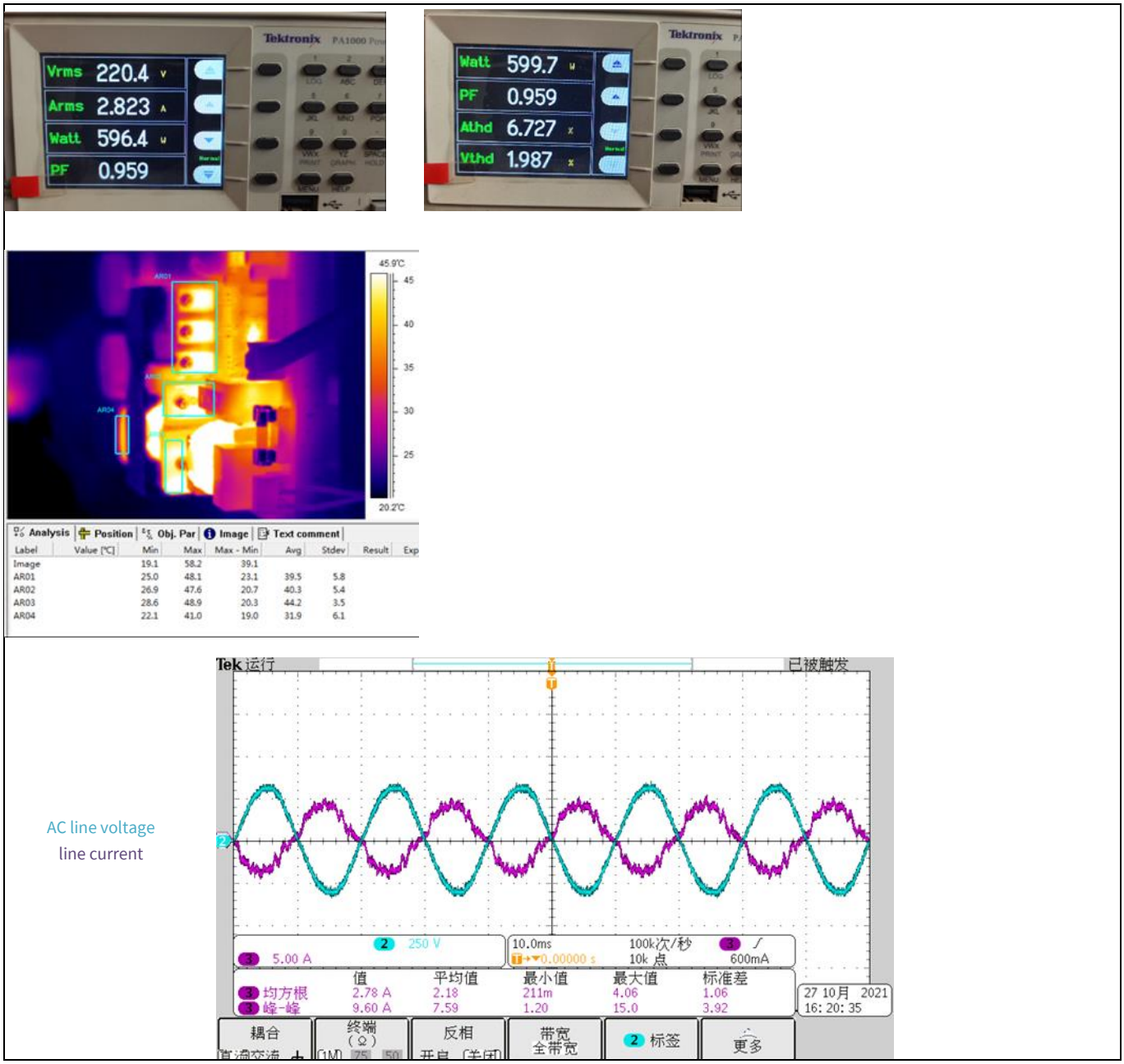
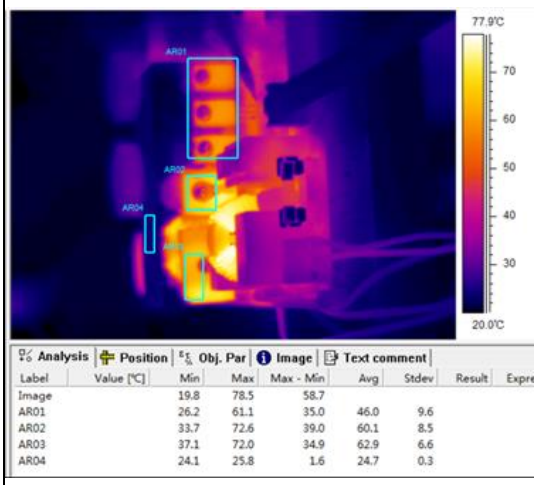


Figure 20 220 V_{ac} input and half-load test



AR01: Inverter IGBT case temperature
AR02: PFC IGBT case temperature
AR03: Rectifier bridge
AR04: PFC choke

AC line voltage
line current

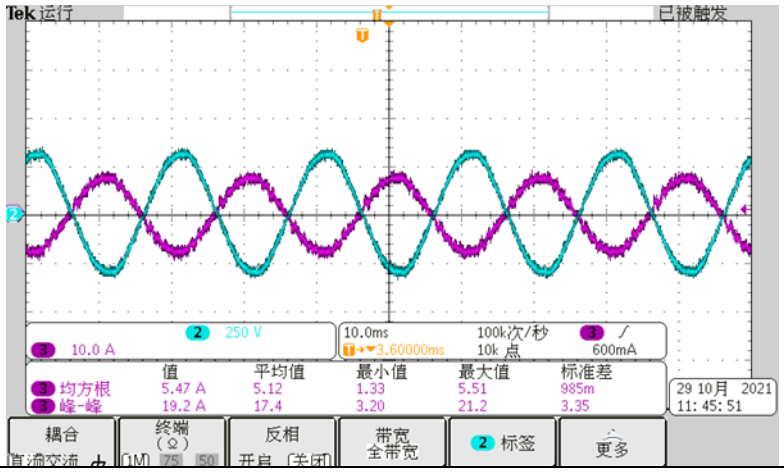
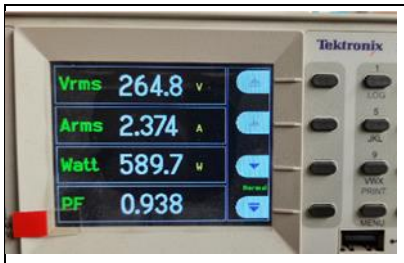
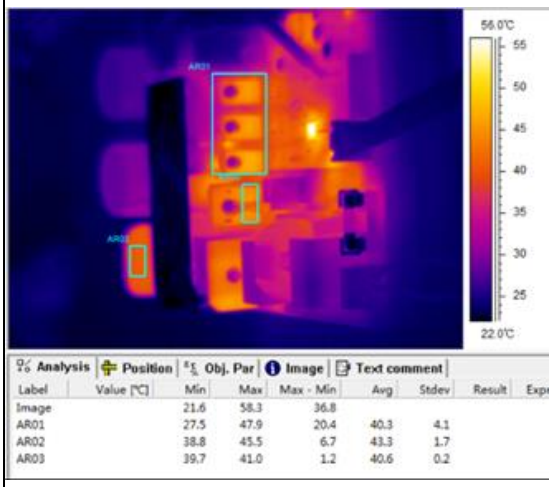


Figure 21 220 V_{ac} input and full-load test





AR01: Inverter IGBT case temperature
AR02: PFC IGBT case temperature
AR03: PFC choke temperature

AC line voltage
line current

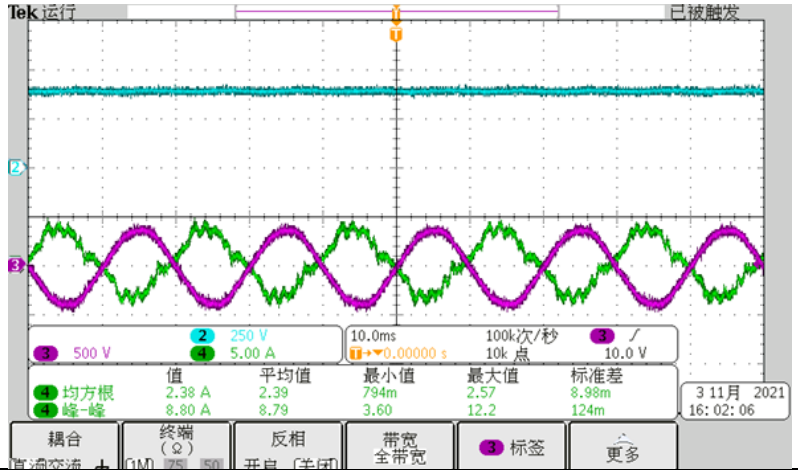


Figure 22 265 V_{ac} input and half-load test

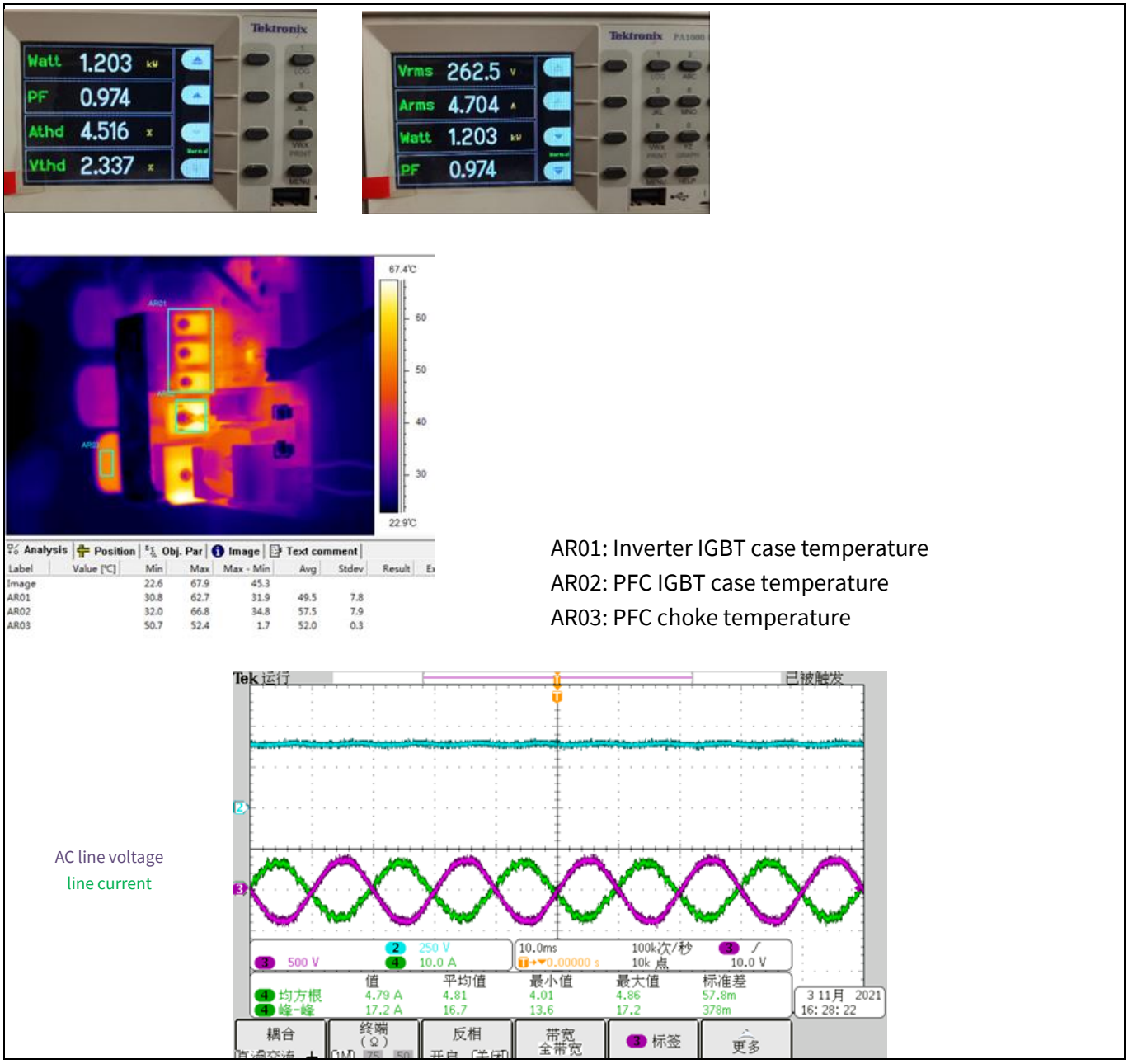


Figure 23 265 V_{ac} input and full-load test

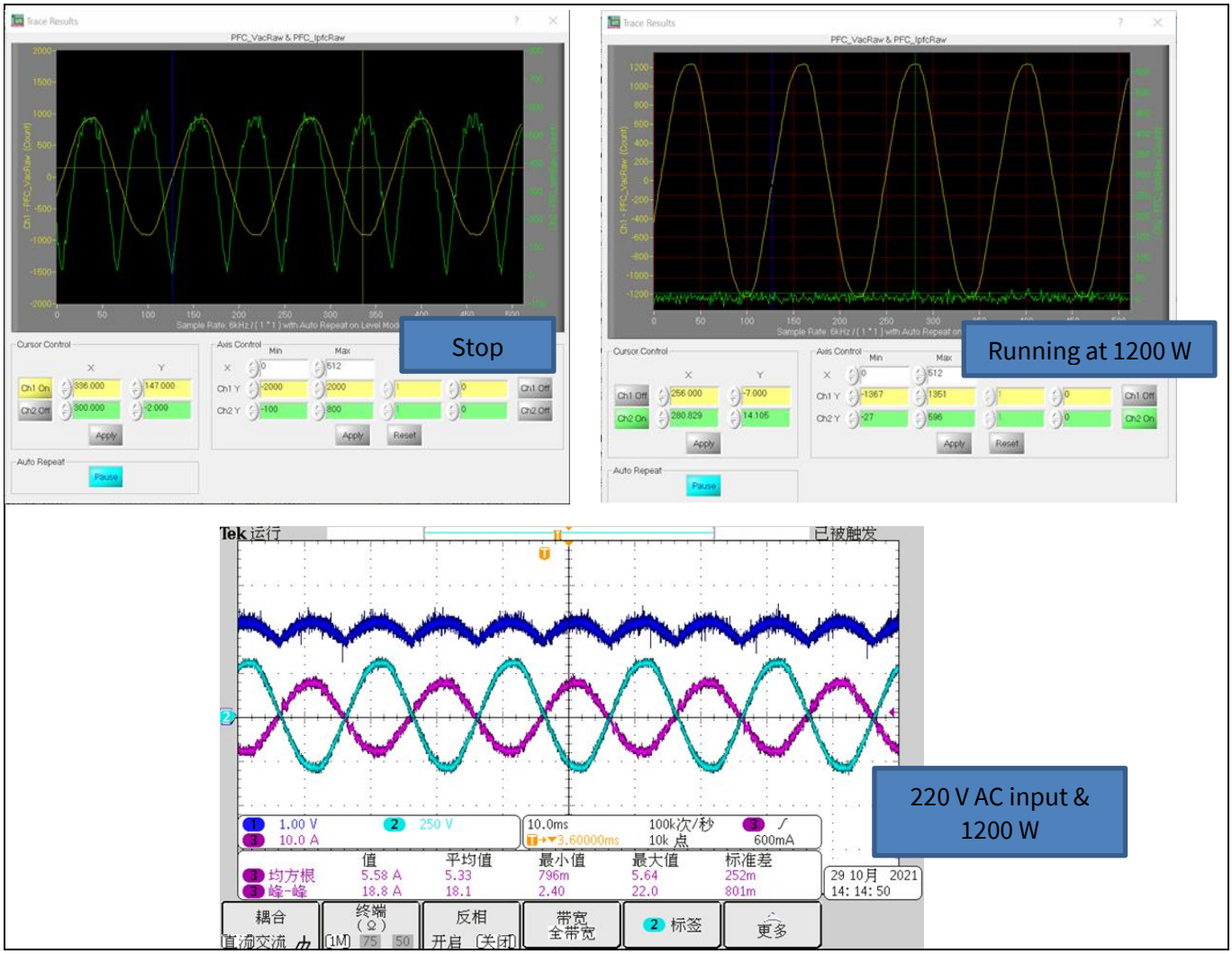


Figure 24 PFC MCE trace and scope waveforms for line current/voltage and PFC current feedback

6.3 Inverter test

Specification

- P_{out} <1500 W

Table 8 Inverter test

PWM (loop rate)	MCE usage (by wizard)	Test result
PFC: 40 kHz motor: 6 kHz	65%	MCE trace noise <15 cnts at static motor phase current is 5 A_{rms} at 1200 W load

Condition

- Motor PWM frequency: 6 kHz, 3-phase-only mode, motor speed: maximum 2500 rpm for GK6063 motor
- PFC control parameters: KpI = 868, KxI =347, KpV = 64, KxV = 31

Result

- P_{out} is up to 1200 W with full pack IGBT IKA15N65ET6

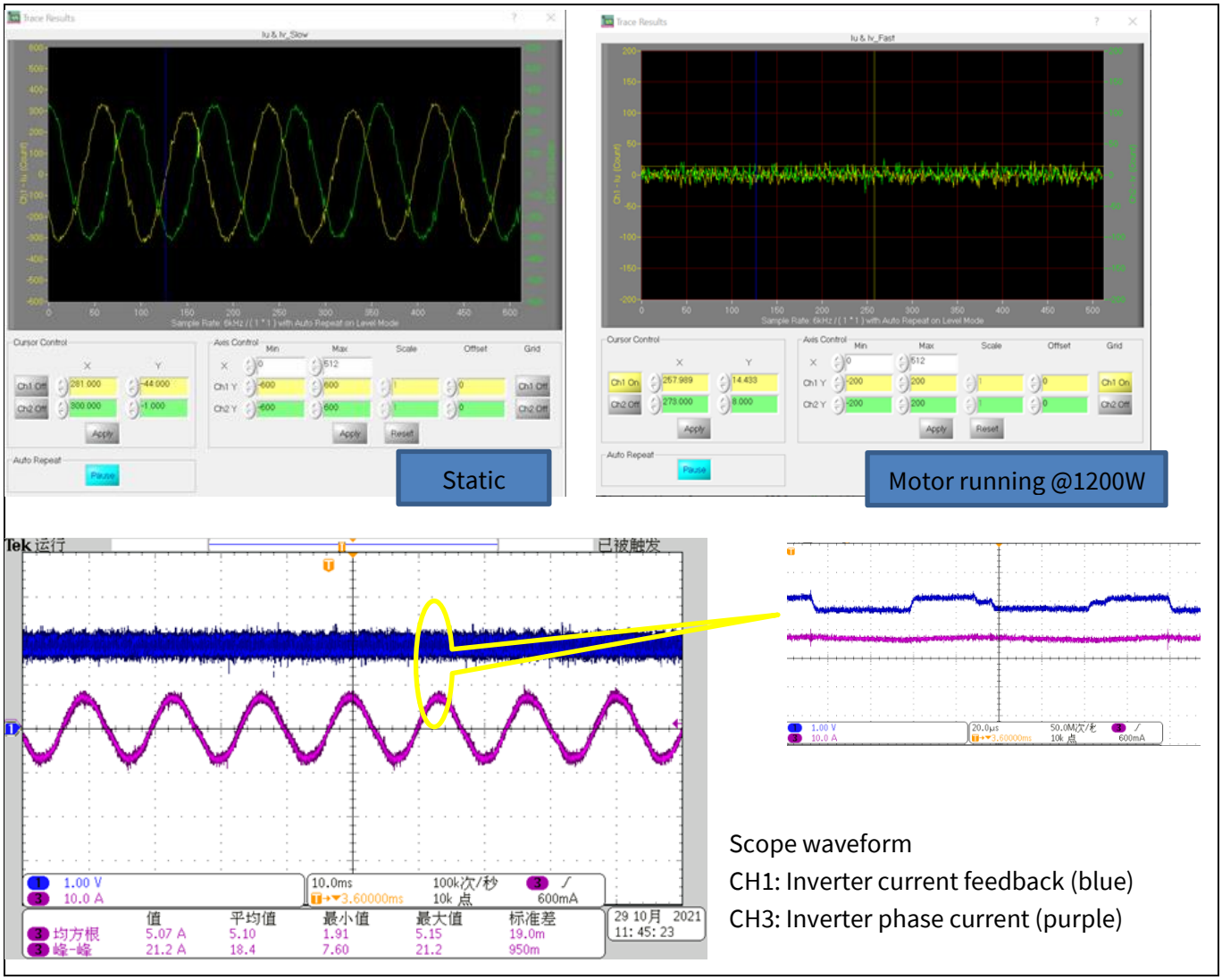


Figure 25 Inverter current waveforms

6.4 dv/dt test

Specification

- Inverter dv/dv is less than 5 V/ns

Table 9

PFC dv/dt on	PFC dv/dt off	INV dv/dt on	INV dv/dt off
10.8 V/ns	3.8 V/ns	3.6 V/ns	2 V/ns
Figure 26		Figure 27	

Condition

- PFC: turn on Rg = 100 Ω, turn off Rg = 15 Ω
- INV: turn on Rg = 200 Ω, turn off Rg = 27 Ω

Result

- Inverter dv/dt is less than 5 V/ns

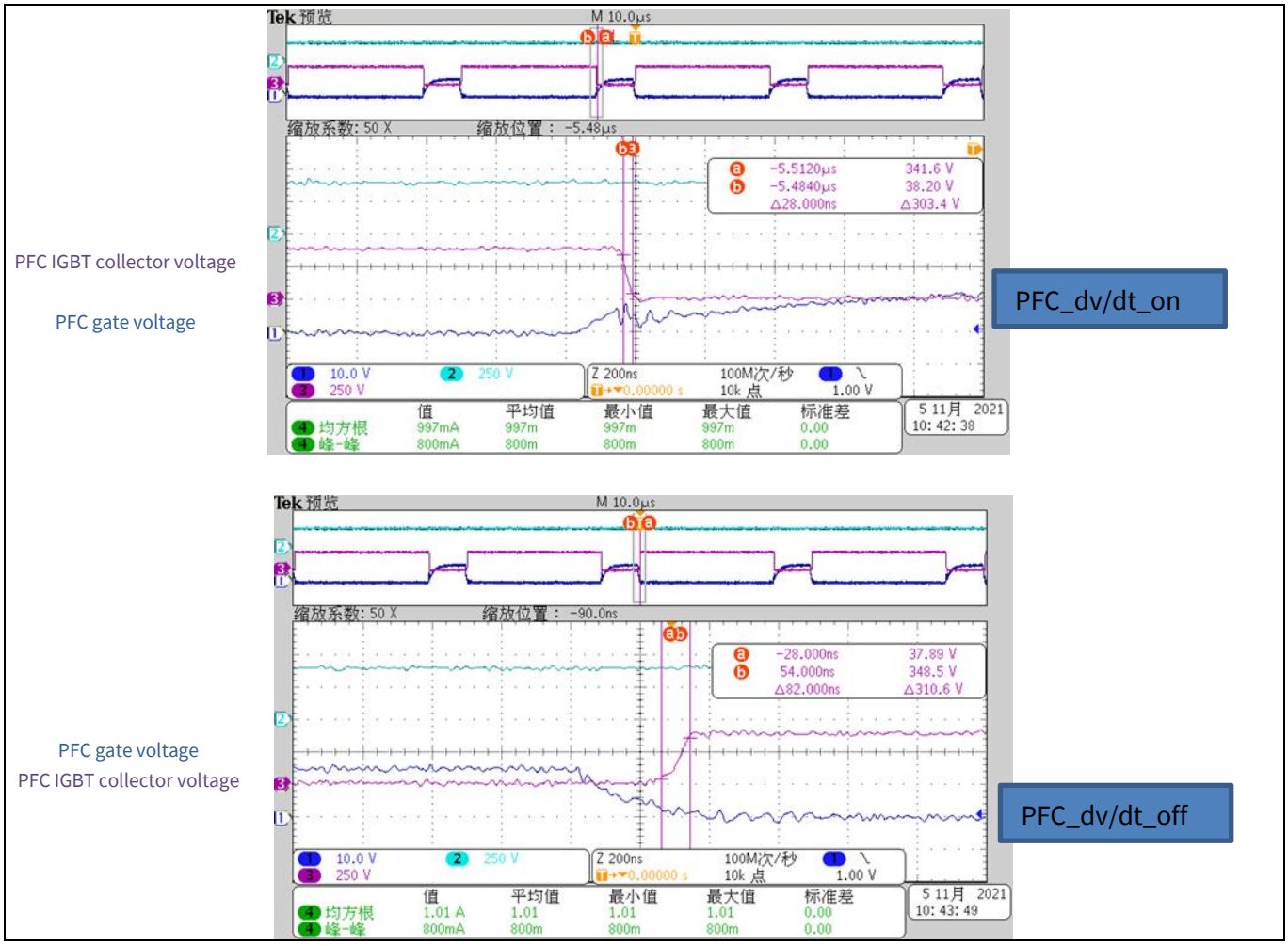


Figure 26 PFC dv/dt test

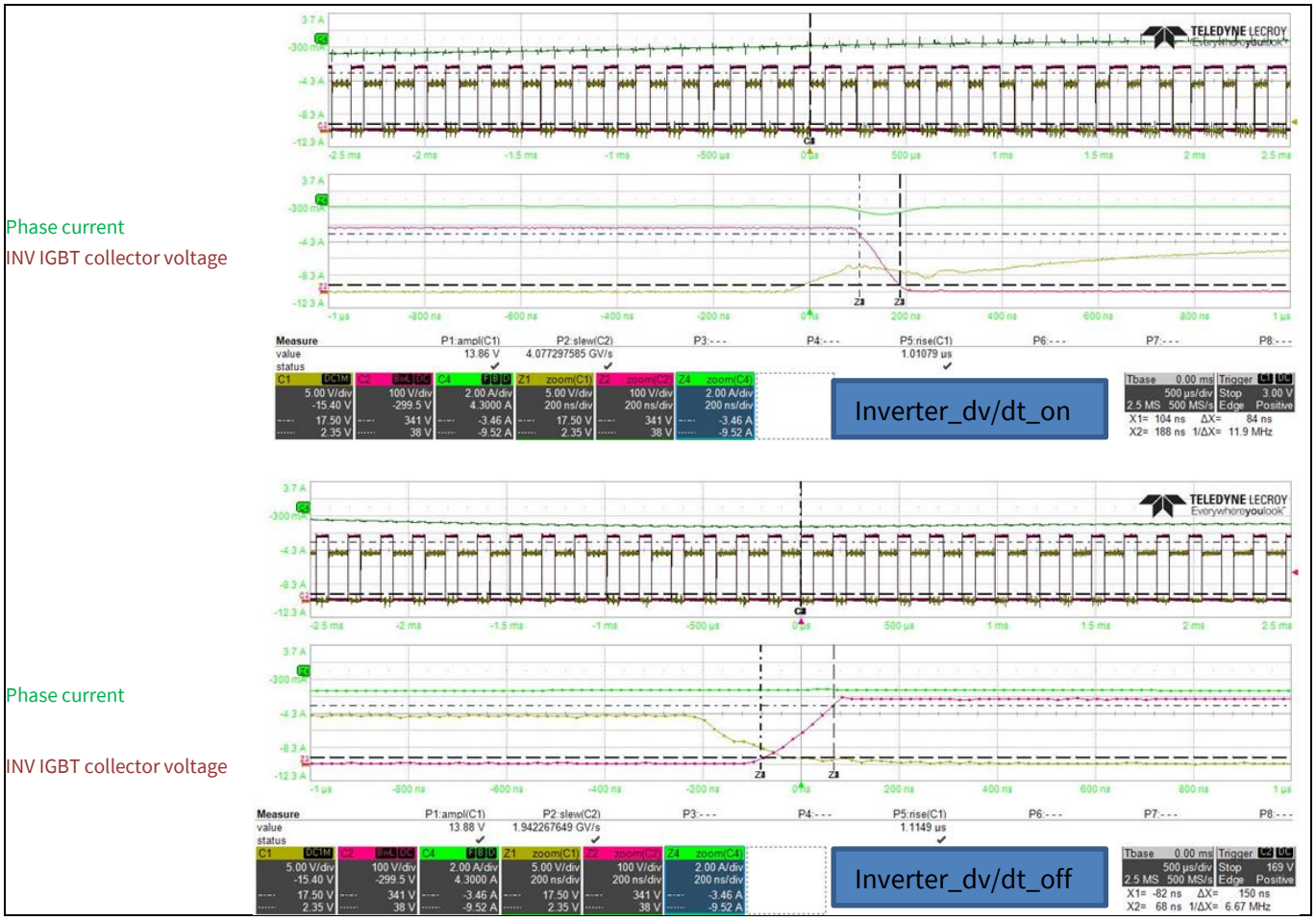


Figure 27 Inverter dv/dt test

6.5 Protection test

6.5.1 Inverter short-circuit/overcurrent protection

Condition

- Short-circuit inverter output U, V with 1 m wire. Start the motor on MCEDesigner

Result

- Protected properly, MCEDesigner motor indicates Gate Kill fault red flag

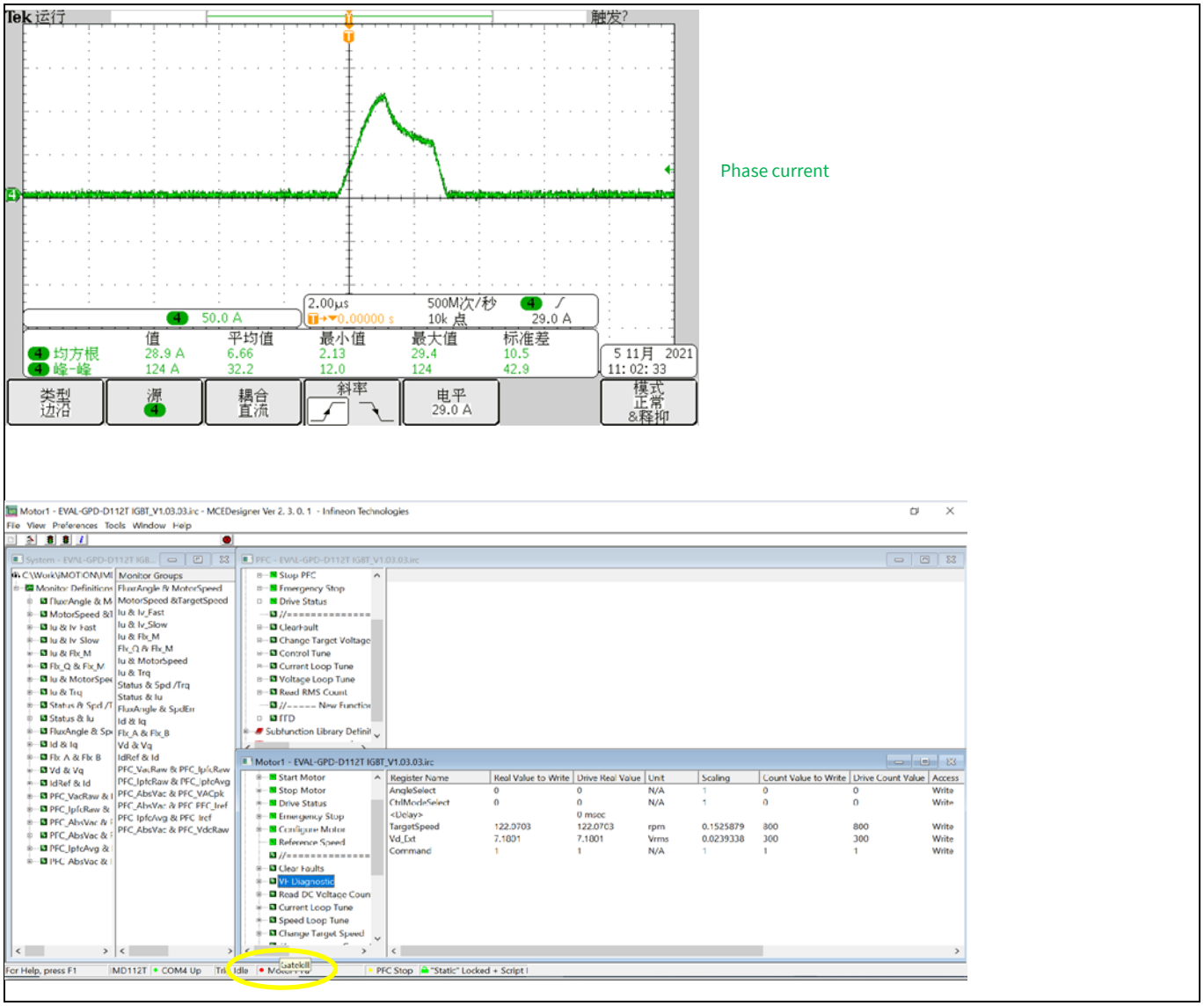


Figure 28 Inverter short-circuit protection

6.5.2 PFC overcurrent protection

Condition

- 15 V and 3.3 V power up, and add a PWM signal to 1ED44175 input pin, then AC line powers up. The inrush current will trigger the TLI4971 overcurrent protection.

Result

- Set OCD1 threshold is 1.2-time scaling. So, the OCD1 output was pulled down when the current reached at 25 x 1.2 = 30 A

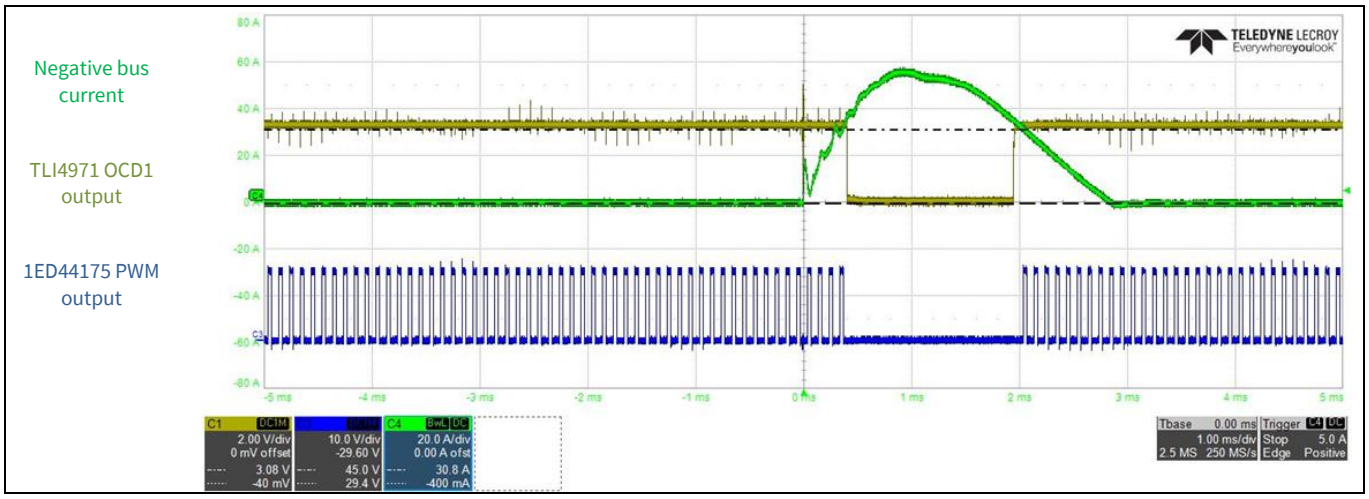


Figure 29 PFC overcurrent protection test

6.6 NTC character test

Table 10

Measured voltage crossed on NTC (V)	PFC IGBT case temperature (℃)
1.699	21.2
1.485	31.6
1.201	41
0.958	50.7
0.83	56.7
0.621	68.9
0.471	79.9
0.345	92.7

Condition

- NTC #: B57703M502G40, TDK, 5 kΩ, mounted on the surface of PFC IGBT

Revision history

Document version	Date	Description of changes
V1.0	2022-04-01	User guide-initial release

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Edition 2022-04-01

Published by

Infineon Technologies AG

81726 Munich, Germany

Do you have a question about this document?

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Document reference
UG-2021-42

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