BUBELA
Power Electronics

SIEMENS SINAMICS

TESTER S1

User Manual

Contents

1. Legal information

1.1. Safety instructions

This manual contains instructions that you must follow to ensure your personal safety and to prevent damage to property. Instructions relating to your personal safety are marked with a warning triangle; instructions relating solely to damage to property are shown without a triangle. Warning notices are listed in descending order of severity as follows.

DANGER	Means that death or serious injury may result if the appropriate safety measures are not taken.

CAUTION	With a warning triangle indicates that minor injury may occur if appropriate safety measures are not taken.

CAUTION	Without a warning triangle indicates that property damage may occur if appropriate safety measures are not taken.

NOTICE	Indicates that an undesirable result or situation may occur if the relevant instruction is not followed.

Where there are several levels of risk, the warning with the highest level always applies. If a warning with a warning triangle warns of personal injury, the same warning may also include a warning of property damage.

Qualified personnel

The relevant equipment/system described in this documentation may only be operated by qualified personnel authorised for the task in question and in accordance with the relevant documentation. In particular, warnings and safety instructions must be observed. Qualified personnel are persons who, on the basis of training and personal experience, are able to identify risk factors and avoid potential hazards when working with these devices/systems.

Disclaimer

To ensure that this publication remains consistent with the current hardware and software of the products, we have revised its content. We reserve the right to make changes to the publication; full consistency with the current status cannot be guaranteed. The information in this publication is regularly updated, and any corrections are included in subsequent editions.

Safety warnings

DANGER

- Do not use the device in dusty, explosive or damp environments.
- Before use, ensure that the insulation of the connecting cables is in good condition and that it is not damaged or broken.
- Do not touch live parts of the device under test unless its main switch is turned off.

WARNING

- Take extra care when working with voltages exceeding 60V DC. There is a risk of electric shock.
- Do not use the device if it is damaged or if parts of the casing have been removed.
- Use only undamaged connecting leads with a dielectric strength of at least 1000V.

2. Introduction

The tester is designed to verify the functionality of selected electrical and electronic components of SIEMENS SINAMICS converters of the G130, G150, S120 Chassis, S120 Cabinet Modules, S150 and MISCROMASTER Chassis series. The device enables diagnostic and functional tests of sensors and internal signal interfaces of the drive without the need to put the power section into operation. The tester is designed as a portable service device intended for use during servicing or maintenance of the equipment.

The tester has the following features (tests):

- IGBT transistor switching test
- Converter current sensor test
- Temperature sensor test
- Fan switching test
- Rectifier switching test
- Measurement of IGBT saturation voltage (only when using SINAMICS TESTER SW)
- Option to connect a power supply for IGBT tests

3. Terminology

CIM	Converter unit forming the interface between the power and control sections
CU320	Converter control unit
DCN	Negative pole of the inverter DC link
DCP	Positive pole of the inverter DC link
IGBT	power semiconductor used in the inverter's switch to switch the DC link voltage and generate the output voltage for the motor
IGD	IGBT Gate Driver, an electronic circuit that controls the gate of the IGBT transistor, provides galvanic isolation of the control section and performs protective functions for the power stage

IPD	Interface Power Device, an internal converter module for connecting and evaluating current sensor signals
IGBT module	Power module containing IGBT transistors, their drivers and protective circuits.
I OUT +	Current loop output for testing current sensors **I OUT -**
	Current loop input for testing current sensors PM Power

module – converter itself

RS485	RJ45 connector for communication with a PSVD-type DC power supply
U11	L1 phase optical cable connector
U21	Phase L2 optical cable connector
U31	Phase L3 optical cable connector
UDC +	Input terminal for measuring DC link voltage DCP **UDC**
-	Input terminal for measuring DC bus voltage DCN **UIN1**
	Input terminal for measuring the voltage of the L1

phase converter **UIN2** Input terminal for measuring the voltage of the L2

phase converter **UIN3** Input terminal for measuring the voltage of the L3

phase converter **USB** Micro USB connector for PC connection

X204	Connector for controlling the converter's thyristor rectifier
X271	Connector for connecting the IGD driver power supply
X272	Connector for switching the inverter fan
X31	Temperature sensor connector
X32	Temperature sensor connector for higher-power inverter variants
X43	Connector for current sensors

4. Description

WARNING

- The tester is intended for use when the inverter's power supply is disconnected.
- Testing is carried out using internal test signals with limited power and is not intended for load testing of the inverter's power section.
- The tester is intended for use by qualified personnel with knowledge of the design and function of SINAMICS S120 converters.

The tester is a portable service device powered by an external 24 V DC adapter, designed for the diagnostics of SINAMICS S120 inverters. It is equipped with connectors corresponding to the CIM module interface, measurement inputs and the output of an integrated test current generator.

Operation is via a touchscreen display, control buttons and a rotary control, enabling convenient operation during testing.

It is equipped with magnetic feet allowing it to be attached to steel parts of the drive cabinet, such as the cabinet door.

The basic components of the tester are shown in Fig. 1; the following figures show the connection connectors.

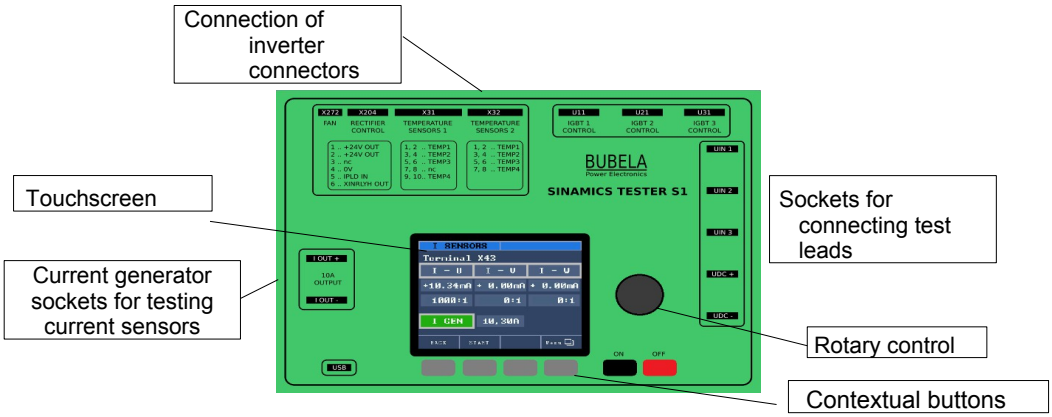

Fig. 1 Basic components of the tester

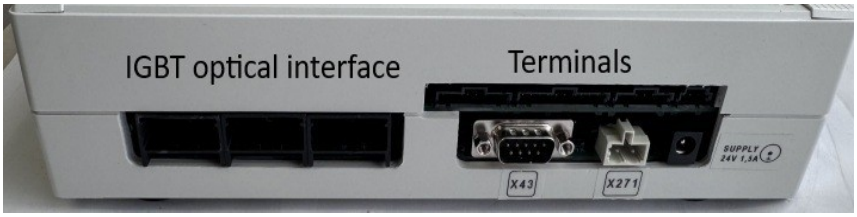

Fig. 2 Rear view – connection sockets

Fig. 3 Terminals for connecting the IGBT switching test and saturation voltage measurement

Fig. 4 Current generator terminals for testing current sensors

5. Controls

The tester is equipped with a fully graphical touchscreen display. It can be operated by touching the screen or, alternatively, using the black rotary control wheel. The rotary wheel also serves as a confirmation button.

The four grey buttons located below the display change their function according to the description shown on the display above the relevant button. The ‘ON’ and ‘OFF’ buttons are used to activate or deactivate the respective test selected on the display.

For basic tests Basic control of the power supply is via four context-sensitive buttons and a rotary control. Some functions are also accessible via the resistive touchscreen.

The power supply output is switched on and off using the “ON” and “OFF” buttons.

The current test being performed is shown in the upper blue square, and the status of the tester is shown in the upper green square. The field changes colour to red in the event of a tester fault or if certain conditions are not met, see Fig. 5.

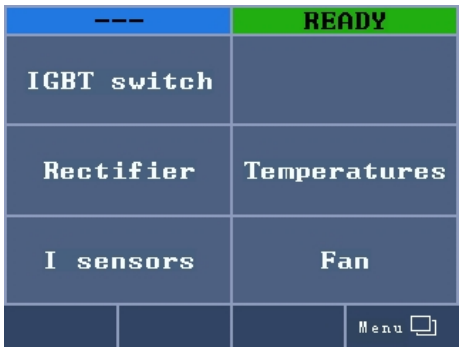

Fig. 5 Home screen for selecting individual tests

Basic tests can be performed using only the tester; however, to measure the saturation voltage of an IGBT, it is necessary to use a computer equipped with the appropriate software.

The following chapter describes testing using only the tester; saturation voltage measurement is described in Chapter 8.

5.1. Connection to a computer

The tester can also be controlled via an application on a Windows computer. Advanced tests, such as saturation voltage measurement, can only be performed via a computer. The tester connects to the computer either via a USB interface or wirelessly via WiFi.

Connection via USB

1. Connect the tester to the computer using a cable with a micro USB connector on the tester side.
2. Once the tester is powered on, a COM port should be automatically installed on the computer.

Connection via WiFi

1. On your computer, select the WiFi network named TESTER-S-xxx, where xxx is the tester's serial number.
2. Enter the authorisation password "password".
3. Once connected, the computer will report that there is no internet connection, which is normal.

S-TESTER application

1. Launch the S-TESTER PC program.
2. Select the connection method, USB COM port or WiFi (the default IP address is 192.168.4.1).

Note: The connection labelled Simulation is used to familiarise yourself with the application's operation even without a connected tester and the converter under test.

3. Select Connect.
4. The connection status is indicated in the bottom left corner: .

Connecting the capacitor charging source

The tester allows connection to a PSVD-1K-1000V type capacitor forming power supply. It is connected using a standard patch cable to the RJ45 connectors on the tester and power supply labelled RS485.

The tester automatically recognises the connected source and allows it to be controlled via the PC application. The use of the source is particularly important during saturation voltage measurement tests, when the tester automatically sets the source voltage and controls its output.

6. Preparation for testing

Removing the CIM

The Sinamics Tester is connected in place of the CIM card. The connectors used on the CIM card are connected directly to the tester. The X43 connector from the current sensors must be removed from the IPD. See figures.

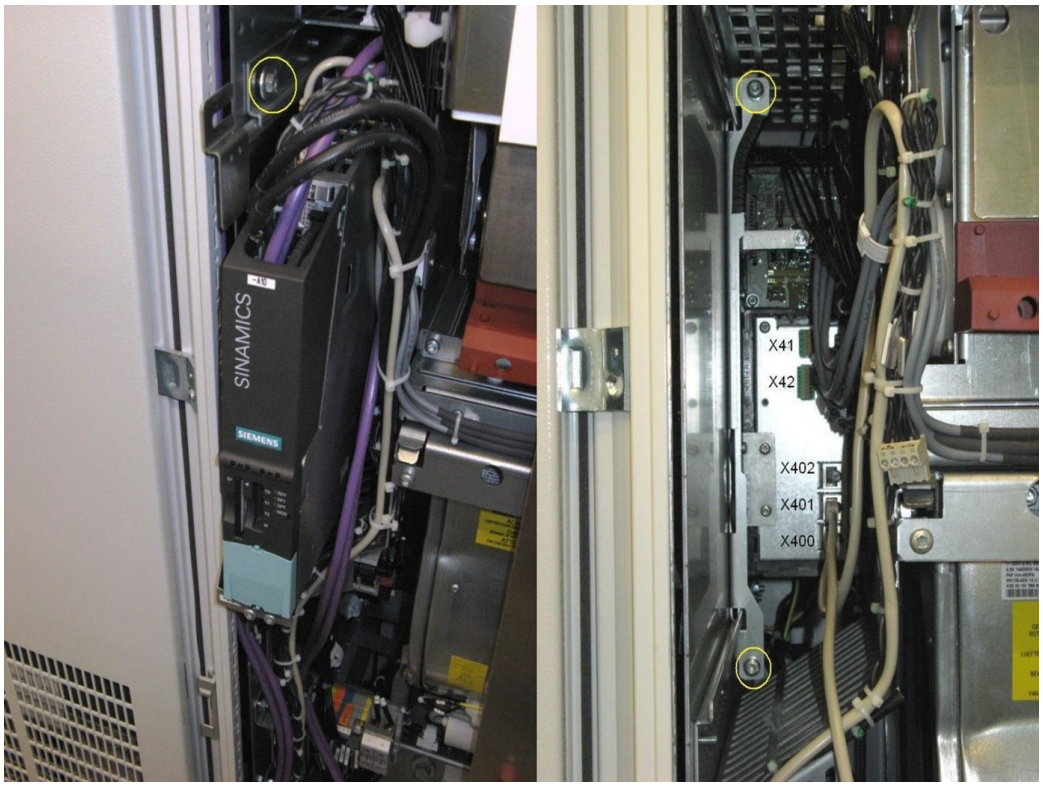

Fig. 6 Procedure for removing the CIM

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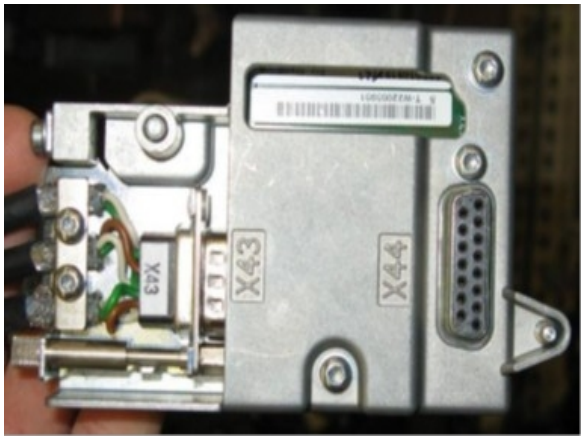


Fig. 7 Fan switching test

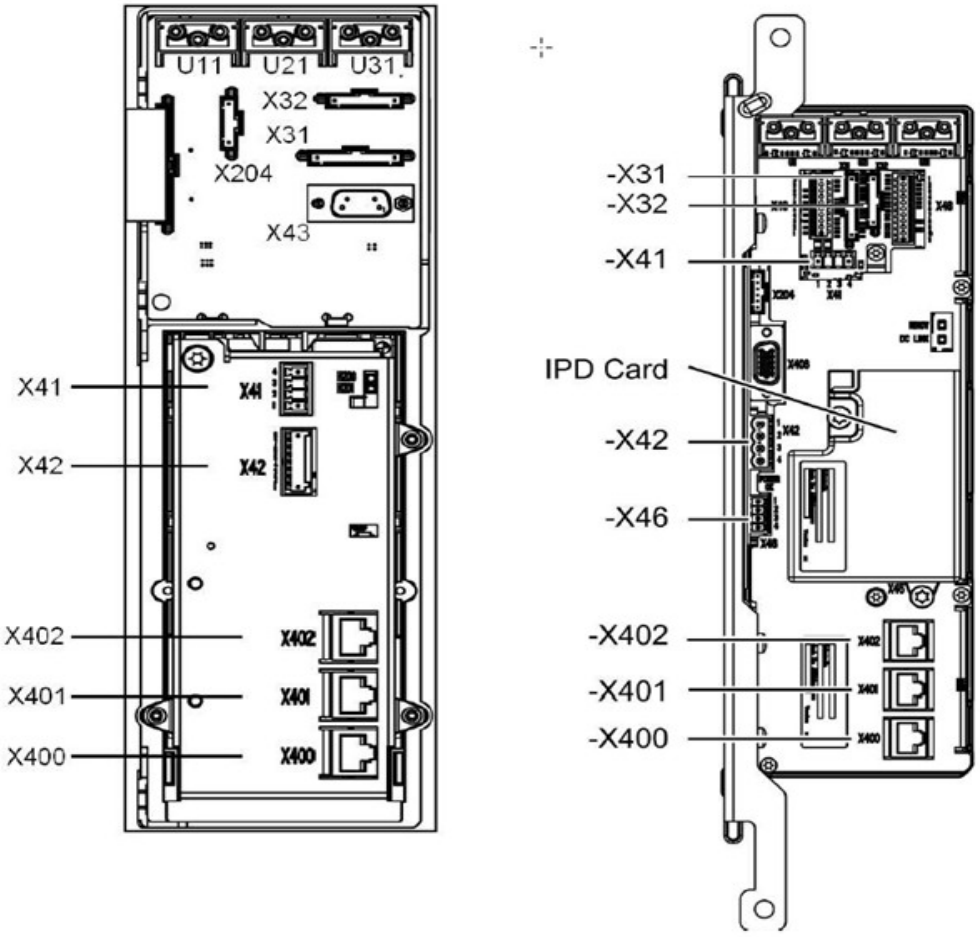


Fig. 8 - Description of connectors on the CIB module (left) and CIM module (right)

WARNING	It is recommended to disconnect all connectors from the CIM/CIB card, particularly X60 (DC link measurement) and X9 (24 VDC power supply for the CIM/CIB card). Otherwise, the card would be powered unnecessarily and draw current from the tester's VDC source.

WARNING	When testing S120, S150, and G150 parallel units, it is recommended to disconnect all power supplies to other untested modules/blocks. In the G150 converter, for example, disconnect terminal block X9 (the orange terminal block at the bottom left). For large S120 converters, it is also necessary to consider isolating the DC links of the other modules. This is not a requirement, but it is important to bear in mind that the tester or VDC source must always charge the DC link of the untested blocks/modules as well.

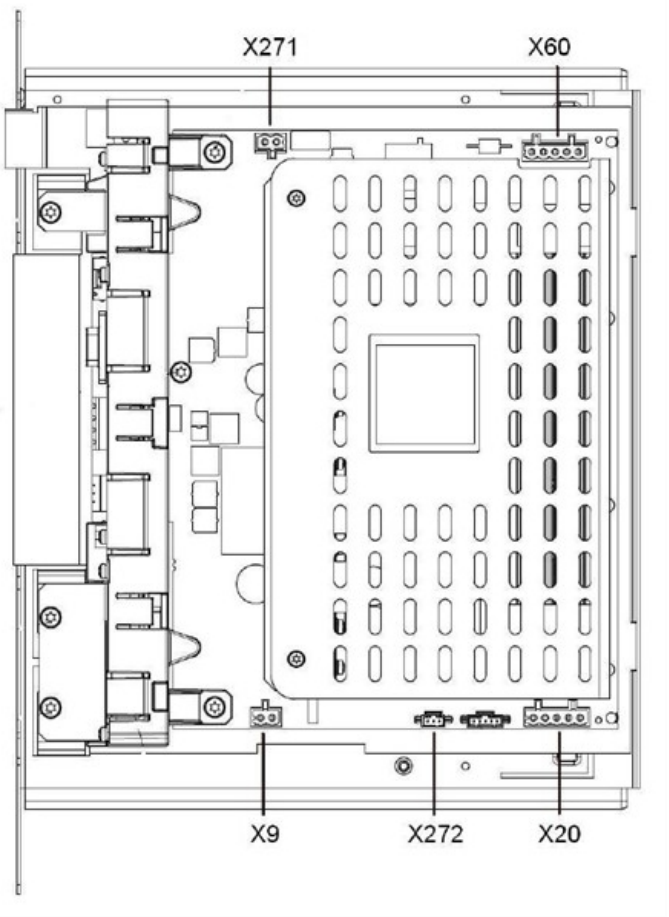


Fig. 9 Description of other connectors on the CIM module

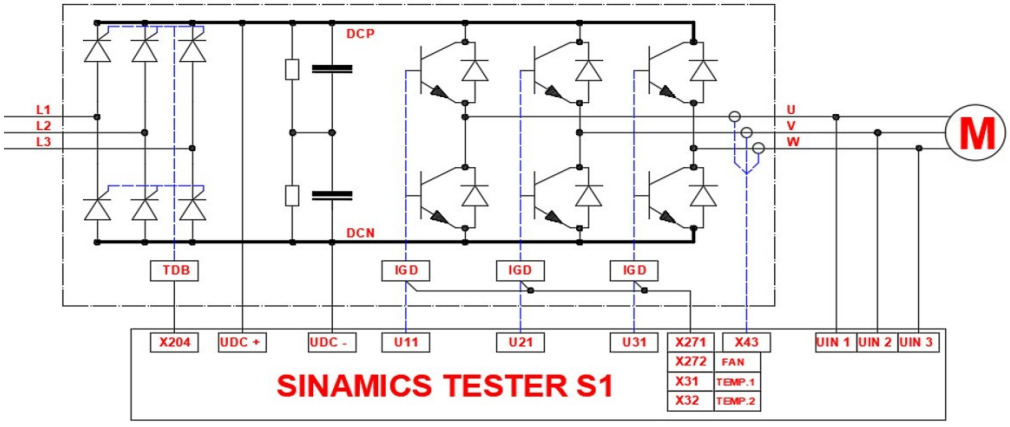


Fig. 10 Block diagram of the Tester connection to the converter's power section

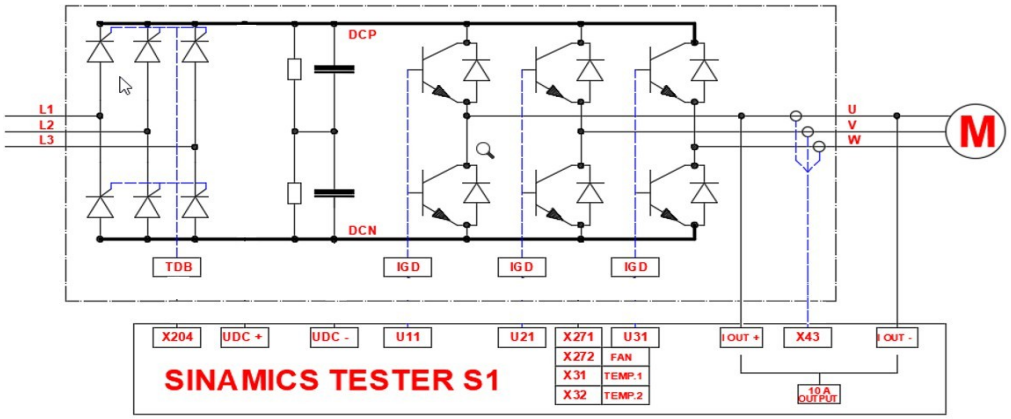


Fig. 11 Block diagram of the Tester connection to the inverter power block for testing current sensors

The wiring diagram shown in Fig. 10 is based on the standard inverter wiring. In this configuration, the Schopen tester is capable of fully testing the entire power section.

The wiring diagram shown in Fig. 11 is for testing current sensors. This test is necessary to determine the exact ratio of the current transformers and it is recommended to perform it on at least one phase (the Tester will then store the ratio for all three phases). The figure is illustrative and shows a measurement in phase U. For measurements in the remaining phases, the connection must be reconfigured or a through-wiring connection of the sensors must be used. For more details, see Section 7.4.

Fig. 12 Example of tester connection

7. Converter tests

7.1. FAN - Fan switching test

This test checks the inverter's fan switching relay. When the test is activated, the relay must close. It is also possible to test the fan's functionality. In this case, the fan's AC supply voltage must be connected to the inverter.

Test procedure:

1. Disconnect the fan switching connector X272 from the CIM unit.
2. Connect the disconnected connector to the Tester.
3. Select the FAN test and press ON.
4. The fan relay in the inverter should close and the fan should start running, provided it is supplied with power.

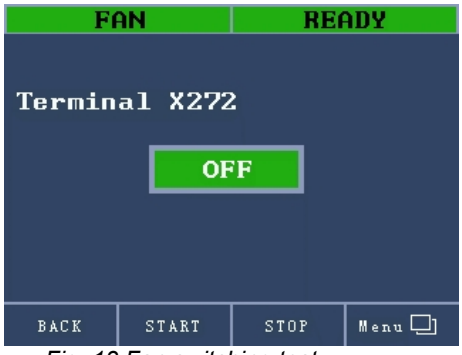


Fig. 13 Fan switching test

Test evaluation:

Possible states:

Relay / fan switches on
Correct condition.

Relay / fan does not respond
Relay is likely faulty, or cable or connector X272 is faulty. The fan or fan power transformer may also be faulty.

7.2. Rectifier - Rectifier test

This is a test of the thyristor rectifier in the G130, G150 and Basic Line for the S120 (G150). The rectifier is connected to the CIM unit via connector X204; it has an activation input marked XINRLYH and a feedback output marked IPLD. However, the feedback only detects the connector connected to the CIM; the function itself is not diagnosed in any way.

Ask Libor for the exact designation of the rectifier board and whether it has any indicator LEDs

Test procedure:

1. Disconnect the X204 rectifier control connector from the CIM unit.
2. Connect the disconnected connector to the Tester.
3. Select the Rectifier test.
4. The IPLD IN input should indicate an OK status.
5. Press the ON button on the tester. The rectifier should activate – check the LEDs on the rectifier board.

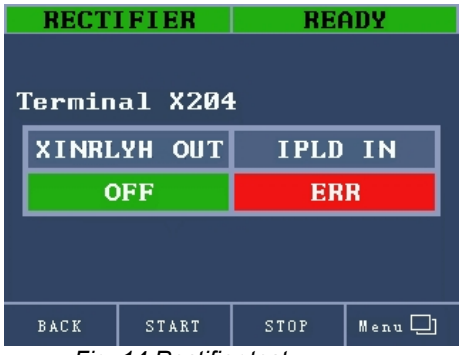


Fig. 14 Rectifier test

Test evaluation:

Possible states:

The IPLD IN input is OK

Indicates correct connection to the rectifier.

IPLD IN input is ERR
Probably a fault in the cabling or in the rectifier connectors.

7.3. Temperatures - Temperature Sensor Test

The purpose of the test is to verify the correct functioning of the temperature sensors and their connection within the converter. Temperatures are monitored in the inverter using NTC 10k resistance temperature sensors. The number and location of the sensors depend on the specific inverter model. They are connected via connector X31 and, for higher-power inverters, also via connector X32. The table below describes the function of each sensor.

Test procedure:

1. Disconnect connector X31 from the CIM module.
2. Connect connector X31 to the corresponding connector on the tester.
3. If necessary, also connect connector X32 according to the inverter configuration.
4. Select Temperatures on the Tester.
5. The display shows the continuously evaluated data from the individual sensors, see Figure 15.

Fig. 15 Fan switching test

Test evaluation:

Possible states:

Temperature displayed (e.g. 25 °C)
The sensor is functional and the value is within the permitted range.

NC (Not connected)
The sensor is not used in this drive model, is not connected, or is open-circuited.

ERR (Error)
The measured value is outside the permitted range. Possible causes:

- sensor short circuit
- damaged sensor
- incorrect wiring

Criteria for a successful test:

The temperature sensor test is successful if:

- all sensors used display a valid temperature
- no sensor used is in ERR status NC statuses

do not necessarily have to be considered an error.

Description of individual sensors, terminal block **X31**

Terminals	Description
1-2	Cabinet temperature
3-4	Inverter heat sink temperature (L1, L2, L3), L1 phase heat sink temperature (top)
5-6	Inverter heat sink temperature (L2, L3), L1 phase heat sink temperature (bottom)
9-10	Rectifier temperature

Description of individual sensors, terminal block **X32**

Terminals	Description
1-2	Temperature in the enclosure
3-4	Inverter heat sink temperature (L1, L2, L3), L1 phase heat sink temperature (top)
5-6	Inverter heat sink temperature (L2, L3), L1 phase heat sink temperature (bottom)
9-10	Rectifier temperature

7.4. I sensors – current sensors

The purpose of the test is to verify the correct functioning of the inverter's current sensors and their cabling. Test principle

During the test, a defined DC current of approximately 10 A DC is fed into the current sensor measurement circuit from a current generator. Based on the ratio between the generated test current and the measured output signal of the sensor, the Tester automatically determines the current sensor's transformation ratio. The Tester classifies the current ratio into several defined grades, which correspond to the commonly used types of current sensors employed in SINAMICS converters. The Tester thus enables an approximate identification of the current sensor's range. An accurate assessment of the suitability of the sensor type used in relation to the specific converter model is carried out by a technician based on the manufacturer's documentation.

Evaluation criteria

The basic criterion of the test is the mutual consistency of the transformation ratios of all current sensors in the drive. The test is considered satisfactory if:

- the current ratio has been correctly detected
- the transmission ratios of all three sensors are identical

Fig. 16 Fan switching test

Test procedure:

1. Disconnect the X43 current sensor connector from the CIM unit and connect it to the Tester.
2. Connect the test leads to the I OUT+ and I OUT- terminals and connect the other ends, using alligator clips, before and after one current sensor.

   Alternatively, thread one test lead through the holes in all current sensors and connect its ends to the I OUT+ and I OUT- sockets on the current generator.
3. On the Tester, select the I sensors test and start the test.
4. After a short while, the detected sensor ratio will appear on the display.

CAUTION	If the tester restarts during the test, a more powerful power supply for the tester must be used.

The display shows all three phases. However, it is recommended to measure one phase at a time and then move on to the next.

The measurement can be performed by threading the cable through the measuring transformer or by connecting directly to the power busbar before and after the measuring transformer.

CAUTION	Before proceeding to the next tests, the measuring cables must be disconnected; otherwise, the tester may be damaged.

7.5. IGBT switching test

The purpose of the test is to verify the switching of all six IGBTs in the converter under test.

Test principle

The tester switches the IGBTs on one by one and uses the measured voltage to diagnose whether the IGBT, including the driver, is in good working order. Conditions for running the test:

- The necessary cabling between the converter and the tester must be connected.
- There must be no driver fault from the optocoupler outputs – the FAULT 1 to 3 indicators on the display must be green
- The voltage in the converter's DC link must be at least 10 V. It is not usually necessary to supply this voltage to the DC link; it is fed there via the driver power supply. Only in larger converters is it necessary to supply the voltage from an external source.

Fig. 17 IGBT switching test – basic fault-free state

Evaluation criteria

The test is considered satisfactory if 'OK' is displayed for all elements shown. Assignment of the displayed elements to individual IGBT switches:

U11 H	*first phase upper switch*	*U11 L*	*first phase lower switch*
U21 H	*second phase upper switch*	*U21 L*	*second phase lower switch*
U31 H	*third phase upper switch*	*U31 L*	*third phase lower switch*

Test procedure:

1. Disconnect the power supply connector for the IGBT drivers X271 from the CIM unit and connect it to the Tester.
2. Disconnect the three opto connectors U11, U21 and U31 from the CIM unit and connect them to the Tester.
3. Connect the red and blue test leads to the UDC+ and UDC- terminals and connect the other ends, using alligator clips, with the correct polarity to any point on the converter's DC link.
4. Connect the black, yellow and green cables to terminals UIN 1, UIN 2 and UIN 3, and connect the other ends using alligator clips to the inverter's output phases U, V and W.
5. Ensure that the tester is in READY mode, i.e. all FAULT indicators are green and the Udc indicator is green.
6. Ensure that the test mode is set to AUTO and not MANUAL.
7. Press the ON button. The individual transistors will be switched on one by one and the result of the switching test will be displayed.

Note: The current switching status (OFF/ON) is indicated for each component, which is evaluated based on voltage measurements at the inverter's output phases. If a motor is connected to the inverter, all phases are interconnected via it, and consequently the switching of all upper/lower IGBT switches is indicated even if only one of them is switched on.

The test can also be performed manually by switching to MANUAL mode, starting the test with the ON button, and then touching the relevant element on the display to switch individual transistors on and off.

8. Measurement of UGBT saturation voltage

8.1. Description of the saturation voltage measurement methodology

The tester can only perform this test via a PC program. Furthermore, to successfully perform this test, a suitable DC power supply connected to the converter's DC link circuit is required. It is also necessary for a motor or other inductive load, such as a choke, to be connected to the converter.

The most suitable DC source is the BUBELA PSVD-1K-1000V capacitor-forming power supply, which the tester can control directly.

The principle of measuring the IGBT saturation voltage involves briefly switching the IGBT on to an inductive load, e.g. a motor. In the switched-on state, the current increases from zero to the maximum set value depending on the DC voltage of the intermediate circuit $_{UDC}$ and the switch-on time – see Fig. 16. The result is the measured voltage across the collector-emitter $_{UCE}$ depending on the current $_{IC}$ – see Fig. 17.

For a three-phase load, the principle is similar; it depends only on the appropriate switching of the IGBT elements, as shown in Figure 18.

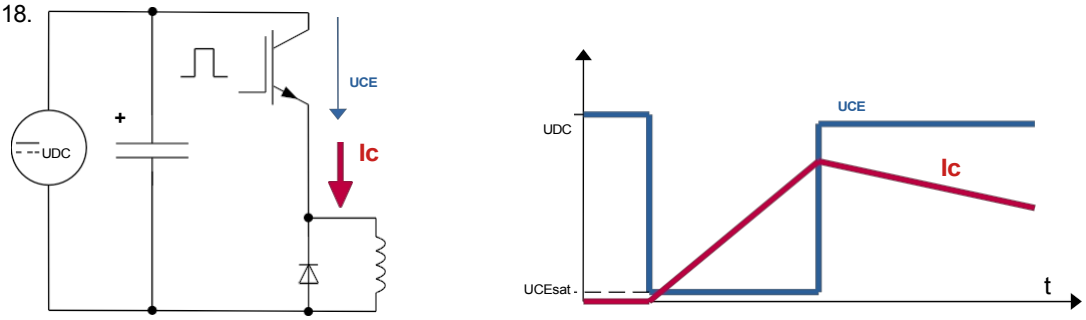


Fig. 18 Basic principle and procedure for measuring saturation voltage

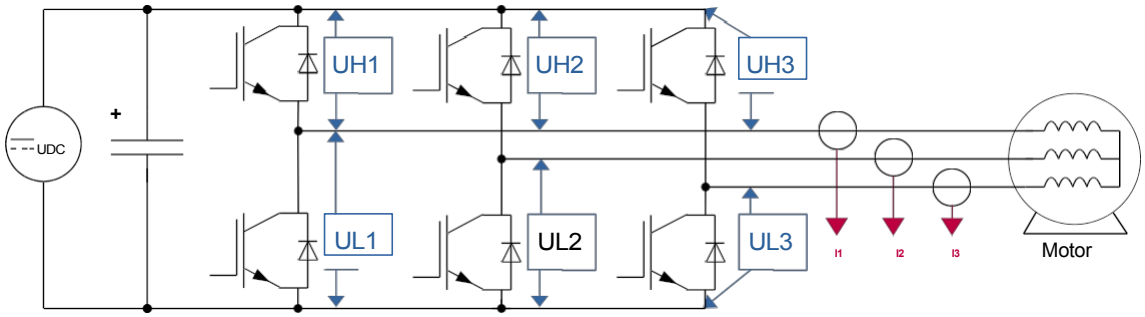
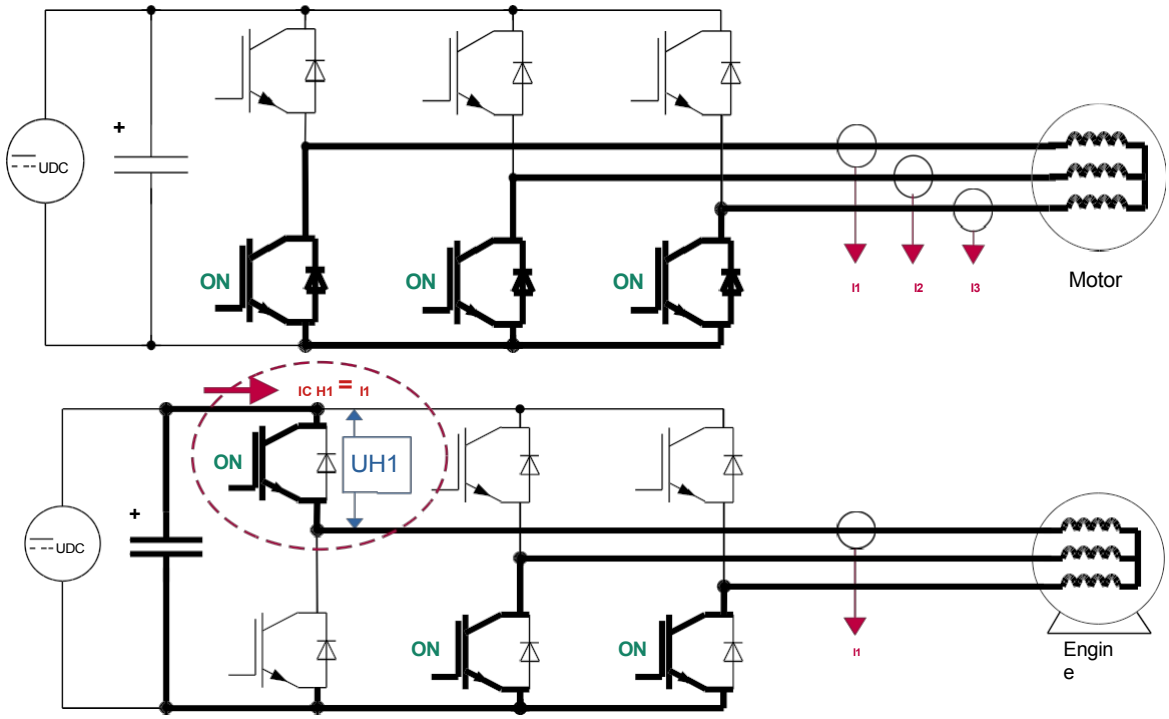


Fig. 19 Topology of a three-phase inverter with a connected motor and voltage saturation measurement

This measurement is for information purposes only and is only suitable in the long term. During the next preventive inspection or check of the inverter, it is ideal to measure again (with the same input parameters) and compare the values. From a long-term perspective, this measurement can be used to detect the gradual ageing of the IGBT elements in the power blocks.



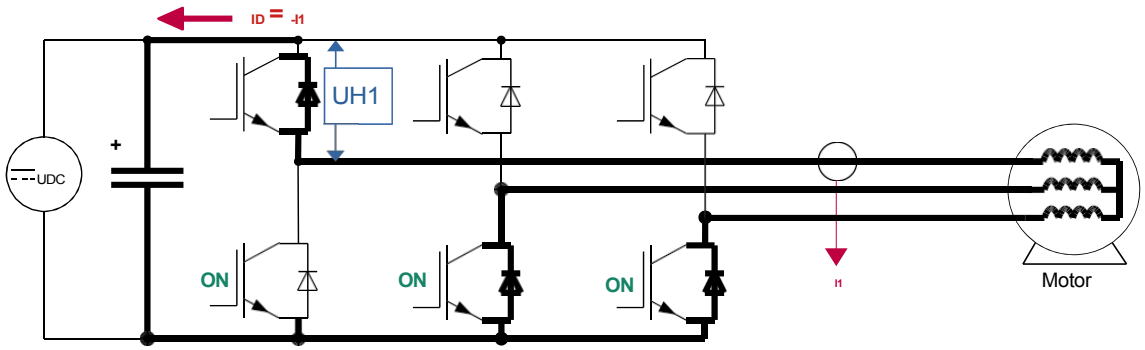


Fig. 20 IGBT switching sequence during the test

8.2. Troubleshooting

Error/problem	Solution
IGBT switching cannot be performed – one of the devices displays FAULT	The IGBT driver power supply is not connected correctly The relevant optical cable is not connected The driver or IGBT is damaged
IGBT switching cannot be performed – one of the elements displays FAULT during the test	The driver or IGBT element is likely damaged due to a faulty saturation protection circuit. This fault manifests as the feedback signal dropping out during the ignition of the relevant IGBT
The tester restarts during any test	The tester's power supply is unable to provide sufficient current to the tester. Use a different power supply; disconnect any unnecessary cables from the tester
Current transformers cannot be measured	Check that the current transformers are connected correctly. Connect the cable from the current transformers correctly.
The IGBT Usat test cannot be performed; only the bottom line is displayed	Check the connection to the tester. Connect the current transformer cable and repeat the current transformer test (for all transformers). Use trial and error to set the voltage-to-current ratio in the PC program
The DC power supply is unable to charge the DC link quickly enough and the program displays an error indicating that the DC link has not been charged	Set a lower voltage. Perform a test where the power supply is not controlled via the tester and charge/power the DC link with a fixed value set directly on the power supply. This must be the same as the voltage value set in the program

8.3. Measurement procedure

To be added.

9. Maintenance

WARNING

Do not attempt to dismantle or repair the device yourself. Entrust repairs to a specialist service centre or the manufacturer.

General maintenance

- Do not use abrasive substances or solvents to clean the appliance.
- Switch off the device when not in use.
- Do not store or use the device in damp environments, in places with high temperatures, in the presence of explosive substances, or in strong magnetic fields.
- Do not use the device if it is damp or wet.

Calibration

We recommend calibrating the measurements once every 24 months. Request a calibration manual from the manufacturer.

10. Disposal

At the end of the device's service life, hand it over to a specialist company for recycling.

11. Contact details

BUBELA Power Electronics, s.r.o.
email: info@bubela.cz
web: www.bubela.cz

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D230021-12