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TopCon series DC power

Manual for model TC.P Quadro

Your distributor:

Schulz Electronic
Professional Power Supplies

Schulz-Electronic GmbH
Dr.-Rudolf-Eberle-Straße 2
D-76534 Baden-Baden
Fon + 49.7223.9636.0
Fax + 49.7223.9636.90
vertrieb@schulz-electronic.de
www.schulz-electronic.de

General

This information in this documentation corresponds to the development situation at the time of going to print and is therefore not of a binding nature. Regatron AG reserves the right to make changes at any time for the purpose of technical progress or product improvement, without stating the reasons.

Identification

Device hardware

Information on the device is to be found on the type plate on the rear side of the TopCon TC.P. power supply.

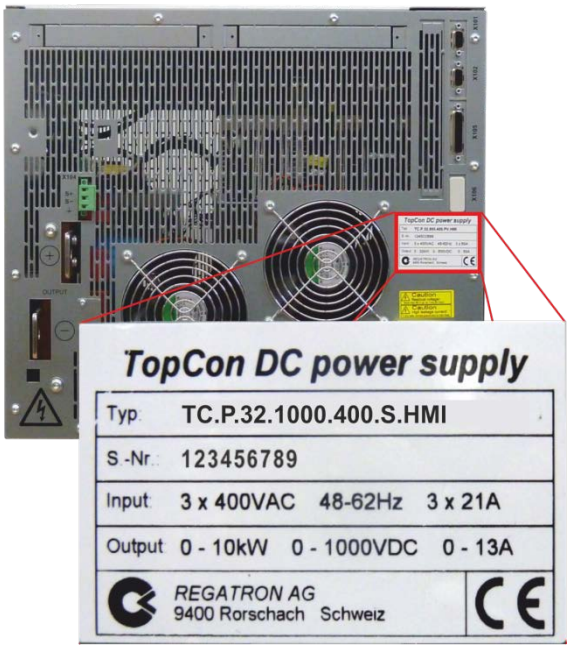

Fig. 1 Example - information on the device type, serial number as well as input and output data on the TopCon TC.P power supply.

Manufacturer

Information on the manufacturer	
Regatron AG	Tel. +41 71 846 67 67
Feldmuehlestrasse 50	Fax +41 71 846 67 77
9400 Rorschach	www.regatron.com
SWITZERLAND	topcon@regatron.ch

Instructions

Version overview	
Operating instructions	**Manual - TC.P Quadro;** V04.55; 23.10.2017
For following modules:	
TopCon MainDSP	From version V4.11.XX
HMI	From version V5.08.00
TopControl	From Version V4.01.66

Table 1 Subject to technical change without notice.
xx: valid for all sub-versions.

General information on the manual

Purpose of the manual

This manual provides information on the usage of the TopCon TC.P DC power supply. It serves as instructions and as a reference work. Familiarise yourself with the contents of these operating instructions to operate the device efficiently.

Availability of the manual

The manual must be available at all times to the personnel who are operating the device.

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1. General information on the manual

1.1. Safety and hazards

Scope and applicability

The general information applies to all TopCon low-voltage systems. The user(s) has (have) the obligation to avoid the risks and hazards mentioned by means of the rigorous application of specialist electrical rules.

The system is subject to the Low voltage directive, it is to be operated by adequately trained and instructed personnel.

1.1.1. Categorisation of the hazard areas

The assessment of the effects of hazards from low-voltage systems with a flow of energy for supply and possibly regeneration is divided into the following areas:

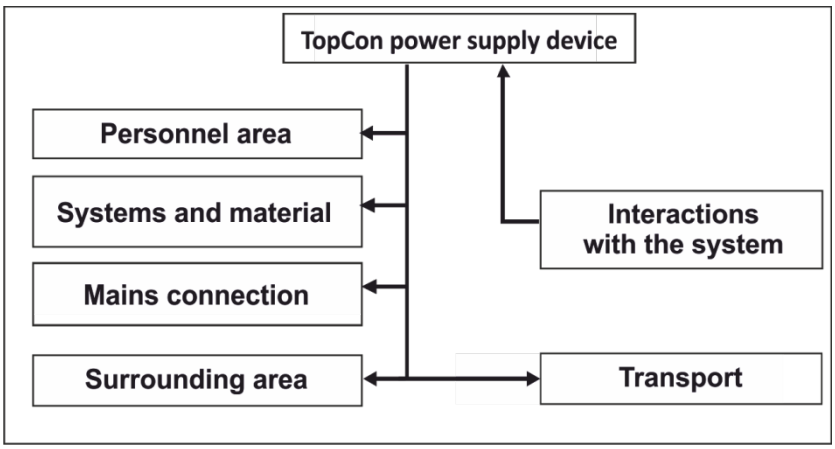

Fig. 2 Categorisation of the hazard areas.

The hazard areas stated are explained in the sub-sections of this chapter that follow.

1.1.2. Personnel area

The utmost attention is to be paid to the hazards for individuals. There are various risks and hazards, of these the most important are mentioned here.

Electric shock

A low-voltage system can produce electrical potentials that can be dangerous or even fatal for individuals. During work on the system the following guidelines are to be observed:

a) **Work in electrically isolated state**
This is the recommended way of working, it should be rigorously applied during all connection and wiring work. Follow the rules:

1. Electrically isolate
2. Secure against switching back on
3. Short-circuit
4. Connect to earth
5. Report and instruct

After shut down, the short-circuiting of the outputs and earthing are particularly important for safety reasons if reactive loads or loads that store energy
(rechargeable batteries, capacitors, ULTRACAP etc.) are used

b) **Work in the vicinity of live parts**
In these circumstances an increased hazard potential is to be expected. Minimise the risks by means of:

1. Guards
2. Covers
3. Insulating encapsulation, cladding
4. Impose separation by means of mechanical features, protective grilles
5. Supervision, reporting

c) **Work on live equipment**
It is imperative this form of working is avoided. If it cannot be avoided, careful work preparation is essential.
Pay attention to the following:

1. The personnel must be specially trained.
   (see NIV Art 26)
2. Work in accordance with recognised specialist methods.
3. Controlled personal protective equipment must be available.
   (passive protection)
4. Organisation of the working area.
5. Supervision and preparatory measures.
   (active protection)
6. Use appropriate protection against physical contact throughout.
   Set up a suitable EMERGENCY STOP chain and test it at regular intervals!
   Mark all wires and cables to prevent mistakes.

Electrical heating

TopCon electrical power supply systems operate with significant amounts of energy. High currents can cause heating of cables and wires. In particular, during unmonitored endurance tests insulation fires and short-circuits may be caused.

- At particular risk are connectors, switchgear and cable terminals. Check these parts particularly carefully and at regular intervals.
- Use wiring material suitable and stipulated for your application with the related insulation class!
- Monitor your system actively or passively using appropriate sensors or by monitoring parameters.

Arcing and sparking on opening contacts

In relation to DC systems, note that on opening a circuit through which a current is flowing, arcing with very high energies can be produced depending on the inductance!

In some circumstances this arcing can result in burns, damage to the eyes as well as damage, destruction or fire on parts of the system.

The usage of normal mains contactors as isolating devices in DC circuits is not recommended! Instead use DC contactors. In case of doubt contact the related manufacturer.

Take into consideration that the protective devices on the TopCon low-voltage system cannot detect an arc as a fault condition, as this situation may be a required function.

Risk of mechanical injury

As on all electrical installations, mechanical injuries to the head and hands may be caused on removing and fitting covers, wire and cable connections.

Always use the correct tool. If necessary protect the head and hands against injuries due to cuts and impacts.

1.1.3. Systems and material area

Risk of fire

In case of fire, electrically isolate the system immediately, on the one hand to interrupt the supply of energy and on the other hand to shut down the fans.

Fight the fire from bottom to top in accordance with the rules in your organisation using suitable fire fighting equipment (CO2 fire extinguisher). If possible use fire extinguishers with asphyxiation action to keep the secondary damage low.

Electromagnetic fields

Like any electrical system, TopCon low-voltage systems produce electrical and magnetic fields. However, these fields comply fully with the usual standards.

Note, however, that particularly the EM fields from your cables and equipment connected could nevertheless produce interference on objects in the immediate area.

Note the following:

- Keep data carriers and PC-based measuring environments an adequate distance from live cables to prevent interference and data loss.
- Protect highly-sensitive sensors and instruments.
- Test effects on communication networks, in particular radio networks.
- Make individuals with electronic implants aware that implants may be affected.

Noise and noise level

The inductive elements as well as the fans on the TopCon low voltage system produce a lower or higher noise level dependent on the operating mode. However, in the immediate vicinity of the cabinet this noise is under the tolerance limit that would make acoustic protection equipment necessary.

The usage of acoustic protection equipment or acoustic insulation measures can, however, be necessary in specific circumstances.

Mechanical damage

Incorrect operation of the systems can result in mechanical damage to the downstream equipment and systems.

In particular, on the supply of power to drives it is to be ensured that excessively high speeds cannot result on load shedding.

The monitoring of the maximum speed with intervention in the safety chain is recommended above all if the system runs unmonitored.

Handling stores containing large amounts of energy

Modern energy storage systems are able to absorb very large amounts of energy. This situation has the following consequences:

- The cabling should not just comply with the maximum charging and discharging currents to be expected, to some extent significantly higher peak currents are to be expected during switching processes.
- Unlike the TopCon low-voltage system, which is fully current-limited, in the case of stores containing large amounts of energy a short-circuit or failure can be very serious. Due to the high currents serious injuries and serious damage can be caused.

The following, incomplete list indicates some this damage:

1. Burning of wires and connectors
2. Sparking
3. Fires, insulation fires
4. Arcing, welding
5. Electric shocks

Note the following points:

1. Never short-circuit energy stores to discharge them!
   Always use a suitable discharge resistor of appropriate power rating!
2. Visibly secure a discharged energy store using a short-circuit bridge.
3. Always monitor the maximum storage voltage, also during practical test operation.
4. Use a device that clearly indicates the charge state of the energy store, e.g. by monitoring the low-voltage limit.

1.1.4. Line connection area

TopCon power supplies are operated with 400V / 480V 3~ AC. When they are switched on there may be an uneven load on the 3 phases; this uneven load may cause older residual current circuit breakers to trip.
Here a modern make of residual current circuit breaker is to be used that will tolerate such asymmetries during the switch-on process.

1.1.5. Surrounding area

TopCon power supplies are generally forced-air cooled. Despite the very high efficiency, a power loss occurs in the components that must be dissipated in the form of heat to the surroundings. The energy is dissipated with the aid of forced ventilation to the rear of the TopCon power supply.

It is to be ensured that the rooms in which TopCon power supplies operate are cool and therefore the heat produced can actually be removed.

- Active cooling is, however, generally unnecessary.
- The forced ventilation discharges air from the rear side of the TopCon power supply.

It is to be ensured that there are no undesirable effects (e.g. stirring up of dust or sand, deformation due to the action of heat etc.) due to the flow of air and the heat, which at high load may be powerful.

On TopCon models with the water cooling option, a large portion of the power loss produced is dissipated via the cooling circuit.

Here it is to be ensured the cooling liquid feed is not too warm. Further requirements on the cooling liquid are given in the option description from p. 93.

1.1.6. Transport area

TopCon power supplies are always supplied with 2 strong carrying handles (steel sheet). These handles are inserted in the slots in the side of case and make it possible to transport the device easily.

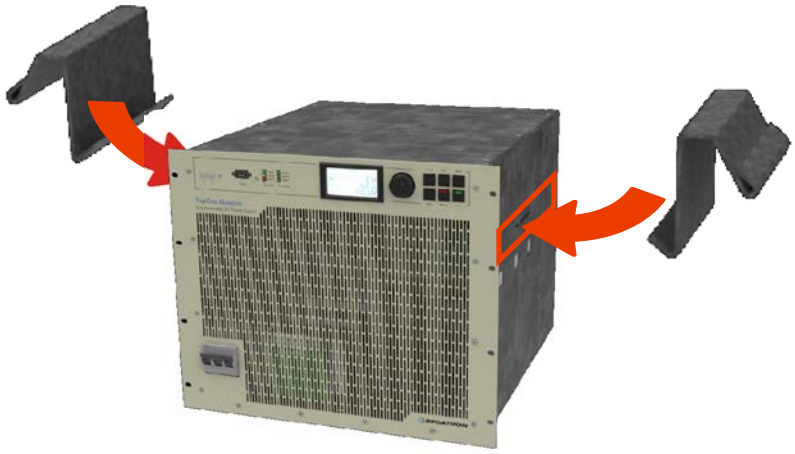

Fig. 3 Attaching the carrying handles supplied to transport a TopCon power supply (here 9 U).

Due the high weight it is advisable to carry the device between 2 people and whenever possible to use a trolley.

Remove the carrying handles after transporting the TopCon power supply and store them in a safe place.

During the transport of systems the following is to be noted:

It is not allowed to tip the system by more than 20 degrees! Larger tipping angles could cause mechanical damage to the carrying frame and the TopCon front panels. As a rule, the doors on the case for the system should be closed during transport so that the case can absorb higher loads.

On moving the system using a forklift truck:

Depending on the design of the system, the cabinet plinth is reinforced with a strong steel frame. This frame is suitable for transport using a forklift truck. It is imperative you pay attention to an adequate contact area and fork overhang!

Take into consideration that the centre of gravity may be high depending on the system!

There is a risk of tipping!

Secure the system against slipping and tipping using fastening gear.

On lifting the system using a crane:

In any circumstance it is recommended to attach blocks of wood to the corners of the cabinet to prevent twisting/distortion of the cabinet structure (see Fig. 4).

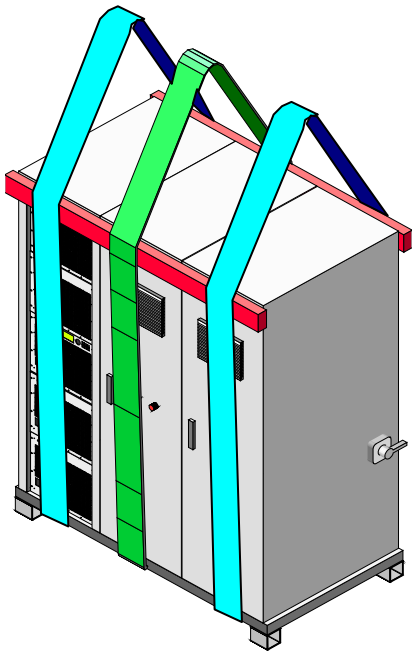

Fig. 4 Usage of blocks of wood as protection against mechanical damage (lifting using 2 (better 3) carrying straps)

- It is imperative you remove all cable connections prior to moving the system!
- Note that between switching off the power supply and disconnecting the power cables on the output side, it is necessary to wait at least 15 min for discharging.
- Keep all doors closed during the transport of cabinets.
- Pay attention to protruding parts such as main switch, controls and fan covers. They must not be damaged by transport aids (straps, blocks of wood, etc.).

1.1.7. Area related to interaction with the system

Compliance with the design data for the specific system is a prerequisite for malfunction-free operation.

Load systems can have significant effects on the power source. The following points are to be noted:

1. The maximum voltage specified is not allowed to be exceeded.
2. Protective measures must be provided against voltage spikes on the load side and their function must be monitored (voltage spikes could damage the filter capacitors and semiconductors in the system).
3. Periodic overcurrents are to be avoided.
4. The DC ripple currents produced on the load side are to be monitored to avoid overloading filter capacitors; in case of doubt ask the manufacturer.
5. The system is always to be operated within the permissible temperature range. High temperatures will significantly reduce the service life of various modules.

1.1.8. Ordinances and regulations

Follow the mounting and installation instructions during electrical installation!

In particular, in the countries of the European Union the following standard applies:

EN 50178
Electronic equipment for use in power installations.

In special applications:

If you want to use the electrical power supply in special applications, you must comply with the related standards and health and safety regulations.

1.2. Pictograms used

Important information in these operating instructions is marked with the following symbols:

Hazard and warning information	
Pictogram	**Meaning**
 **DANGER**	For an immediate hazard that will result in serious injuries or fatality**.**
 **WARNING**	For an immediate hazard that can result in serious injuries or fatality.
 **CAUTION**	For a possibly hazardous situation that can result in serious injuries or fatality.
CAUTION	For a possibly hazardous situation that could result in damage to the product or another item in its surroundings.

Table 2 Basic hazard and warning information.

Further warning and hazard information	
Pictogram	**Meaning**
	DANGER, WARNING or CAUTION due to electrical power
	DANGER, WARNING or CAUTION related to suspended load

Table 3 Symbols included in the table can be used for more specific depiction of warning information from Table 2 "Basic hazard and warning information".

Instructions	
Pictogram	**Meaning**
	Important information

Table 4 Mandatory signs that are important for the operation of the device or the software.

General notes	
Pictogram	**Meaning**
	Tip, for working efficiently with the device

Table 5 Additional information, so that you can find possibly important information quickly.

2. Introduction

2.1. Getting started with the TopCon power supply

These operating instructions contain a two-part “Getting Started” tutorial with the aid of which new users of TopCon power supplies can “get started” with the device.

Contents	Chapter	Page
Setting up the hardware, connection to the power system, cables	2.1.1	20
Switching on and off the TopCon power supply	2.1.2	21
Usage of the control panel (HMI/RCU)	6.3.4	162
Application software TopControl	6.2	157

Table 6 Overview of getting started with the TopCon power supply.

We strongly recommend you to take the time to become familiar with the new TopCon power supply using these instructions.

Reading the instructions will result in the following advantages:

1. **Device check:**
   You will become familiar with the TopCon power supply and the TopControl application. You will understand the basic functionality of the device.
2. **Learning how to use the device:**
   You will become familiar with the controls on the TopCon power supply and the software.
3. **Standardisation of the terminology:**
   You will become familiar with the most important terms that are used in the operating instructions and during support requests.

2.1.1. Setting up the hardware/connecting a TopCon power supply

Checking device and accessories

- 1 TopCon power supply (single device).
- 1 dummy plug Sub-D 25-pin,
  “Interlock” for X105 interface.
- 1 dummy plug Sub-D 9-pin,
  “Interlock and CAN-Term”.
- If RCU is available,
  RCU (bench unit) and connection cable.

Preparing interlock and communication bus correctly

For an illustration see Fig. 29 and Fig. 30, from page 64.

- Connect the control interface (X105) to the 25-pin dummy plug (device rear side)

↳ The CAN bus for the device communication is connected.

↳ Situation: no RCU (Remote Control Unit) available.
The communication and interlock interface (X101) on the rear side of the TopCon power supply is terminated using the “Interlock and CAN-Term” dummy plug (9-pin) (device rear side).

↳ Situation: RCU (Remote Control Unit) available.
Connect the connection cable to the communication and interlock interface (X101) on the rear side of the TopCon power supply. The other end is connected to the RCU interface (X101).
The “Interlock and CAN-Term” dummy plug is connected to connector X102 on the RCU. (Device rear side)

Connecting TopCon power supply to the power system

WARNING

Possible mortal danger due to electric shock!

Avoidance:

- Never connect or disconnect electrical connections while they are live.
- Lay cables carrying high currents using an adequate cable cross-section.
- Only use the devices for the intended application and type of load.
  In particular, the mains voltage and load must match the information on the type plate, as well as the settings on the device.
- Protection against touching the output current bars!
  E.g. by fitting a suitable case.
- The mains cable is connected to the related terminal on the rear side of the TopCon power supply.
- Any direction of rotation is acceptable and the N conductor is not used

2.1.2. Switching on and off a TopCon power supply

Switching on the device

- Switch on main switch.
  On the front of the TopCon power supply in the form of a triple switch.

↳ The TopCon power supply is booted.
The signal processors are initialised and a device self-test performed.

↳ Can be seen on the HMI/RCU during the login process:
Login: HMI login on the system
System information screen:
The system information screen appears for approx. 5 s and changes to the main screen.

↳ At the end of the successful start process, the green “Power” LED on the front of the device illuminates.

Switching off the device

- Switch off the device via the main switch.

↳ The shutdown process is indicated on the front of the TopCon power supply as a running light on the STATUS LED.
The running light continues until the internal energy stores are discharged.

2.2. General information

2.2.1. Supplying electrical power using the TopCon power supply

The digitally regulated TopCon electrical power supplies allow the straightforward, rapid and reliable planning, installation and commissioning of industrial power supply systems in the power range from a few kW to several 100 kW.

The TopCon power supply family includes devices with maximum output voltages from 50 to 1200 V_{DC}.

The maximum output current is between 13 and 700 A. In addition, an internal resistance simulation of up to 3.2 Ω is possible.

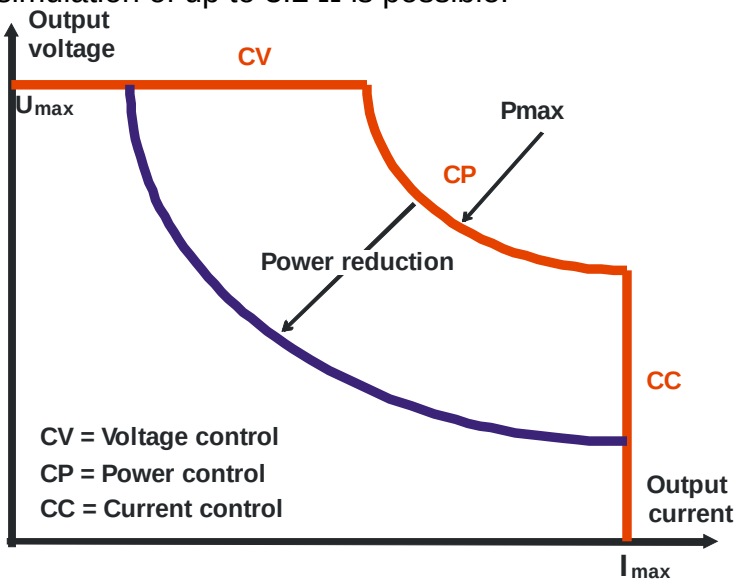

Fig. 5 Voltage, current and power characteristics of the regulated TopCon power supplies.
Here the maximum output values are the nominal output values.
Nominal signifies a constant maximum output value
The maximum value can also include time-limited output values that are greater than the nominal value.

Controller	
CV	**Voltage control** The device is in the voltage control range
CP	**Power control** In the power control range the range for the voltage control and current control will become smaller on a power reduction.
CC	**Current control** The device is in the current control range

Table 7 Controller ranges.

Stand-alone and multi-unit operation

The TopCon power supplies form the heart of even larger electrical power supply systems:

They contain all the necessary basic functions for ‘stand-alone’ operation; however the multi-unit operation (connected in series and/or parallel) of several power supplies with one or more loads is also possible. (See multi-unit operation chapter 4.4, from page 134)

2.2.2. Model range: overview of the standard models

The model range is divided as follows:

- Nominal voltage 400 V (see Table 8, 24)
  mains input AC: 3 x 360-440 VAC, at frequency: 48-62 Hz
  (for further information: see related data sheets)
- Nominal voltage 480 V (see Table 10, page 26)
  mains input AC: 3 x 432-528 VAC, at frequency: 48-62 Hz
  (for further information: see related data sheets)
- Depending on your requirements, it is also possible to manufacture other models.

Standard models with nominal voltage 400 V

Voltage (VDC)	Power (kW)	Current (A)	Dimensions width x height[1] x depth (mm)	Weight (kg)	Type
0 – 52	0 – 10	0 – 250	19“ x 6 U x 495	42	TC.P.10.52.400.S
0 – 52	0 – 16	0 – 400	19“ x 6 U x 495	44	TC.P.16.52.400.S
0 – 52	0 – 20	0 – 500	19“ x 9 U x 590	64	TC.P.20.52.400.S
0 – 52	0 – 32	0 – 700	19“ x 9 U x 590	68	TC.P.32.52.400.S
0 – 65	0 – 10	0 – 193	19“ x 6 U x 495	42	TC.P.10.65.400.S
0 – 65	0 – 16	0 – 308	19“ x 6 U x 495	44	TC.P.16.65.400.S
0 – 65	0 – 20	0 – 385	19“ x 9 U x 590	64	TC.P.20.65.400.S
0 – 65	0 – 32	0 – 600	19“ x 9 U x 590	68	TC.P.32.65.400.S
0 – 100	0 – 10	0 – 125	19“ x 6 U x 495	42	TC.P.10.100.400.S
0 – 100	0 – 16	0 – 200	19“ x 6 U x 495	44	TC.P.16.100.400.S
0 – 100	0 – 20	0 – 250	19“ x 9 U x 590	64	TC.P.20.100.400.S
0 – 100	0 – 32	0 – 400	19“ x 9 U x 590	68	TC.P.32.100.400.S
0 – 130	0 – 10	0 – 96	19“ x 6 U x 495	42	TC.P.10.130.400.S
0 – 130	0 – 16	0 – 153	19“ x 6 U x 495	44	TC.P.16.130.400.S
0 – 130	0 – 20	0 – 192	19“ x 9 U x 590	64	TC.P.20.130.400.S
0 – 130	0 – 32	0 – 308	19“ x 9 U x 590	68	TC.P.32.130.400.S
0 – 200	0 – 10	0 – 63	19“ x 6 U x 495	42	TC.P.10.200.400.S
0 – 200	0 – 16	0 – 100	19“ x 6 U x 495	44	TC.P.16.200.400.S
0 – 200	0 – 20	0 – 125	19“ x 9 U x 590	64	TC.P.20.200.400.S
0 – 200	0 – 32	0 – 200	19“ x 9 U x 590	68	TC.P.32.200.400.S
0 – 400	0 – 10	0 – 31	19“ x 6 U x 495	42	TC.P.10.400.400.S
0 – 400	0 – 16	0 – 50	19“ x 6 U x 495	44	TC.P.16.400.400.S
0 – 400	0 – 20	0 – 63	19“ x 9 U x 590	64	TC.P.20.400.400.S
0 – 400	0 – 32	0 – 100	19“ x 9 U x 590	68	TC.P.32.400.400.S
0 – 500	0 – 10	0 – 25	19“ x 6 U x 495	42	TC.P.10.500.400.S
0 – 500	0 – 16	0 – 40	19“ x 6 U x 495	44	TC.P.16.500.400.S
0 – 500	0 – 20	0 – 50	19“ x 9 U x 590	64	TC.P.20.500.400.S
0 – 500	0 – 32	0 – 80	19“ x 9 U x 590	68	TC.P.32.500.400.S

Table 8 TopCon Quadro standard models (U_{in} = 400V, Europe).
[1] 1U = 44.4mm = 1 ¾ inch

Standard models with nominal voltage 400 V (continued)

Voltage (VDC)	Power (kW)	Current (A)	Dimensions width x height[1] x depth (mm)	Weight (kg)	Type
0 – 600	0 – 10	0 – 20	19“ x 6 U x 495	42	TC.P.10.600.400.S
0 – 600	0 – 16	0 – 32	19“ x 6 U x 495	44	TC.P.16.600.400.S
0 – 600	0 – 20	0 – 40	19“ x 9 U x 590	64	TC.P.20.600.400.S
0 – 600	0 – 32	0 – 66	19“ x 9 U x 590	68	TC.P.32.600.400.S
0 – 800	0 – 10	0 – 16	19“ x 6 U x 495	42	TC.P.10.800.400.S
0 – 800	0 – 16	0 – 25	19“ x 6 U x 495	44	TC.P.16.800.400.S
0 – 800	0 – 20	0 – 32	19“ x 9 U x 590	64	TC.P.20.800.400.S
0 – 800	0 – 32	0 – 50	19“ x 9 U x 590	68	TC.P.32.800.400.S
0 – 1000	0 – 10	0 – 13	19“ x 6 U x 495	42	TC.P.10.1000.400.S
0 – 1000	0 – 16	0 – 20	19“ x 6 U x 495	44	TC.P.16.1000.400.S
0 – 1000	0 – 20	0 – 25	19“ x 9 U x 590	64	TC.P.20.1000.400.S
0 – 1000	0 – 32	0 – 40	19“ x 9 U x 590	68	TC.P.32.1000.400.S
0 – 1200	0 – 20	0 – 20	19“ x 9 U x 590	64	TC.P.20.1200.400.S
0 – 1200	0 – 32	0 – 33	19“ x 9 U x 590	68	TC.P.32.1200.400.S

Table 9 Continued Table 8 TopCon Quadro standard models (Uin = 400V, Europe)

[1] 1U = 44.4mm = 1 ¾ inch

Standard models with nominal voltage 480 V

Voltage (VDC)	Power (kW)	Current (A)	Dimensions width x height[1] x depth (mm)	Weight (Kg)	Type
0 – 52	0 – 20	0 – 500	19“ x 9 U x 590	64	TC.P.20.52.480.S
0 – 52	0 – 32	0 – 700	19“ x 9 U x 590	68	TC.P.32.52.480.S
0 – 65	0 – 20	0 – 385	19“ x 9 U x 590	64	TC.P.20.65.480.S
0 – 65	0 – 32	0 – 600	19“ x 9 U x 590	68	TC.P.32.65.480.S
0 – 100	0 – 20	0 – 250	19“ x 9 U x 590	64	TC.P.20.100.480.S
0 – 100	0 – 32	0 – 400	19“ x 9 U x 590	68	TC.P.32.100.480.S
0 – 130	0 – 20	0 – 192	19“ x 9 U x 590	64	TC.P.20.130.480.S
0 – 130	0 – 32	0 – 308	19“ x 9 U x 590	68	TC.P.32.130.480.S
0 – 200	0 – 20	0 – 125	19“ x 9 U x 590	64	TC.P.20.200.480.S
0 – 200	0 – 32	0 – 200	19“ x 9 U x 590	68	TC.P.32.200.480.S
0 – 400	0 – 20	0 – 63	19“ x 9 U x 590	64	TC.P.20.400.480.S
0 – 400	0 – 32	0 – 100	19“ x 9 U x 590	68	TC.P.32.400.480.S
0 – 500	0 – 20	0 – 50	19“ x 9 U x 590	64	TC.P.20.500.480.S
0 – 500	0 – 32	0 – 80	19“ x 9 U x 590	68	TC.P.32.500.480.S
0 – 600	0 – 20	0 – 40	19“ x 9 U x 590	64	TC.P.20.600.480.S
0 – 600	0 – 32	0 – 66	19“ x 9 U x 590	68	TC.P.32.600.480.S
0 – 800	0 – 20	0 – 32	19“ x 9 U x 590	64	TC.P.20.800.480.S
0 – 800	0 – 32	0 – 50	19“ x 9 U x 590	68	TC.P.32.800.480.S
0 – 1000	0 – 20	0 – 25	19“ x 9 U x 590	64	TC.P.20.1000.480.S
0 – 1000	0 – 32	0 – 40	19“ x 9 U x 590	68	TC.P.32.1000.480.S
0 – 1200	0 – 20	0 – 20	19“ x 9 U x 590	64	TC.P.20.1200.480.S
0 – 1200	0 – 32	0 – 33	19“ x 9 U x 590	68	TC.P.32.1200.480.S

Table 10 TopCon Quadro standard models (Uin = 480V, US)
[1] 1U = 44.4mm = 1 ¾ inch

2.2.3. Control and internal controller structure

The digital signal processor (DSP) in every power supply undertakes the following tasks:

- Device control
  The output voltage and output current are controlled fully digitally with high dynamic performance and long-term stability.
- Comprehensive protection and monitoring functions.

You configure the device and set the parameters very easily using the TopControl application for Windows PCs.

In addition, you can set parameters for the majority of internal signals via software. Corresponding programming interfaces support dedicated programming.

Controller structure

TopCon power supplies have the following controller structures:

- Parallel arrangement for voltage controllers **-1-** and current controllers **-2-**
- Cascaded arrangement on power control and RI simulation

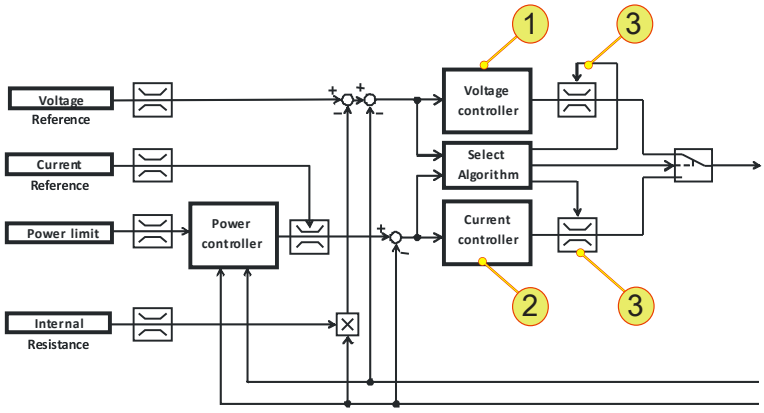

Fig. 6 Overview of controller structure and internal resistance simulation.

Intermediate circuit compensation

An intermediate circuit voltage correction is connected downstream of the controller. This feed-forward path **-3-** is intended to primarily compensate for the mains fluctuations and in particular the residual ripple. The ripple is at:

- 300Hz on 3x400V/50Hz systems
- 360Hz on 3x480V/60Hz systems

2.2.4. Principle of the scope of operation/authorisation concept

TopCon power supplies have numerous functions.

The actual scope of operation available is dependent upon:

- The authorisation level (user level)
- The functions enabled (options)

During this process all interfaces are used to set the necessary parameters and, if necessary, to transfer additional data to the TopCon power supply.

After the parameters for the power supply have been set to a specific function, the device undertakes its function autonomously, possibly also without interaction with the interfaces.

Of course an interface can request information or data from the TopCon power supply in the mean time. The power supply returns the information requested, however not as a “real-time” function.

2.2.5. Parameterisation – the process in principle

The basic principle of the control of the TopCon Quadro power supply is based on the provision of parameters. After the necessary parameters have been entered in the power supply, the power supply operates autonomously.

Parameters – definition

The term parameter covers the following data:

- Limits, settings and specified values.
- Control and program options for the power supply.
  You will find further information on control variables and their utilisation in the separate part of the manual and in special manuals.

Depending on the type of data, the data are saved differently internally and processed internally by the power supply.

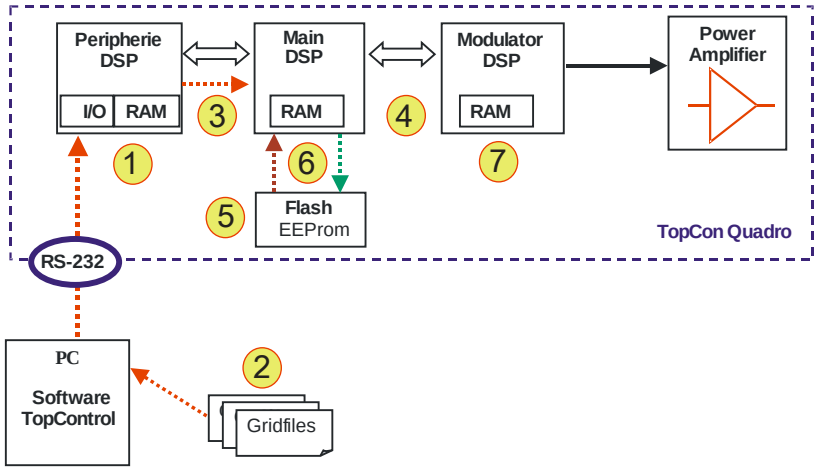

Fig. 7 Scheme: setting the parameters for the control of the TopCon Quadro.

Parameters that are cached in RAM are lost when the device is restarted.

TopControl application

Parameters can be changed or transferred to the power supply using the TopControl application (graphical user interface) (Peripheral DSP -1-).

These parameters can be read into the software as gridfile parameter sets **-2-** (for short: gridfile) and passed to the Peripheral DSP or saved on the PC as a file.

Peripheral DSP

The Peripheral DSP manages the individual input and output features for parameters according to the interface used.

First the data are cached in the RAM for the Peripheral DSP before the data are forwarded to the Main DSP **-3-**.

Main DSP

The Main DSP loads an actual parameter data set into its RAM from its flash EEProm **-5-** and forwards these parameters to the Modulator DSP **-4-.**

New parameter sets from the Peripheral DSP overwrite the actual data in the RAM for the Main DSP. Only after the entry of the command “Store Settings” are the data saved **-6-** in the non-volatile flash EEProm **-5-**.

Saved data are retained!

When the power supply is restarted, the new parameters are automatically loaded from the flash memory **-5-** into the RAM for the Main DSP **-6-**

Data that are not saved will be lost!

If temporary parameters are only written to the RAM and are not saved in the flash memory **-5-**, these parameters will no longer be present at the next start.

Modulator DSP

The Modulator DSP receives its parameters from the Main DSP. The Modulator DSP caches these parameters in its RAM **-7-** and processes them autonomously during the control cycle.

On a restart or the entry of new parameters, the data are updated via the Main DSP.

3. The TopCon Quadro power supply (single device)

3.1. Technical data

You will find detailed data in the related type-specific data sheet.
Data subject to technical change.

3.1.1. Device layout / views of the device

3.1.1.1. The front side of the device

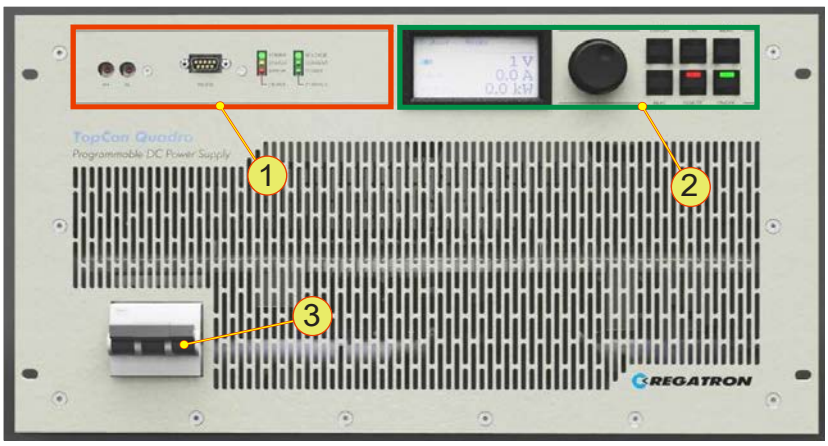

Fig. 8 Overview of the front side of the TopCon Quadro power supply (6 U) with HMI.

Front side of TopCon Quadro power supply (cf. Fig. 8)	
1	**TopCon standard interface** With address selection; interface RS-232; status LED For further information see chapter 3.1.1.2, page 31
2	**HMI control panel (option)** For further information see chapter 3.1.1.3, page 32
3	**Main circuit breaker**

Table 11 Front side of TopCon power supply (incl. HMI).

3.1.1.2. Elements of the TopCon standard interface

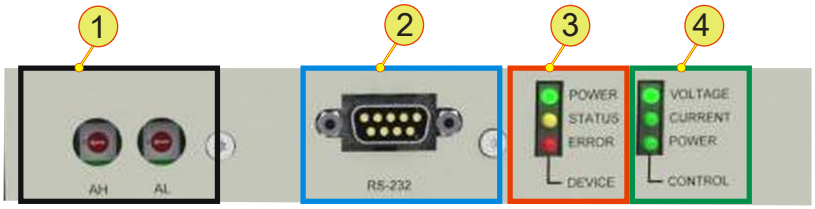

Fig. 9 Standard controls on the front side of the device.

Standard controls (cf. Fig. 9)	
1	**Device address selection switch** For multi-unit operation Standard: covered by plastic caps AH: Upper address range AL: Lower address range
2	**RS-232, interface** For operation via a PC using the TopControl application
3	**DEVICE,** LED indicator Indication of the device status Green: POWER Yellow: STATUS/WARNING Red: ERROR
4	**CONTROL,** LED indicator Green LED illuminates in front of the related label for the operating state: VOLTAGE: Voltage control CURRENT: Current control POWER: Power control

Table 12 Overview of the standard controls.

3.1.1.3. Controls on the Human Machine Interface /HMI (option)

Fig. 10 Controls for the optional HMI (or the RCU).

Standard controls (cf. Fig. 10)	
1	**LC display** Indication of the actual device settings and various menus
2	**<JogDial>**, rotary selector switch For the selection of menu items and scaling of parameters
3	**<DISPLAY >**, button Return to the last interactive display used
4	**<ESC>**, button Active on main screen and system screen
5	**<MENU>**, button Opens the main menu
6	**<ON/OFF>**, switch ON: Green LED illuminated. On reaching the operating state the output value set is present on the device output. OFF: Green LED is off, device output is electrically isolated
7	**<REMOTE>**, switch Change over as to whether the TopCon power supply is to be remotely controlled. Deactivated: Red LED off. HMI is ready for entries Activated: Red LED illuminated. HMI is remotely controlled, only indicates the device state.
8	**<NEXT>**, button In case of two-page menus for data entry used to jump to next page.

Table 13 Controls on the HMI or RCU. You will find detailed information on the usage of the HMI (or RCU) in chapter 6.3 (HMI and RCU, page 159).

3.1.1.4. Device rear side of 10/16 kW devices

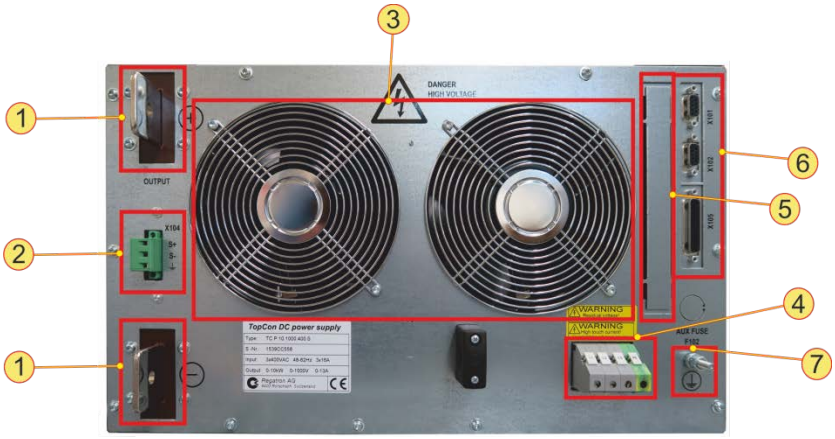

Fig. 11 Device rear side on the TopCon Quadro 10/16 kW

Controls (cf. Fig. 12)	
1	**DC output** Plus and minus pole
2	**Sense connection** For the selection of menu items and scaling of parameters
3	**Regulated fans** As an option there may also be connections for the water cooling (LC) (option)
4	**Mains connection**
5	**Blind cover strip** Can be removed for further interfaces
6	**Interfaces,** D-Sub Upper area: CAN communication interfaces X101/X102 Lower area: analogue and digital interface X105
7	**Earth**

Table 14 Rear side of TopCon power supply 6 U

3.1.1.5. Device rear side of 20/32 kW devices

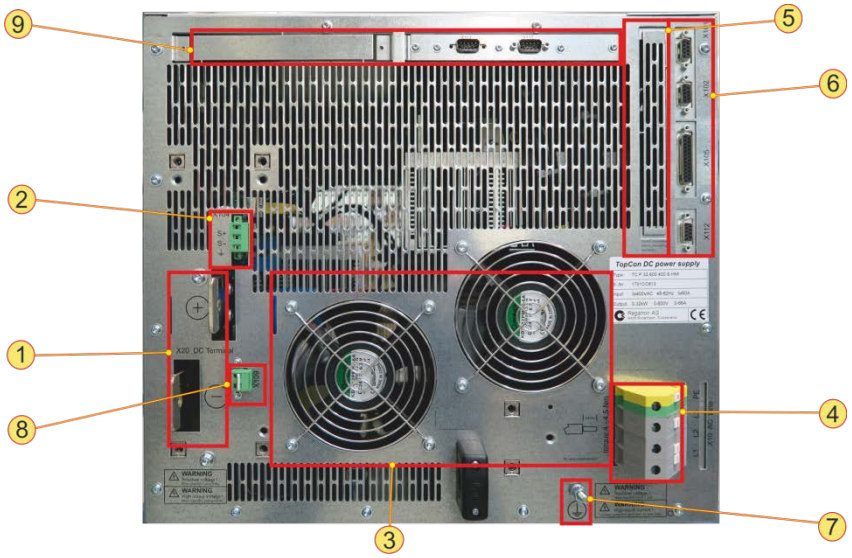

Fig. 12 Device rear side on the TopCon Quadro 20/32 kW.

Controls (cf. Fig. 12)	
1	**DC output** Plus and minus pole
2	**Sense connection** For the selection of menu items and scaling of parameters
3	**Regulated fans** As an option there may also be connections for the water cooling (LC) (option)
4	**Mains connection**
5	**Blind cover strip** Can be removed for further interfaces
6	**Interfaces,** D-Sub Upper area: CAN communication interfaces X101/X102 analogue and digital interface X105 Lower area: optional ISR interface X112-2
7	**Earth**
8	**Jumper** Disconnectiong discharge resistors
9	**Blind cover strip** Can be removed for further interfaces

Table 15 Rear side of TopCon power supply 9U.

3.1.2. Mains connection

Device type	TC.P.10	TC.P.16	TC.P.20	TC.P.32
Connection type	3 LPE (without neutral conductor)			
Mains voltage (3-phase, phase to phase)	400 V_{eff} : 360 V_{eff} – 440 V_{eff} ; 480 V_{eff} : 440 V_{eff} – 520 V_{eff} for US			
Mains frequency	48 – 62 Hz			
Permissible mains imbalance	< 3%			
Connection rating	16 kVA	20 kVA	25 kVA	40 kVA
Current consumption[1] Model 400 VAC (3-phase) Model 480 VAC (3-phase)	20 A_{eff} 17 A_{eff}	32 A_{eff} 27 A_{eff}	40 A_{eff} 33 A_{eff}	60 A_{eff} 50 A_{eff}
Inrush current [1]	< 15 A			
Nominal current Circuit breaker [2]	25 A	32 A	40 A	63 A
Breaking capacity Circuit breaker [2]	10 kA			
Power factor (cos φ)	> 0.85 – 0.87			
Harmonics content	< 0.72			
Efficiency approx.	90 %	92 %	93 %	95 %
Power loss approx.	1.1 kW	1.4 kW	1.5 kW	2.0 kW

Table 16 Electrical parameters for the various TopCon power classes.
[1] At nominal voltage on the mains connection.
[2] Built-in circuit breaker.

Leakage current	
Leakage current AC 230 V_{AC}; 50 Hz	Approx. 22 mA
Leakage current DC 1500 V_{DC}	< 1 mA

Table 17 Leakage current.

3.1.3. Control

Remote programming	
Analogue operation X105	Input impedance 20 kΩ
Voltage set value	0 – 10 V_{DC} for 0 – 100 % V_{nom}
Current set value	0 – 10 V_{DC} for 0 – 100 % I_{max}
Power limit	10 – 0 V_{DC} for 0 – 100 % P_{nom}
Internal resistance simulation[3]	0 – 10 V_{DC} for 0 – R_{max}
Digital operation (interfaces)	RS-232[1]; HMI[2]; TC.CANOpen[2]; TC.GPIB[2];TC.USB[2]
Isolation in relation to mains voltage	2500 V_{AC}

Table 18 Analogue and digital operation.
[1]Standard,[2]Option
[3]Maximum resistance value as standard 1.2 Ω or optional : 3.2 Ω

Accuracy – measurement resolution[1]	
Analogue input and output	0.1 % at 10-bit resolution
Actual voltage	0.025 % at 12-bit resolution
Actual current	0.025 % at 12-bit resolution
Temperature measurement	0.2 °C

Table 19 Measuring accuracy of the TopCon power supply.
[1]Absolute value or referred to nominal values.

Times	
Starting time	
Control electronics[1]	5.0 s
Power section[2]	0.1 s
Cycle times	
Power section	25.0 µs
Voltage and current controllers	50.0 µs
Power controller	50.0 µs
Protection and monitoring	50.0 µs
State machine	1.0 ms
System communication	1.0 ms

Table 20 Starting and cycle times for a TopCon power supply.
[1]After switching on the mains voltage.
[2]After output voltage enable.

3.1.4. Output

Device type	TC.P.10	TC.P.16	TC.P.20	TC.P.32
Output power	10 kW	16 kW	20 kW	32 kW
Control range				
Output voltage[1]	0 – 100 %			
Output current[1]	0 – 100 %			
Output voltage and current	See separate technical data sheets			
Residual ripple	See separate technical data sheets			
Isolation to earth and power line	At 1000 V_{DC} 10 MΩ			

Table 21 DC output parameters.
[1] Referred to nominal values, with Ohmic load.

3.1.5. Protection functions

Overvoltage protection	
In operation as current source	Voltage limiting
In case of malfunction	Electronic inhibit
Response threshold[1 2]	0 – 110 %
Response time[2]	50 µs – 1600 ms

Table 22 TopCon power supply overvoltage protection
[1] Referred to nominal voltage
[2] Adjustable

Overcurrent protection	
In operation as voltage source	Current limiting
In case of malfunction	Electronic inhibit
Response threshold [1 2]	0 – 110 %
Response time[2]	50 µs – 1600 ms

Table 23 TopCon power supply overcurrent protection.
[1] Referred to maximum current
[2] Adjustable

3.1.6. Ambient conditions

Ambient conditions for standard devices[1]	
Maximum ambient temperature	
Storage temperature	-25 – 70 ˚C
Cooling air temperature in operation	5 – 40 ˚C
Ventilation type	
Standard	Forced ventilation and temperature-controlled
Liquid cooled (LC) (option)	(Partially) liquid cooled (see chapter 4.2.1, page 93)
Atmospheric humidity	15 – 85 %, non-condensing
Installation altitude	0 – 1000 m above sea level
Nominal power operation	Max. 1000 m above sea level
Reduced power	Max. 2000 m above sea level
Ingress protection (IEC 60529)	
Basic version	IP 20
Appropriate case [2]	Up to IP 43
Utilisation category	
Protection class	I
Overvoltage category	I I I
Degree of soiling	2
Vibration [2]	Up to 2 g

Table 24

[1] For versions with expanded characteristics, please contact your TopCon sales partner.
[2] Tested in accordance with standard IEC 60068-2-6.

3.1.7. Interfaces (standard)

In the following the interfaces that are included with a power supply in the TopCon Quadro series are briefly described.

As an option the power supplies can be manufactured with numerous additional interfaces. (See chapter 4.4, from page 134)

3.1.7.1. RS-232 interface – X301

Task of the interface X301

Calibration or parameterisation and control of the power supply via a PC using:

- TopContol software
- Customer-specific software

Pin definition for the interface X301: see chapter 3.2.4.9, page 69

RS-232 (standard)	
Electrical level	RS-232/V.24
Baud rate/parity start bits/data bits/stop bits	38400 Baud/none 1/8 /1
Isolation in relation to controller and earth	125 V
Connector	D-Sub, 9-pin, front side

Table 25 Information on the interface X301 (RS-232).

3.1.7.2. Analogue and digital inputs and outputs – X105

Task, interface X105

- Set value specification (U, I, P, R_i), actual value output (U, I)
- Digital remote control
- Safety circuit interlock

Pin definition for the interface X105: see chapter 3.2.4.7, page 66

Analogue inputs	
Configuration	Quantity 4, can be configured to a certain extent, single ended
Input voltage range	0 – 10 V_{DC}
Input impedance	20 kΩ
Reference ground	Common for all analogue inputs
Isolation in relation to controller and earth	125 V
Physical connections	On X105: pin 2, 3, 14, 15

Table 26 Analogue inputs on the interface X105.
Further information: chapter 3.3.3.2, page 76.

Analogue outputs	
Configuration	Quantity 2, can be configured to a certain extent, single ended
Input voltage range	0 – 10 V_{DC}
External output impedance	Min. 1 kΩ
Reference ground	Common for all analogue outputs
Isolation in relation to controller and earth	125 V
Physical connections	On X105: pin 4,16

Table 27 Analogue outputs on the interface X105.
Further information: chapter 3.3.3.2, page 76.

Reference output	
Configuration	Quantity 1
Output voltage	10 V_{DC}
Output current	Max. 10mA
Reference ground	Common with 24 V control voltage
Physical connections	On X105: pin 6

Table 28 Reference output on interface X105.
Further information: chapter 3.3.3.2, page 76.

Digital inputs	
Configuration	Quantity 3, can be configured to a certain extent
Input voltage active	10 – 28 V
Input voltage inactive	0 – 2 V
Input impedance	4.7 kΩ
Isolation to earth	125 V
Physical connections	On X105: pin 18, 19, 20

Table 29 Digital inputs in the interface X105
Further information: chapter 3.3.3.6, page 79.

Digital outputs	
Configuration	Quantity 3, can be configured to a certain extent
Relay contacts	Floating, 2x normally open, 1x change-over
Max. switching voltage	250 $V_{AC;}$ 50 V_{DC}
Max. switching current	1 A
Isolation in relation to controller and earth	125 V
Physical connections	On X105: pin 10, 11, 12, 13, 21, 22, 23

Table 30 Digital outputs on the interface X105.
Further information: chapter 3.3.3.6, page 79.

3.1.7.3. CAN communication interfaces X101/X102

Tasks

- Communication between the devices in multi-unit operation
- Safety circuit interlock
- Terminating resistor

Pin definition for the interface X101/X102: chapter 3.2.4.7, page 66

Interfaces X101 /X102 on the device rear side	
1	**X101** interface, D-Sub, 9-pin For connecting interlock or terminating resistor to the CAN bus
2	**X102** interface, D-Sub, 9-pin For connecting interlock or terminating resistor to the CAN bus

Table 31 Short description of the interfaces X101/X102.
Further information: chapter 3.2.4.6, page 63.

3.1.7.4. Sense X104

Sense – X104	
Input resistance	1 kΩ
Voltages max.	Same as maximum device voltage
Current max.	Approx. 1 mA
Isolation in relation to controller and earth	Same as the device power output
Physical connections	Plus and minus pole; earth

Table 32 Short description of the interface X104.

Further information on the sense function:

- Single devices: chapter 3.2.4.3, page 56.
- Multi-unit system: chapter 5.2.1, page 145

3.1.7.5. Disconnecting discharge resistors - X109

TOPCON power supplies have a multi-level concept to minimize the EMI - effects. One of these measures is the capacitive bleeding of interference frequencies by means of so-called Y-capacitors. The Y-capacitors are connecting the corresponding DC output bars with PE (protective earth).

The Y-capacitors shunt out the interference signals effectively, which produced by the internal switching, while they are isolating the DC voltage. A side effect of this circuit is, that the DC voltage, which is present between the DC bars and PE is maintained for long time when the device is switched off (VOLTAGE OFF).

Although the capacitors are of small capacitance, unintentional contact could cause an unpleasing electrical shock or sensitive measuring devices could be damaged.

With the built-in discharging resistor the Y-capacitors can be discharged, but in some applications such resistor are not permitted.

The new interface X109 allows to discharge the internal Y-capacitors of the DC terminals via an external jumper bridge.

The interface is available for the following devices:

- TopCon TC.Quadro, 9HE from 100 V_{DC} nominal voltage

The external jumper is inserted

The Y-capacitors will be discharched against earth via the discharging resistor.

The external jumper is not inserted

Any possible existing charge of the Y-capacitors will not be discharged against earth and will stay on a free floating potential.

Device leakage capacitance

The internal Y-capacitors are located at the secondary side in the DC output filter. They are placed between positive output and earth and between negative output and earth.

The capacity of the internal Y-capacitors are: 13.6 nF.

Internal discharging resistor

The discharging resistor is located at the secondary side in the DC output filter. It is placed at the DC output.

The resistor value is: 10.8 MΩ.

Function description

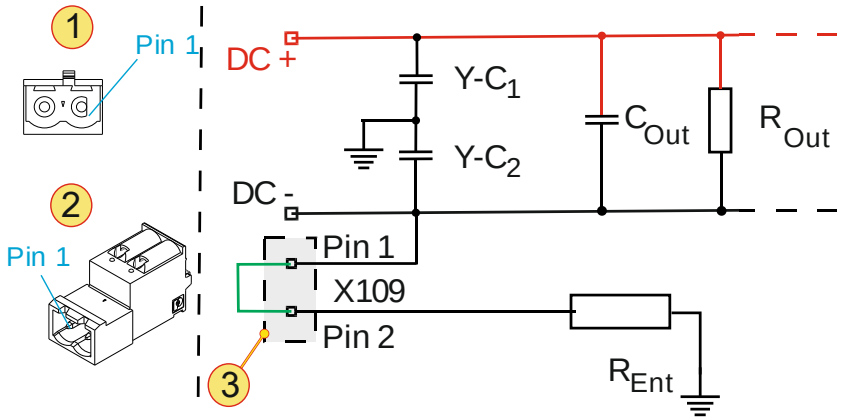

Fig. 13 Schema of a device.
-1- Interface of the device.
-2- External plug with the contained bridge.
-3- Connection of the interface X109 with the inserted bridge (green).

Pay attention in multi-unit mode

A jumper is inserted

In case that is wanted to discharge the Y-capacitors Y-C_1 and Y-C_2 via the device internal discharging resistor, it is necessary to have inserted one jumper at minimum in the multi-unit system.

Several jumpers are inserted in a multi-unit system

It is possible to insert several jumper in a multi-unit system.

Possible multi-unit modes:

- Devices in parallel
- Devices in serial
- Devices in matrix connection

Pay attention that according to the multi-unit mode the values of the total capacity and the value of the total resistance may change.

3.1.8. Mechanical properties

3.1.8.1. Device weight

Weight/power class	TC.P.10	TC.P.16	TC.P.20	TC.P.32
Weight	42 kg	44 kg	64 kg	68 kg

3.1.8.2. Installation height 6U for TopCon power supplies with 10/16 kW

Rear view

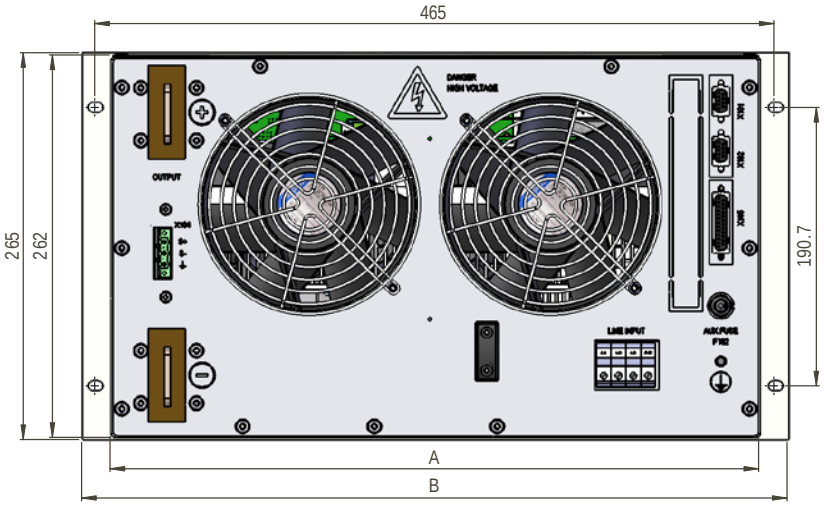

Fig. 14 Rear view of the TopCon power supplies with 6 U.

Side view

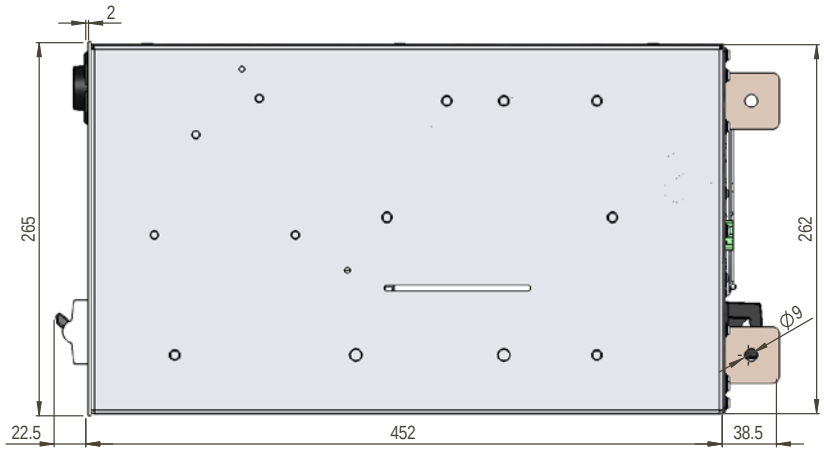

Fig. 15 Side view of the TopCon power supplies with 6 U.

3.1.8.3. Installation height 9 U for TopCon power supplies with 20/32 kW

Rear view

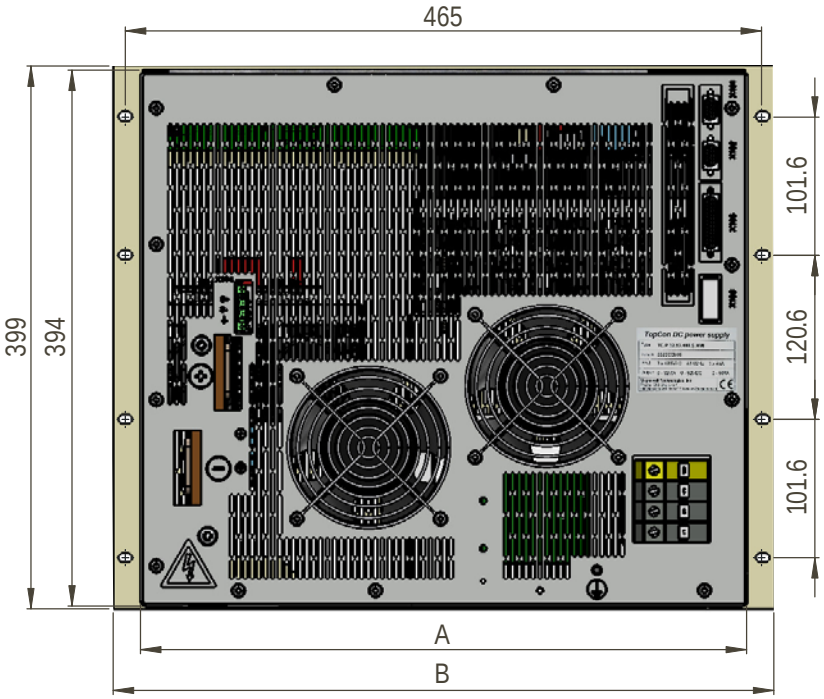

Fig. 16 Rear view of the TopCon power supplies with 9 U.

Side view

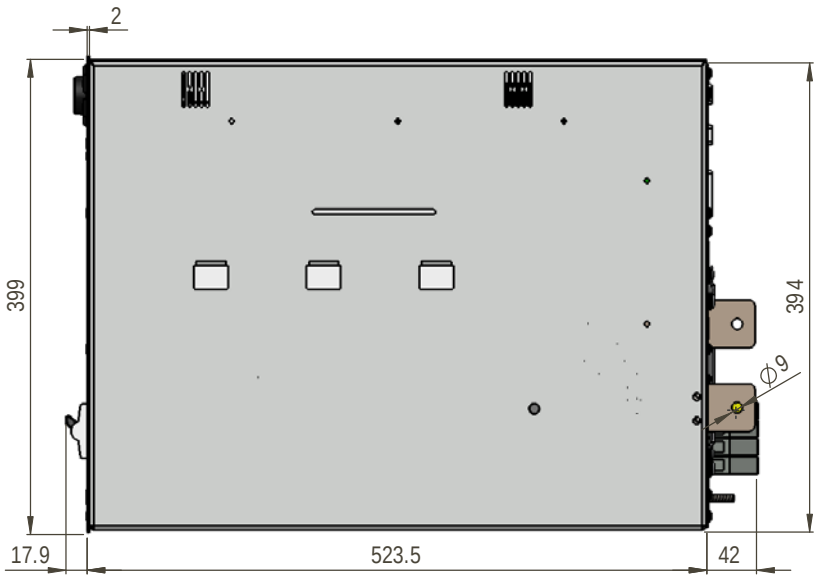

Fig. 17 Side view of the TopCon power supplies with 9 U.

3.2. Commissioning

3.2.1. General information

TopCon power supplies are built-in devices for a fixed connection to the electrical supply system. They must be correctly mounted and installed in compliance with the applicable regulations and standards.

In the countries of the European Union (EU), to place systems with integrated TopCon power supplies on the market the system or machine must comply in particular with the following standards:

- Low voltage directive EN 50178
- EC EMC directive EN 61000-6-2
  EN 61000-6-4

TopCon power supplies are prepared so that they can be installed, wired and interference suppressed in accordance with the applicable regulations with as little effort as possible. Nevertheless, the responsibility for the compliance of systems and machines with built-in TopCon power supplies remains with the manufacturer of the system or machine.

On the usage of the electrical power supply in certain application areas, the related applicable standards and health and safety regulations are to be followed.

3.2.2. Safety information

WARNING

Possible mortal danger due to electric shock!

Avoidance:

⇒ Never connect or disconnect electrical connections while they are live.

⇒ Do not open the device if it is in operation, as it contains live parts.

⇒ Lay cables carrying high currents using an adequate cable cross-section.

⇒ Wait min. 5 minutes!
In the devices built-in there can be dangerous voltages after switching off the mains voltage, as well as in case of loads that store energy.

⇒ Only use the devices for the intended application and type of load.
In particular, the mains voltage and load must match the information on the type plate, as well as the settings on the device.

⇒ Protection against touching the output current bars!
E.g. by fitting a suitable case.

3.2.3. Installation instructions

These installation instructions apply to standard TopCon power supplies with a complete case and air cooling (if not otherwise stated).

General information

CAUTION **Possible damage!**

- Due to soiling and foreign bodies at the installation location.
- Due to a build-up of heat.

Avoidance:

⇒ The installation location must be free of conductive and aggressive substances as well as moisture.
⇒ No foreign bodies such as drilling swarf or screws are to be allowed to fall into the system.
⇒ It imperative you observe the minimum distances during installation.
⇒ The ventilation openings on the front panel and rear wall of the devices must not be covered or sealed under any circumstances.

Case installation/delivery with case

TopCon power supplies are installed in standard cases or switch cabinets either separately or in multi-unit systems.

In the standard design TopCon power supplies are intended to be installed in standard 19” cases and switch cabinets with an external air flow. In this case they are to be placed on rails or shelves and fastened at the points provided on the front panel.

Number of screws:

- For 6 U devices typically: 4 x screws M6.
- For 9 U devices typically: 6 x screws M6.

On installation in cases or switch cabinets, the following points are to be noted:

- Use robust rails or shelves (from the case/cabinet manufacturer): the cases for TopCon power supplies must be in contact over the full installation depth.
  At the rear a cross-member is to be installed for additional fastening of the power supplies.
- Suitable transport aids must be used for the installation and removal of the power supplies. E. g. fit the carrying handles supplied in the side walls of the power supplies.
  The power supplies are to be lifted at these handles.

Cooling

TopCon power supplies are equipped with forced air cooling in the standard version. For this reason the supply of cooling air is to be ensured while complying the maximum permissible temperature and humidity (see chapter 3.1.6, page 38).

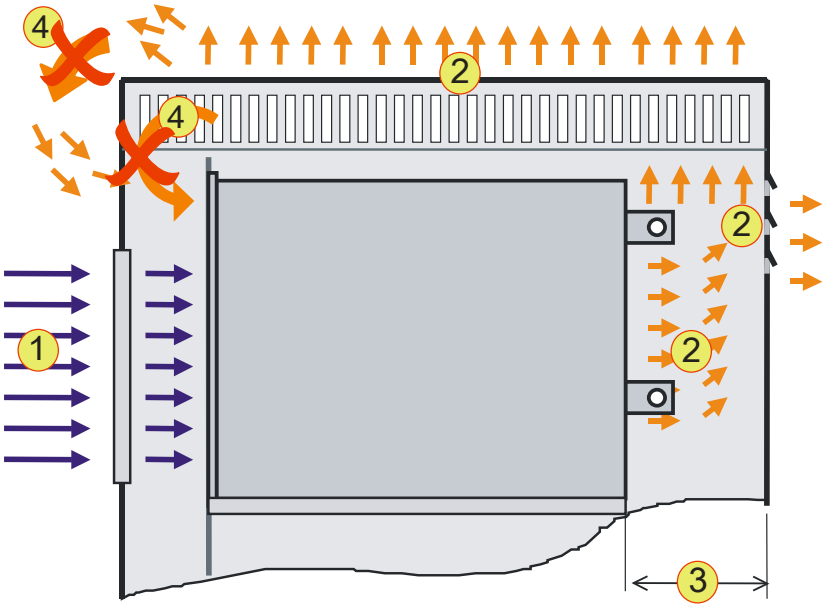

Fig. 18 Scheme of the passage of the air on installation in a cabinet case.

1	**Air supply**
2	**Air exhaust**,
3	**Depth to the rear wall**, 150 mm
4	**Air short-circuit,** must be prevented

Table 33 Schematic illustration of the cooling air flow.

For the supply and removal of cooling air, sufficiently large, suitable cases with corresponding inlet and outlet openings for the passage of the cooling air are to be used.

Air supply -1-: The cooling air is drawn in at the front. The air must be supplied unhindered, any air filters necessary are to be installed in the cabinet door or directly on the front of the power supplies. For an adequate supply of air, an inlet opening of at least 300 mm x 300 mm is to be provided per power supply and, if necessary, covered with a correspondingly large air filter.

Air removal -2-: The cooling air discharged from the power supplies at the rear. It is imperative there is adequate clearance for the passage of the air:
at least 150 mm deep **-3-** over the full width of the power supply.
The cooling air can be discharged via the roof and/or rear wall. During this process an “air short-circuit” **-4-** must be avoided.
(Directly drawing back in discharged cooling air)

Air filter

If the TopCon power supplies are to be operated in an environment with medium or heavily soiled air, the cooling air supplied must be filtered either externally (e.g. on entry into a switch cabinet in the cabinet door) or directly at the devices so that inadmissible deposits of dirt in the devices are prevented.

The air filters available as an accessory TC.AIRFILTER-6U/9U comprise a filter mat as well as a frame with quick-release fastenings for mounting on the front of the TopCon power supplies.

Further information in chapter 4.2.2, page 100.

Liquid cooling

The power section of the TopCon power supply can be equipped with liquid cooling as an option. For this purpose one of the two fans is replaced with a corresponding liquid cooling module.

Further information in chapter 4.2.1, page 93.

3.2.4. Electrical connections

3.2.4.1. Electrical installation – general

In the following basic requirements on the electrical installation of electrical power supplies with TopCon power supplies are described.

General information on installation

Prior to installation and commissioning, these operating instructions as well as any other information and instructions are to be read carefully.

WARNING

Possible mortal danger due to electric shock!

- Due to tampering with electrical modules

Avoidance:

⇒ The electrical installation is to be undertaken by personnel with electrical training.

⇒ Never connect or disconnect electrical connections while they are live.

The correlation of the modules and documentation supplied must be checked:

1. Do the type plates match the order and delivery documentation?
2. Are the device nominal data suitable for the intended application?
3. Do the cables/connector supplied match the intended connections?

During the installation work, pay particular attention to the following:

1. Never connect or disconnect electrical connections while they are live!
2. Lay cables carrying high currents using an adequate cable cross-section as per VDE0110!
3. Ensure correct earthing of each power supply to a common PE rail!
4. It is imperative cable shields are connected via the cable clamps and/or connector cases to earth or the case on the power supplies using large area connections!
5. Follow measures for compliance with EMC regulations in the following section on electromagnetic compatibility page 52.
6. Provide safety shutdown feature (EMERGENCY STOP/interlock) and test it!

Electromagnetic compatibility

TopCon power supplies have interference protection and suppression filters on all power and signal connections such that immunity is achieved on correct installation compliance with the applicable IEC and EN standards in relation to interference.

The following standards are applicable:

- Interference immunity: EN 61000-6-2
- Interference emission: EN 61000-6-4

For the interference protection components to be able to perform their function, the following conditions must apply:

- Large area earthing suitable for EMI.
- Shield mains and load connection.
  (Depending on load and installation situation)
- Connect both ends of shields to earth.
  (Depending on load and installation situation)

Interference immunity

The system must be fully earthed (encompassing all parts) and earthed suitable for EMI.

Correct earthing and shielding of the cable connections are key elements for interference immunity.

- All cable shields must be connected to earth potential at both ends using large area connections.
- Ideally shielded connectors are used that are earthed directly via the earthed sockets on the electrical power supply.
- Star topology earthing (suitable for EMI) of the device.

Interference suppression

TopCon power supplies have integrated interference suppression. For the interference protection components to be able to perform their function, the following conditions must apply:

- Large area earthing suitable for EMI.
- Shield mains and load connection.
  Depending on load and installation situation.
- Connect both ends of shields to earth.
  Depending on load and installation situation.

3.2.4.2. System overview/connections

Block diagram

The mains voltage is rectified and smoothed in a DC intermediate circuit with capacitors. From this smoothed voltage a high frequency AC voltage is generated using a full IGBT bridge in the power section (printed circuit board LP PWR); this features makes it possible to control the output voltage using phase modulation.

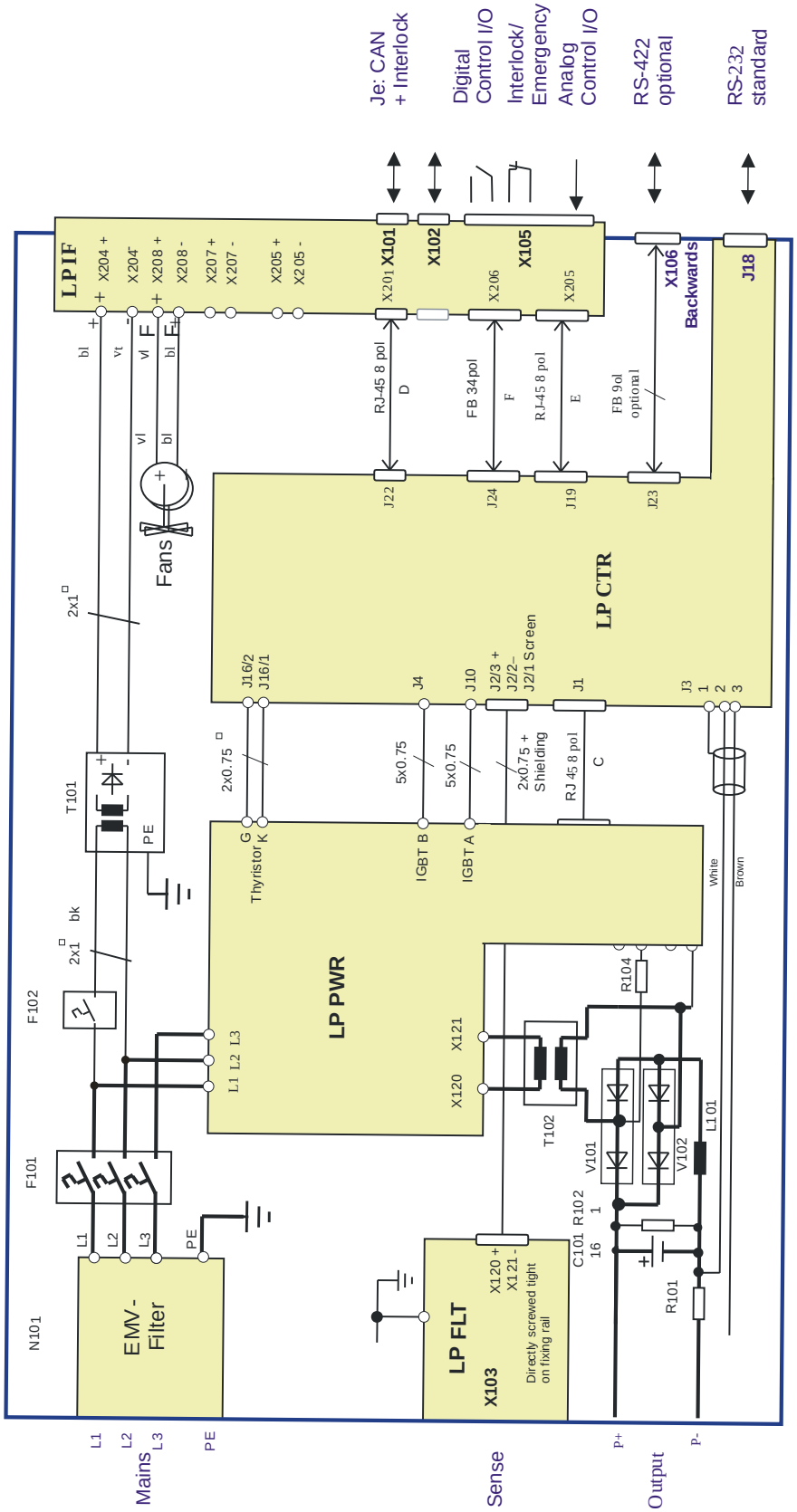

Fig. 19 Block diagram of connectors and internal connections
All external interfaces are explained in this section Table 34, page 55.

Control connections

The standard version can be switched on and off as well as remotely programmed via digital and analogue inputs and outputs or directly via the RS-232 interface.

The entire control and monitoring is undertaken by a powerful controller (LP CTR) based on a DSP.

Further interaction options are provided via optional interfaces (e.g. RS-422, GPIB (SCPI command set) or CAN/CANOpen®).

Isolation

- All control interfaces are isolated in relation to the power line, earth and output.
- The analogue inputs and outputs are isolated in relation to the power line, earth, output and digital interfaces.
- The RS-232 interface is isolated in relation to the power line, earth, output and controller.

The connections given above are described in more detail in this section:

Name	Interface
Mains connection	3~ 400/480 VAC
Sense	X103 remote voltage sensor/ Correction of the voltage drop as measurement is made directly at the load.
Output (voltage)	0 – U_{NOM}
Communication bus	X101/102, device communication (only TopCon and dedicated peripheral devices, not a general interface)
Digital control I/O	X105
Analogue control	X105

Table 34 Overview of interfaces described in this section.

3.2.4.3. Mains connection

The mains connection is made via the terminals L1, L2, L3 and PE.

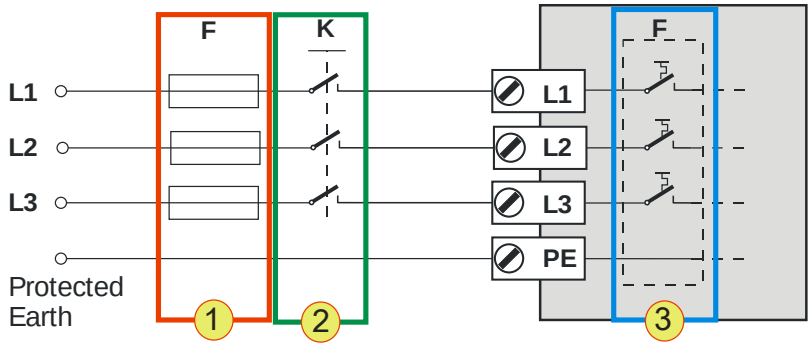

Fig. 20 Circuit diagram – mains connection to the TopCon power supplies.

Protection of the TopCon power supply

- **Circuit breaker F -3-**
  The internal circuit breaker is designed for the related current and power consumption of the TopCon power supply.
- **External main switch K (option) -2-**
  The external main switch is mostly used for devices in a multi-unit system in a switch cabinet.
- **Fuse F -1-**
  In case of cable lengths over 3 m, a fuse must be included in the circuit in accordance with VDE636.
  The rating is to be selected as appropriate, see Table 35, page 56.
- **Cable cross-section**
  The external cables must have the necessary cable cross-section, see Table 35, page 56.

Mains connection/ mains voltage	TC.P.10	TC.P.16	TC.P.20	TC.P.32
Fuse				
400 V_{AC}	25 A	35 A	50 A	80 A
480 V_{AC}	n.a.	n.a.	40 A	63 A
Connection cross-section				
400 V_{AC}	6 mm^2	10 mm^2	16 mm^2	25 mm^2
480 V_{AC}	n.a.	n.a.	10 mm^2	16 mm^2

Table 35 Specification of fuse and connection cross-section.

3.2.4.4. Sense- remote voltage sensing connection

To compensate for the voltage drop over the load cables, TopCon power supplies have a "**Sense**" connection feature.
The voltage can be measured directly at the test specimen and controlled more accurately.

If this sense function is not required, the connection is simply left unconnected.

Modifications and restrictions apply for multi-unit systems. First read this section to become familiar with the principle. You will find a further description on the usage of the function in multi-unit systems in the chapter on multi-unit systems.
(See chapter 5.2.1, page 145).

Characteristics of the sense function

On the usage of the sense function the following characteristics apply to the overall system:

- The controller compensates for losses that result in particular due to high load currents and high cable resistances.
- The load cable may be interrupted in operation.
- The maximum voltage compensation is adjustable.
- The voltage difference between device output and sense sensor can be monitored
  TopControl: Voltage sensing - Error level.
  The device will shut down if the limit is exceeded.

The circuit diagram in Fig. 21 shows the connection of the load and the sense connections.

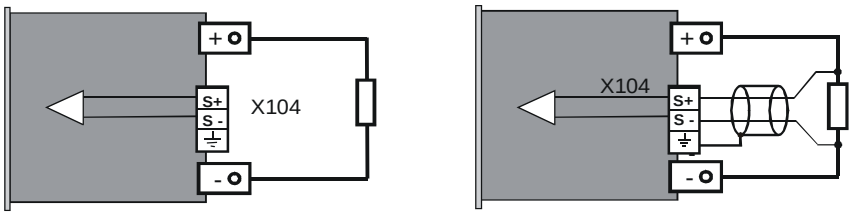

Fig. 21 Connection of load without/with sense functionality.

Connection cables

On selecting a sense cable you must take into account the following:

- **Cable cross-section: 0.5 mm^2, per cable**
  Single cables are mostly adequate.
- **Cable resistance: can be ignored**
  Only a low current flows through the sense cable.
  (OP-Amp input)
- **Voltage class**
  The sense cable must correspond to the voltage class of the device. (Particularly from 800 V output voltage).
- **EMI shielding/coupling of interference**
  Use shielded cables to prevent the coupling of electrical interference onto the sense input.

Increase the interference immunity by means of simple measures:

- Simply twist the sense cables.
- Lay the sense cables physically separate from power cables.

Software requirements

The following conditions must be met for the sense function to be supported and so that it can be activated.

- Main DSP firmware: **from V4.11.33**
- TopControl application: **from V4.01.12**
- User rights for TopControl application:
  "**Advanced User**"
- Connection must be established between TopCon power supply and TopControl application.
- **State: " VOLTAGE_OFF"**
  The sense function can only be activated if there is no voltage present on activation.

Sense activation/deactivation in the TopControl application

The sense function can be found on the **<CONFIG> -1-** tab, and the parameters defined in the “Voltage sensing” **-2-** group.

The entire function is activated/deactivated via the “Use sense input” **-3-** check box.

For information on the significance of the parameters see TopControl manual.

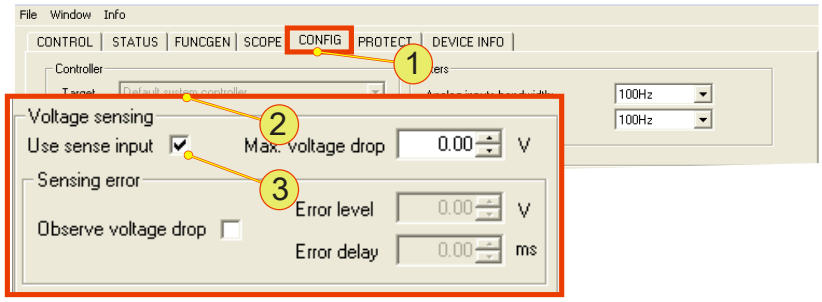

Fig. 22 Configuration of the sense function in TopControl.

Sense actual value indication

On the activation of the sense function, the following indications alternate:

- **<CONTROL>** tab
  The labels “Output Voltage” **-1-** and “Output Power” **-1-** change to “Sense Voltage” **-2-** and “Sense Power” **-2-**

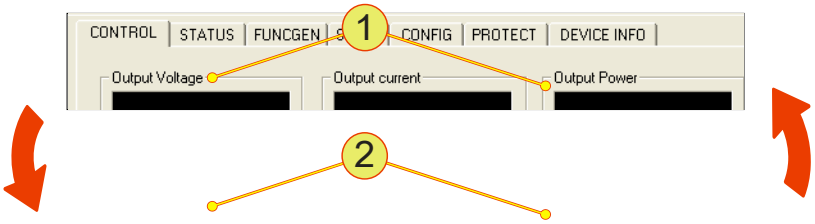

Fig. 23 Indication change between output voltage and sense voltage.

- **<STATUS> -3-** tab
  Along with the indication of the output values **-1-** the sense actual values **-2-** are also displayed.

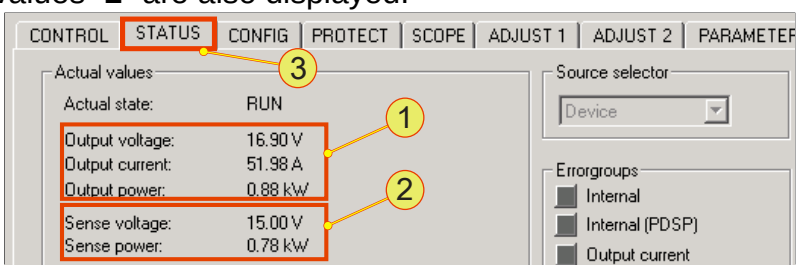

Fig. 24 Indication of the output values.

Sense configuration

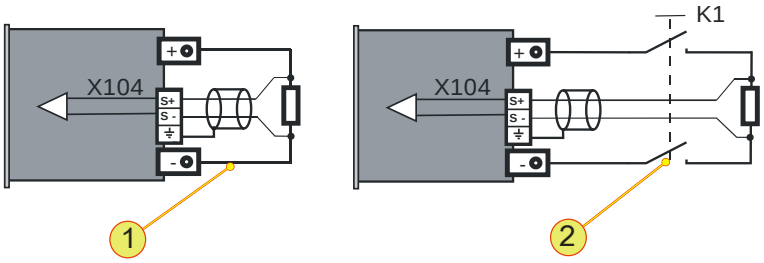

Fig. 25 Connection of load with sense function, not switched **-1-** or switched **-2-**.

The sense cables are connected directly across the load. Here it is allowed to install a switch (contactor) **-2-** in the load circuit. The maximum output voltage U_{out} can be configured via the software. The output voltage can be limited via the value configured.

Output of the sense voltage via the analogue interface X105

With the sense function activated, the analogue sense voltage actual value can be used for the indication via the analogue interface X105.

For further information on the pin definition of X105 see chapter 3.2.4.7, page 66.

Sense function indication change

- **On the <CONTROL>** tab
  If the corresponding sense actual values cannot be achieved, the sense indication (voltage or power) changes from red (normal state) **-1-** to yellow **-2-.**

Fig. 26 Indication of the sense actual values. Example voltage value in normal state **-1-** and actual value is not reached -**2-.**

- **On the front panel**
  The related LED on the front panel of the TopCon power supply starts to flash.

Fig. 27 Flashing LED with the sense function
VOLTAGE LED **-1-** , POWER LED -**2-**

The following cases will produce an indication change:

- **Max voltage drop**
  The value set on the **<CONFIG>** tab **<Max voltage drop>** is insufficient to compensate for the voltage drop over the load cable.
- **The required sense voltage is not reached**
  The maximum module voltage allowed is insufficient to achieve the required sense voltage.
- **The required sense power is not reached**
  The maximum module power allowed is insufficient to achieve the required sense power.

3.2.4.5. Output connection/load connection

The output connections are laid to the rear side of the device as current bars.

For the load connection you must pay attention to the following aspects:

- Use a cable cross-section to suit the device power and nominal voltage.
  (See Table 36, 62.)
- Screw cable to current bars using cable lugs
  Hole diameter: 9 mm

Follow the standards applicable to the related application and type of cable laying. The values in the table are only a recommendation.

Nominal voltage on the output	Cross-section [mm²] - load cable			
	TC.P.10	TC.P.16	TC.P.20	TC.P.32
50 V	50	70	95	150
100 V	35	50	70	70
200 V	16	25	35	50
500 V	4	10	16	25
1000 V	2.5	4	6	10
1200 V	2.5	4	6	10

Table 36 Cross-section sizing for the load cable as a function of the output voltage.

For cable lengths of more than 5 m the next size cross-section up should be selected to keep the voltage drop over the load cable in limits.

3.2.4.6. System-internal CAN communication (X101/102)

TopCon power supplies that are operated in a multi-unit system require system-internal communication via the related interfaces X101/X102.

The tasks of the individual TopCon power supplies and their peripheral modules, e.g. RCUs and series controllers are controlled via the CAN communication. At the same time the CAN communication is used for communication between the system master and the slaves assigned.

The interfaces X101 and X102 have the following tasks:

- CAN interface, for the communication
- Interlock connection

The related interface must always be “terminated”, i.e. fitted with the related dummy plugs or a bus connection.

Pin definition for connection X101/X102

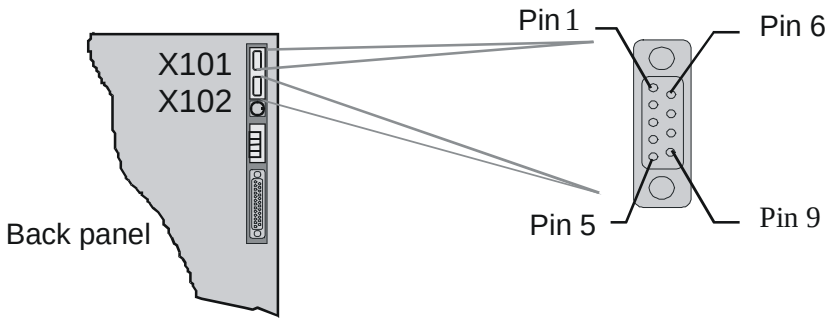

Fig. 28 Pin arrangement X101/X102 (D-Sub 9, female).

In the following tables an overview of the pin definition and the electrical characteristics of the CAN and SYNC connections is given.

Pin	Signal	I/O	Description
1	**INTERLOCK_CAN**	I	Interlock CAN
2	**CAN_L**	I/O	CAN low
3	**GND_CAN**	O	CAN common
4	**---**		
5	**---**		
6	**GND_CAN**	O	CAN common
7	**CAN_H**	I/O	CAN high
8	**0 VDC I/O**	O	Auxiliary supply common
9	**+24 VDC I/O**	O	Auxiliary supply (+ 24 V_{DC})
	Shield		connected to earth

Table 37 Pin definition on the interfaces X101/X102 as per Fig. 28.

Recommended cable characteristics for the system communication

Properties	Description
Characteristic impedance	120 ± 20 Ω
Cable cross-section	4 x 2 x 0.14 mm^2 with shielding
Twisting	In pairs 1+8/2+7/3+6/4+5
Recommended types	Dätwyler Uninet –4P, Dätwyler Uninet –4P flex

Table 38 Recommended cable for system communication.

Assignment of interface and dummy plug

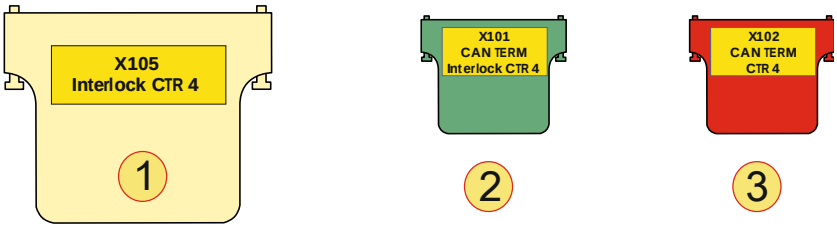

Fig. 29 Schematic illustration of the D-Sub dummy plugs used with their labelling.

Dummy plug	
1	**Interlock connector, D-Sub, 25-pin (dummy plug)** Label: "**X105; Interlock CTR 4"** Is connected on the rear side of all devices to interface X105.
2	**Interlock or CAN-Term, D-Sub, 9-pin (dummy plug)** Label: "**X101; CAN TERM; Interlock CTR 4**" Is connected to interface X101 on the rear side of the device at the start of the CAN multi-unit system.
3	**CAN-Term, D-Sub, 9-pin (dummy plug)** Label: "**X102; CAN TERM;"** Is connected to interface X102 on the rear side of the device at the end of the CAN multi-unit system.

Table 39 Dummy plugs and their labelling.

Only one CAN-Term is allowed to be connected to a single device. Independent of whether X101 or X102 is used.

Establishment of communication connection TopCon with/without HMI and RCU

In the following the configuration of a TopCon power supply and its peripheral devices is considered.

With the possible combinations of HMI and RCU, there are 4 standard configurations for a TopCon power supply.

For further information on multi-unit systems with at least 2 or more TopCon power supplies, see chapter 5, from page 143 .

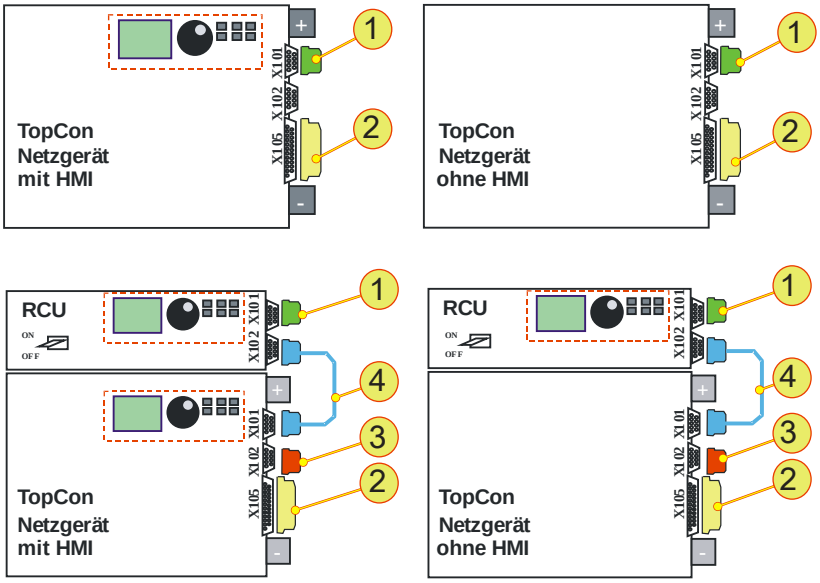

Fig. 30 Circuit diagram for TopCon with HMI (left) and without HMI (right).

No.	Function	Dummy plug used	Device	Interface
1	**“Interlock” + “CAN TERM”**	Dummy plug X101	TopCon RCU	**X101**
2	**“Interlock”**	Dummy plug X105	TopCon	**X105**
3	**“CAN TERM”**	Dummy plug X102	TopCon	**X102**
4	**“CAN CABLE”**	---	TopCon RCU	**X101**

Table 40 Allocation of components to Fig. 30.

3.2.4.7. Digital/analogue control connection (X105/digital and analogue interface)

The tasks of the interface X105 cover

- Set value specification (U, I, P, R_i) and actual value output
  For further information see chapter 3.3.3.2, page 76.
- Digital remote control
  For further information see chapter 3.3.3.6, page 79.
- Interlock safety circuit
  For further information see chapter 3.2.4.8, page 67.

Arrangement/pin definition

All control signals for the device control and set value specification are connected to a 25-pin D-Sub connector (female) on the rear of the device.

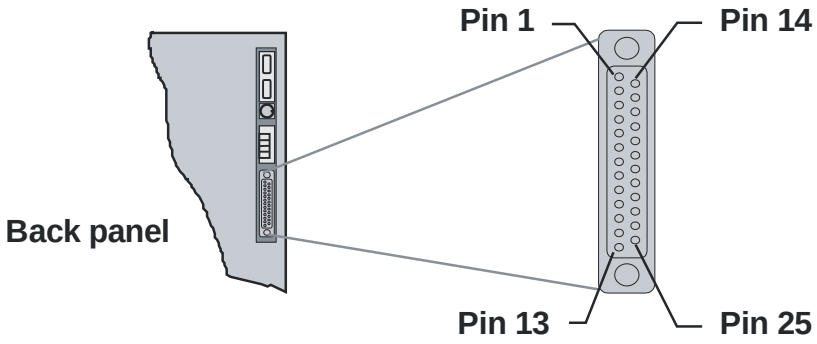

Fig. 31 Pin arrangement at analogue/digital interface X105 (Sub-D, 25-pin, female).

Pin	Signal	I/O	Description
1	**AGND**	I	Analogue ground for pins 2–4, 14–16
2	**VREF**	I	Voltage setpoint input 0–10 V
3	**IREF**	I	Current setpoint input 0–10 V
4	**IACT**	O	Current feedback output 0–10 V
5	**0 VDC**	O	0 V_{DC} I/O ground for pin 25 [1]
6	**+10 VDC**	O	Analogue reference voltage
7	**COM**	I	(connected to pin 17) 0VDC DigIn; common ground for pins 8–9, 18–20, 24
8	**APP_DIGITALIN_4; CLEAR_ERROR**	I	Digital input 0-2V /10-24V DC
9	**VOLTAGE_ON**	I	Digital input 0-2/10-24V DC
10	**OK/ALARM_b** [2]	O	Relay output 1 normally open

Table continued on next page.

Pin	Signal	I/O	Description
11	**OK/ALARM_a**[2]	O	Relay output 1 common
12	**RUN_b**[2]	O	Relay output 2 normally open
13	**RUN_a**[2]	O	Relay output 2 common
14	**PREF**	I	Power limit analogue input 0–10 V
15	**RREF**	I	Ri-simulation analogue input 0–10 V
16	**VACT**	O	Voltage feedback output 0–10 V
17	**COM**	I	(connected to pin 7) Common ground to pins 8–9, 18–20, 24
18	**APP_DIGITALIN_1**	I	Digital input (low) 0-2 V_{DC}/(high) 10–28 V_{DC}
19	**APP_DIGITALIN_2**	I	Digital input (low) 0-2 V_{DC}/(high) 10–28 V_{DC}
20	**APP_DIGITALIN_3;** **ANAOG_** **REFERENCE_** **SELECT**	I	Digital input ((low) 0-2 V_{DC}/(high) 10–28 V_{DC} Analogue reference select
21	**WARN_a**[2]	O	Relay output 3 normally open
22	**WARN_b**[2]	O	Relay output 3 normally closed
23	**WARN_c**[2]	O	Relay output 3 common
24	**INTERLOCK_IN_+**	I	Input Interlock +
25	**+24 VDC**	O	24VDC I/O Aux power output 24 V_{DC}, max. 0.2 A

Table 41 Pin definition for the X105 interface.
[1] Pin 5 (0 V_{DC}) is used as the reference earth for pin 25 (24 V_{DC}) and is connected internally to the equipotential bonding via a 1 kΩ resistor to earth.
[2] Maximum switching current: 1 A; maximum switching voltage: 24 V .

3.2.4.8. Interlock circuit with X101 and X105

Ring structure of the interlock safety circuit

The interlock circuit makes it possible to setup a safety infrastructure. The basis for the function is an electrical ring structure that must be closed for operation.

Safety elements **-2-** (e.g. EMERGENCY STOP buttons) can interrupt the ring and as a result switch off the TopCon power supply.

For higher safety requirements, e.g. safety class 1, the option: ISR (Integrated Safety Relay) is available.
For further information see chapter 4.2.4 on page 107.

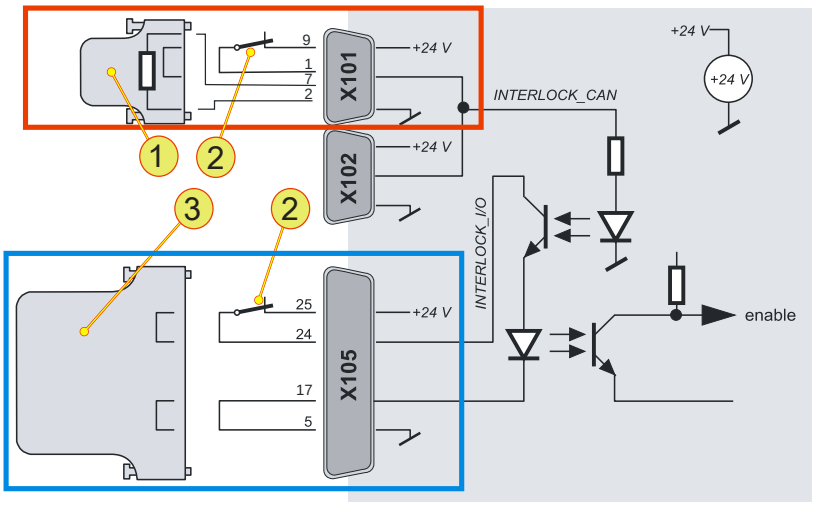

Fig. 32 Explanation of function of interlock circuit for single device.

Connection of the interlock circuit	
1	**Dummy plug X101** **Safety circuit is closed using a jumper.** **Terminating resistor for the CAN bus**
2	**External EMERGENCY STOP button**
3	**Dummy plug X105** **Safety circuit is closed using a jumper.**

Table 42 Connection of the interlock circuit.

Interfaces used for the interlock safety circuit

- **X101/X102**
  Suitable for external **EMERGENCY STOP button**.
  In multi-unit systems the interlock circuit is interrupted immediately on the operation of an EMERGENCY STOP. All devices in the multi-unit system are shut down simultaneously.
- **X105**
  Suitable for an external **EMERGENCY STOP button on a single device**. The interlock contact is interrupted on the local single device.
  In the multi-unit system the shutdown signal is only passed on via the internal device communication with a delay.

To be able to place a TopCon power supply in operation, these interfaces must be connected appropriately.

Use dummy plugs supplied!

In the simplest configuration corresponding dummy plugs must be fitted to the two interfaces X101 and X105.

For information on dummy plugs see chapter 3.2.4.6, page 64.

3.2.4.9. Control connection X301 (RS-232 on front)

The communication interface is used to connect the TopCon power supply to the PC. The connection is made using an RS-232 cable that is included in the items supplied.

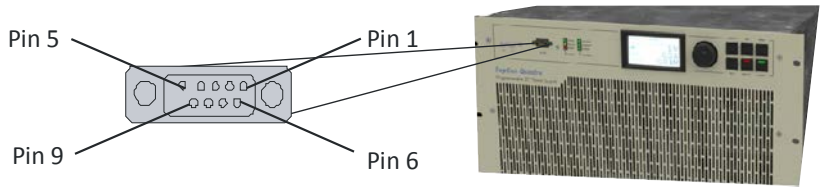

Fig. 33 RS-232 interface on the front panel
9-pin D-Sub connector, female.

Position of the interface on the device:

- **On the front panel**
  Standard access to the TopCon power supply.
- **On the rear side** (option)
  If the device is part of a multi-unit system or a Q14 ReGen system and it is installed in a switch cabinet, the interface is often fitted on the rear side of the device.

The RS-232 interface on the front side of the TopCon power supply cannot be operated at the same time as other interface options.

Pin definition for the RS-232 interface

TopControl end				PC end
Pin	**Description**	**I/O**	**Signal**	**Signal**
1	not connected (n.c.)	-	**-**	**-**
2	Transmit data	O	**TXD**	**RXD**
3	Receive data	I	**RXD**	**TXD**
4	n.c.	-	**-**	**-**
5	Common ground	-	**GND**	**GND**
6	n.c.	-	**-**	**-**
7	n.c.	-	**-**	**-**
8	n.c.	-	**-**	**-**
9	n.c.	-	**-**	**-**
	Connected to earth	-	**Shield**	**-**

Table 43 Pin definition RS-232 interface as per Fig. 33, 69.
n.c.: not connected.

3.2.5. Commissioning – electrical power supply

CAUTION

Possible mortal danger due to electric shock!

Avoidance:

⇒ Installation and commissioning are only allowed to be undertaken by appropriately skilled personnel.
⇒ During commissioning, proceed as per the following list step-by-step.

Prior to switching on for the first time

Prior to switching on for the first time, the following points are to be checked:

- Does the information on the type plate match the mains connection and load?
- Mains connection correctly wired?
  Adequate cable cross-section used?
  For further information see chapter 3.2.4.3, page 56.
- Loads connected with correct polarity?
  For further information see chapter 3.2.4.5, page 62.
- Control signals connected correctly?
  For information on X101/X102 see chapter 3.2.4.6, page 62.
  For information on X105 see chapter 3.2.4.7, page 66.
- Interlock/emergency stop circuit wired?
  For further information see chapter 3.2.4.8, page 67.

3.2.6. Switching on the device

Condition:

- All external control signals for controlling device on/off must be inactive.
- All circuit breakers must be switched on.
  On switching on the circuit breakers all LEDs illuminate for approx. 1 s and the DSP controller starts a device self-test.

Device self-test

The duration of the device self-test is approx. 5 seconds.
In multi-unit operation the system is also configured and the communication between the power supplies connected checked for correct function.

Self-test reports status: “OK”.

- READY light emitting diode (green) illuminates continuously.
- The device is ready.
- State machine changes to the “READY” state.
  For further information see chapter 3.3.6, page 80.

Self-test reports status: “Error”.

- Error light emitting diode (red) illuminates or flashes.
  Flashing code on the ERROR light emitting diode indicates the reason for the error.
- State machine changes to the “ERROR” state.
  For further information see chapter 3.3.6, page 80.
- If the state machine remains in the “ERROR” state after a repeated start attempt, look for the reasons for the error using the “TopControl” application and take the necessary corrective measures.

Parameterisation

If possible do not make any changes to the factory settings, as the factory settings take into account your needs, the operation foreseen and your individual applications in the majority of cases.

If you nevertheless need to make application-specific settings, you can make them using the TopControl application from your PC.

However, prior to changing the settings we recommend undertaking the function test described in the following and only then changing the settings. In particular for monitoring values, ramp functions or controller settings.

Function test

Condition for the function test:

- Mains voltage switched on.
- Connected load.

Vary the procedure depending on which interface you use.

- With analogue interface X105
  The control signal VOLTAGE_ON can be applied from a possible input device (e.g. PLC, 12 V_{DC} power supply) via the interface X105. Set values can also be defined via this interface.
  For further information see chapter 3.3.3.3, page 77.
- With the HMI (option)
  Set values can be defined via a rotary switch on the related menu.
  Further information from chapter 6.3.4, page 162.
- With the RS-232 interface
  In combination with a PC and the TopControl application the set values can be defined on the <CONTROL> tab and the device switched on.
  For further information see TopControl manual.

Check the output voltage or current to ensure it matches the set values.

Please note that, depending on the configuration of ramp functions, the set values specified may in some circumstances only be reached after the related ramp functions/time have been completed.

Error-free state

After you have set the set values, the following occurs in the error-free state:

- The output is switched on and regulated to the related set value defined.
- The device is in the state: RUNNING,
  One CONTROL LED illuminates depending on the controller that is providing the limiting.
  CV for voltage controller
  CC for current controller
  CP for power controller

Error state

In the error state a flashing error code is output on the front via the CONTROL LED.
If there is no output voltage at the device, check the interlock safety circuit using the related dummy plugs.

For further information see chapter 3.3.1, page 73.

3.3. Control

3.3.1. Interlock output inhibit

TopCon power supplies have a feature for rapidly inhibiting the output using an interlock signal.

All external EMERGENCY STOP contacts must close the interlock circuit for operation to be possible.

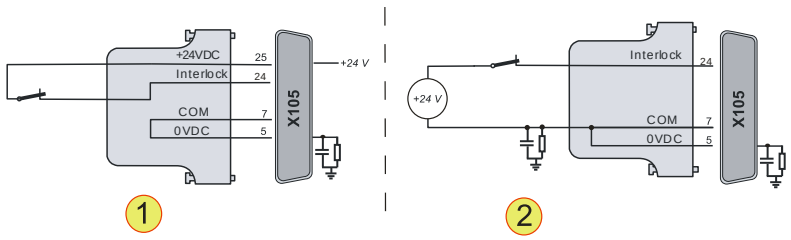

Fig. 34 Example interlock circuit on the interface X105.
-1- External EMERGENCY STOP button with internal voltage source.
-2- External EMERGENCY STOP switch with external voltage source.

With interrupted interlock circuit

- The power stage is switched off directly via a hardware link.
- The controller remains switched on.
- The device changes to the state: “Error”.

To work using the TopCon power supply (or a system with TopCon modules), check that the interlock circuit is actually closed.

Ensure that the correct dummy plug has been used for the termination of the interface X101.
For further information see chapter 3.2.4.6, page 64.

The description of the interlock circuit for multi-unit systems is different due to the utilisation of the interface X102 for the different devices in the system.
For further information see Fig. 78, page 147.

3.3.2. Interface hierarchy

In principle, all interfaces have the same priority, i.e. control can be transferred to another interface at any time.

An exception are the interfaces CANOpen, USB and GPIB.

There is an interface hierarchy during the power-up process. Depending on which interface was saved previously in the device as “activated”, control is superimposed via the system state. Settings from an interface lower in the hierarchy can be overwritten by a interface higher up in the hierarchy.

3.3.2.1. Interface hierarchy during power-up:

1. **HMI/RCU (optional)**
   All settings from interfaces lower in the hierarchy are overwritten by the HMI /RCU interface provided this interface is in the active state.
   In the case of multi-unit systems with several active HMI /RCU interfaces, the interface that was switched on first takes over the control.
   If several active HMI are switched on at the same time, the selection is random.
   The HMI/RCU interface can be set to “passive” such that it does not make any attempt to take control.
2. **Analogue interface X105**
   If the HMI is set to “passive” and there is a high level on pin 20, the analogue interface takes over control.
   For further information see chapter 3.3.3, page 75.
3. **RS-232**
   If the HMI and the analogue interface are not activated, the RS-232 interface takes over control.
   The interface can be selected on the interface using a PC with the TopControl application. It is also possible to transfer set values to the TopCon.
4. **CAN/CANOpen (optional)**
   and USB (optional) as well as GPIB (optional)
   If the CAN/CANOpen interface is allocated the function of exclusive control over all interfaces, it is first in the hierarchy.
   Exclusive control means that a change in the interface configuration via other interfaces is no longer allowed and the analogue interface is switched off.
   HMI /RCU settings are overwritten.

3.3.3. Analogue control (X105)

3.3.3.1. Activation of the analogue interface for remote control

The analogue interface can be activated via all the interfaces in the device, and also via the analogue interface itself.

Activation of the analogue interface without HMI for remote control

The analogue interface is activated via itself.

Activation is via pin 20 on the digital input on the analogue interface by means of the following signals:

- Rising edge from 0 V to 24 V.
- If the ANALAOG_REFERENCE_SELECT signal has already reached the high level of 24 V on power-up.

For information on the pin definition see Table 41, page 67.

Pay attention to the interface hierarchy.

Activation of the analogue interface with HMI (option) for remote control

Using the “analogue” selection in the HMI, the control over the system can be transferred to the analogue interface.

If this setting is to be retained on the next system start, to save the settings the RS-232 interface and the TopControl application must be used.

The HMI interface does not have any feature for saving settings.

Activation of the analogue interface via RS-232 using the TopControl application for remote control

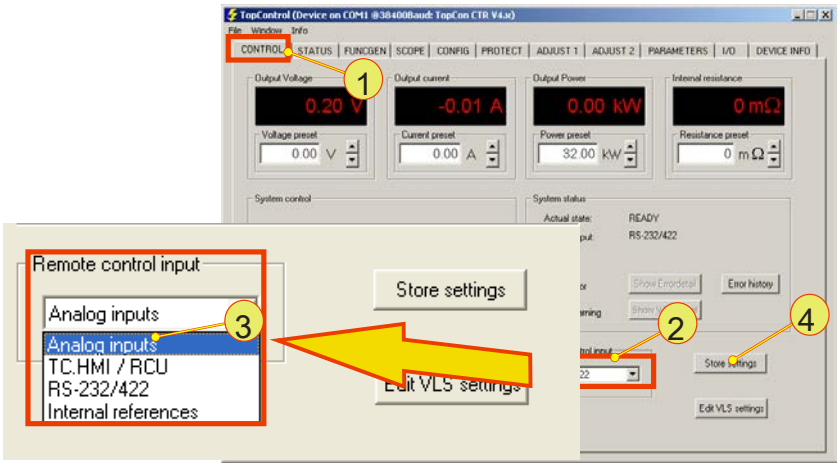

Fig. 35 Activation of the analogue interface via the <Remote control input> list box.

The remote control is transferred to the analogue interface as follows:

1. On the <CONTROL> **-1-** tab, select in the <Remote control input> **-2-** list box the “Analog inputs” **-3-** entry.
2. If the analogue interface is to be activated the next time the TopCon power supply is powered up, you must save the selection using the <Store Settings> **-4-** button.

3.3.3.2. Analogue remote programming

Isolation of the signal inputs

All four analogue inputs for current I_{REF}, voltage V_{REF}, R_{REF} and power P_{REF} are fully isolated, as a result external isolating amplifiers are not required.

Reference ground

The reference ground is common for all analogue inputs and must be connected to the reference potential of the supplying signal source.

If individual set values are not required, these inputs can be left unconnected or connected to the analogue reference earth.

Digital entry

The set values for current I_{REF}, voltage V_{REF}, power P_{REF} and internal resistance R_{REF} can also be entered digitally via the RS-232 interface instead of using analogue specification.

3.3.3.3. Analogue remote programming – switching on/off the device

The control signal VOLTAGE_ON controls the power section of the electrical power supply and is coupled directly to the state machine for the device and system control.

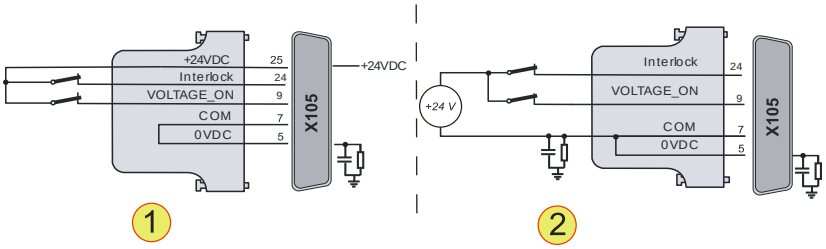

Fig. 36 On/Off control of the TopCon power supply.
-1- External ON/OFF contact with internal voltage source.
-2- External ON/OFF contact with external voltage source.

Pin	Analogue control	Function
9	**VOLTAGE_ON**	Device switched on: 24 VDC are present Device switched off: open connection

Table 44 Switching states VOLTAGE_ON

Use dummy plugs supplied!

In the simplest configuration the related dummy plug must be used; this plug is fitted to interface connection X105.

For information on dummy plugs see chapter 3.2.4.6, page 64.

3.3.3.4. Analogue remote programming for current and voltage

If this set value setting is not required, these inputs can be left unconnected or connected to the analogue reference earth.

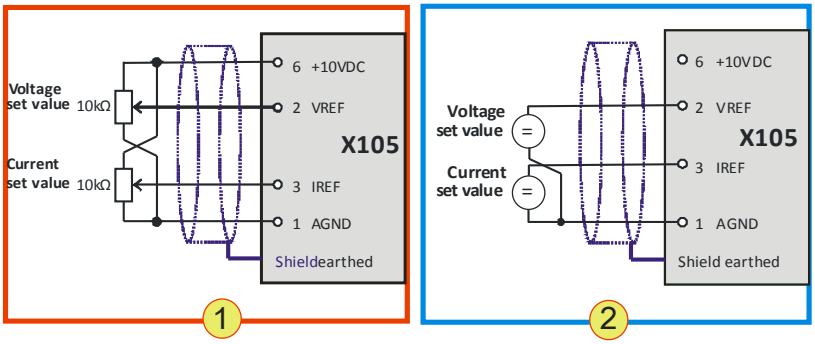

Fig. 37 Analogue set value specification using potentiometers **-1-.**
Analogue set value specification using external sources **-2-**.

Pin	Analogue control	Function
2	**Voltage V_{REF}** 0…10 V or 0…10 kΩ	Output voltage $U_{max=}$= U_{nom} * [0.. 100%] where V_{REF} ≙ [0.. 100%]
3	**Current I_{REF}** 0…10 V or 0…10 kΩ	Output current I_{max} = I_{max} * [0..100%] where I_{REF} ≙ [0.. 100%]

Table 45 Factory pin definition and value range for the control values V_{REF} and I_{REF}.

3.3.3.5. Analogue remote programming for power limit and internal resistance simulation

If this set value setting is not required, these inputs can be left unconnected or connected to the analogue reference earth.

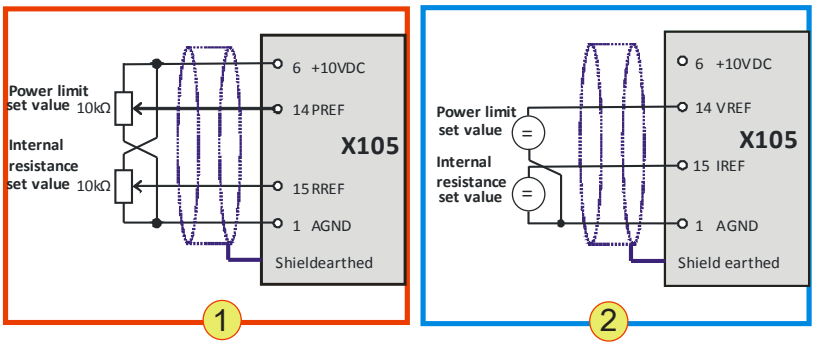

Fig. 38 Analogue specification of power limit and internal resistance.
Analogue set value specification using potentiometers **-1-**
Analogue set point specification using external sources **-2-**

Pin	Analogue control	Function
14	**Power limit P_{REF}** 10..0 V or 10…0 kΩ	Output power $P_{max=}$ = P_{nom} * [0.. 100%] where P_{REF} ≙ [0.. 100%]
15	**Internal res. R_{REF}** 0..10 V or 0…10 kΩ	Internal resistance R_{REF} = 0…1000 mΩ

Table 46 Factory pin definition and value range for the control values P_{REF} and $_{REF}$

Internal resistance extension (option)

With an optional internal resistance extension, the same pin definition and specification values apply.

For the power limit the specification is inverted!

In the case the power limit input voltage P_{REF} = 0 V, there will not be any limiting of the maximum power, i.e. the power limit is set to the (full)

nominal power. Conversely, the power limit is set correspondingly on operation via pin 14 (P_{REF}).

3.3.3.6. Digital outputs (relay contact)

These relay contacts can be used, e.g., for a Versatile Limit Switch (VLS).

For further information on VLS see chapter 3.3.7, page 86.

As standard the definition of the digital outputs is as follows:

Name	Meaning	X105 Pin no.	Contact type
DIGOUT_1	OK/ALARM	Pin 10, 11	Closed ≙ OK OK = Device ready for operation
DIGOUT_2	RUN	Pin 12, 13	Closed ≙ Run RUN = “VOLTAGE_ON”
DIGOUT_3	WARN	Pin 21, 22, 23	Change-over contact WARN ≙ Warning

Table 47 Standard function of the X105 relay outputs.
Maximum switching current 1 A; maximum switching voltage: 125 V
The rest of the pin definition for X105 is listed in Table 41, page 67.

3.3.4. Diagnostic and control connection RS-232/DLL/ TopControl application

The diagnostic and control connection can be in the following positions on the device:

- Built-in on the front
- Built-in on the rear (option)
  If this option is available, it is not possible to use the interface on the front at the same time.

The RS-232 interface is the main access point for digital control information.

Typically the connection is made via a PC using the TopControl application. The communication between software and the interface is defined by function calls from a library file (DLL).

The library makes possible:

- Complex control and polling functions
  Additional device information and function calls in relation to other interfaces such as the HMI or analogue interface are possible.
- Custom programs
  You can use your own custom programs to access TopCon power supplies via the software interfaces in the function library.

For further information on TopControl see chapter 6.6, page 188.

3.3.5. System-internal communication CAN (X101/102)

The communication between TopCon power supplies connected to a multi-unit system and other peripheral devices (e.g. TC.LIN, RCU) takes place via the system-internal interface X101/X102.

For information on multi-unit systems see chapter 4.4, page 134.

For information on peripheral device interfacing see chapter 3.2.4.6, page 64.

Use dummy plugs supplied!

In the simplest configuration corresponding dummy plugs must be fitted to the two interface connections.

For information on dummy plugs see chapter 3.2.4.6, page 64.

3.3.6. Internal system status and troubleshooting

This section explains the internal control processes. It will help you to better understand the system messages, in particular warnings and error messages provided by the device in various ways.

3.3.6.1. Monitoring device-internal processes

The internal processes are monitored using a state machine. For the correct starting and operation of the device, the state machine works through the following tasks:

- The device self-test is started.
- The charging of the intermediate circuit is monitored.
- It reacts to user commands.
- Warning and error flags are polled
  and the resulting state changes are made.

Device states

As a consequence there exist different device states:

State	Description
ST_POWERUP	Initialisation phase, CAN login, all modules asynchronous
ST_READY	All modules ready, output electrically isolated, fans off [1]
ST_RUN	Output live, controlled to set values, fans on
ST_WARN	As for ST_RUN, at least one warning flag set
ST_ERROR	Error in at least one module, output electrically isolated, fans off[1]
ST_STOP	Stop state for software update
FATAL_ERROR	Internal communication failed

Table 48 Internal system states.
[1]Depending on the temperature, the fans may continue to operate at reduced speed.

The device state is output to the exterior on the following interfaces:

- Light emitting diode on the front panel
  Green: POWER
  Yellow: STATUS
  Red: ERROR
  For information on the control console see chapter 3.1.1.2, page 31.
- Digital outputs
  The relay contacts are operated in a corresponding manner and permit the connection of external status indications.
  For further information see chapter 3.3.6.3, page 83.

3.3.6.2. Indications on DEVICE and CONTROL LEDs

State of the device	DEVICE and CONTROL LEDs on the front of the device			
	"READY"	"STATUS"	"ERROR"	"CV"; "CC" and "CP"
Power UP	OFF	**ON**	OFF	OFF
STOP	ON	**ON**	OFF	OFF
READY	**ON**	**FLASH-ING** [3]	OFF	OFF
RUN	**ON** [1]	OFF	OFF	**ON** [2]
warn	**ON** [1]	**FLASHING** [3]	OFF	**ON** [2]
Error	**ON**	OFF[4]	**FLASHING** [3]	OFF
FATAL ERROR[5]	**FLASH-ING**[5]	**FLASH-ING**[5]	**FLASH-ING**[5]	OFF

Table 49 Indication of the system status via LED indication (front).
[1] Flashing, if a discharge device is active.
[2] One of the three LEDs, as per the actual control mode.
[3] Flashing code as per the error table or warning table (see chapter on troubleshooting).
[4] Flashing, if a warning is active at the same time.
[5] The three LEDs are flashing together: internal communication failed.

Description of the shutdown process

On devices with 20 kW and 32 kW:

Changing the position of the main switch does not shut down the Top-Con power supply immediately, instead a shutdown process is initiated. In particular, the discharge of the internal capacitors takes a certain amount of time during which the device is still live internally and to some extent the outputs are still live.

As long as the shutdown process is running:

- The three DEVICE LEDs form a running light.
- The HMI display indicates "shutting down…"

For this reason it imperative to wait until this process is complete before undertaking further tasks on the device.

On devices with 10 and 16 kW the shutdown process is so fast that there is no indication and no delays.

3.3.6.3. Indications via digital outputs (relays)

The internal system status of the TopCon power supply is output to the exterior via the relay connections. External signalling devices or a superior system controller that monitors several devices can be connected via the relays. The device state can then be evaluated.

State	RELAY 1 "OK/ALARM"	RELAY 2 "RUN"	RELAY 3 "WARN"
Power UP	OPEN	OPEN	OPEN
STOP	OPEN	OPEN	OPEN
READY	CLOSED	OPEN	OPEN/CLOSED[1]
RUN	CLOSED	CLOSED	OPEN
warn	CLOSED	CLOSED	CLOSED
Error	OPEN	OPEN	OPEN/CLOSED[1]
FATAL ERROR	OPEN	OPEN	CLOSED

Table 50 Indication of the system status using relays (interface X105).
[1] Closed if there is a warning, otherwise open.

3.3.6.4. Monitoring function - current monitoring concept

The current limiting is intended on the one hand to protect the device (above all the semiconductors) against damage, on the other hand certain monitoring functions can also be used to protect the load connected.

Monitoring	Protection in case of	Implementation	Time range
Short-circuit monitoring by IGBT driver	Transformer saturation, hardware faulty	Hardware level fixed	3 µs – 6 µs
Monitoring of $I_{Primary}$	Transformer saturation	Hardware	10 µs – 50 µs
Monitoring of $I_{Secondary}$	High load current peaks (electrical power supply or load protection)	Software	50 µs – 10 ms
I^2t algorithm $I_{Secondary}$	Temporary overload (electrical power supply or load protection), "fuse substitute"	Software	10 ms – as req.[1]
Current limiting by the controller	Output current too high (load protection)	Software	1 ms – ∞

Table 51 Properties of the internal monitoring functions in the TopCon.
[1] The maximum value is defined by the specific I^2t value

3.3.6.5. Causes of errors

There are various reasons for undesired, possibly erroneous system states:

- Faulty component
- System limits are reached or exceeded.
- Application error by the user

3.3.6.6. Division into group and detail errors (warnings)

To be able to troubleshoot errors as quickly and accurately as possible, the possible errors and warnings are divided into 16 group errors. Each of these group errors is in turn broken down into 16 detail errors. The list of all errors and possible rectification measures is given in the manual error list.

The **group errors, detail errors and warnings** are output as follows:

- **Direct indication via TopControl or HMI/RCU**
- **LED flashing codes on the front of the device**
  Group and detail errors are indicated sequentially as flashing codes on the red “ERROR” light emitting diode on the front of the device.
  Warnings are indicated via the yellow “STATUS” light emitting diode on the front panel.
  Output in the form of flashing codes is important in multi-unit systems, as in this case as a rule only one TopCon power supply has a HMI user interface. However, all TopCon power supplies have the LED indicator.
- **Output via digital outputs (relays)**
  For further information see chapter 3.3.6.3, page 83.

3.3.6.7. Error and warning indication on the front panel LEDs

The number of flashes indicates the possible reasons for the malfunction (group error and detail error). A complete flashing code comprises the following: <Flashes for group error><Pause in flashing><Flashes for detail error>

The following illustration shows a period in the indication cycle.

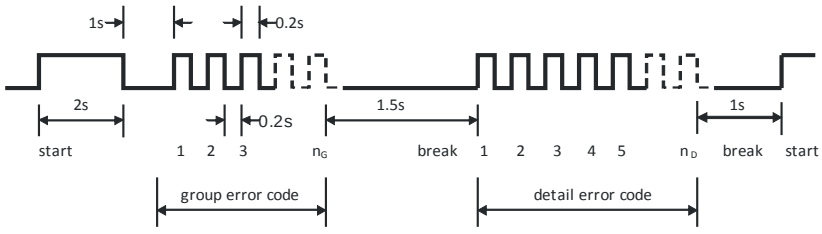

Fig. 39 Structure of the flashing code for error/warning indication via LED.

Flashing code sequence with errors or warnings

1. Error codes and warning codes are identical.
   All errors and warnings are output one after the other based on the scheme in Fig. 39, page 84.
2. After the output of the last error or warning the flashing sequence starts again with the first error or first warning.

Practical example

After switching on the TopCon Quadro power supply and setting the set values, the device is activated (On/Off). The buzzer comes on and an error code is indicated via the light emitting diodes:

Count the flashes:

- Group error code = 16,
- Detail error code = 3.

Reference to the error code list shows that an interlock error has been detected (F-2).

Note that the error coding is in hexadecimal. $F_{Hex} = 15_{10}$, 3 is the third element in 0, 1, 2, 3....

The indication on the HMI or in TopControl is: 0… 15 or 0 …F_{Hex}. The flashing code on the “ERROR” LED does not have a zero and therefore assumes the counting order 1…16. 0 signifies a pause in the flashing.

3.3.6.8. Acknowledging an error

After the occurrence of an error, the device remains in the ERROR state until the reason for the error has been rectified (as per error list) and the error has been acknowledged.

It is possible to acknowledge an error via the following interfaces:

- HMI
  Using the **<ESC>** button on the front of the device
- TopControl
  Using the **<Clear error>** button on the **<CONTROL>** tab
- Analogue interface X105
  Positive edge on pin 8 with 10-24 V relative to ground

3.3.7. Versatile Limit Switch (VLS)

3.3.7.1. Description of VLS function

With the aid of the VLS (Versatile Limit Switch) one of the following actual DC output values can be monitored:

- Voltage
- Current
- Power

If programmed limit values are not respected, an output relay is switched.

You can select the type of relay that is operated via the interface X105:

- “Warn” relay (normally open)
- “Run” relay (normally open)
- “OK/Alarm” relay (normally closed/normally open)

For further information see chapter 3.3.3.6, page 79.

The following VLS functions can be selected:

- Exceeding a threshold
- Dropping below a threshold
- Entering a window
  Defined value range is reached
- Leaving window
  Defined value range is left

Each threshold can also be assigned a hysteresis range above or below a threshold value.

A value of zero will deactivate the hysteresis.

Programmable switching delays help to suppress brief irrelevant transients (settling processes, pulses).

Due to the cyclical digital sampling, rapid changes (duration < 50µs) on the signals monitored may not be detected in some circumstances.

Exceeding or dropping below a threshold

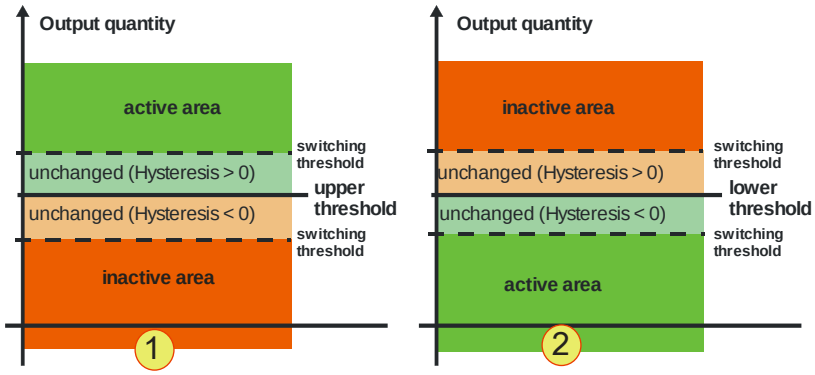

Fig. 40 VLS functions:
Exceeding the threshold **-1-**
Dropping below the threshold **-2-**

Entering a window/leaving a window

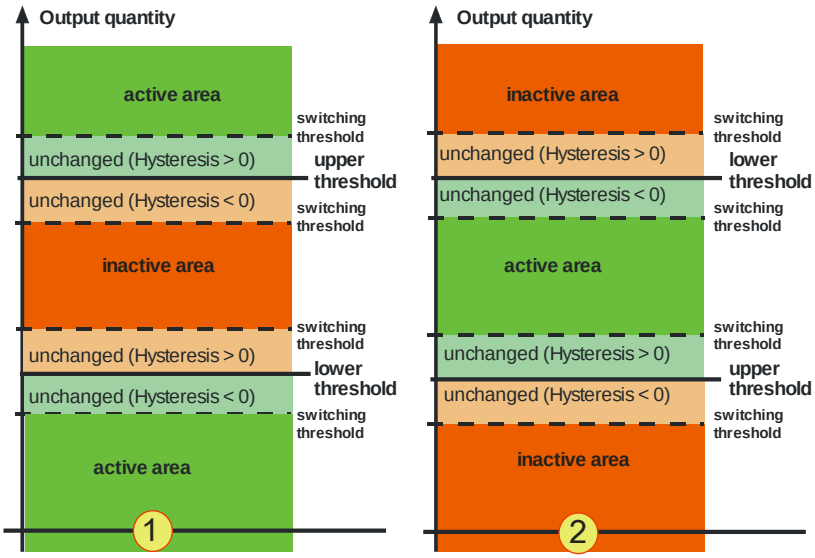

Fig. 41 VLS function:
Leaving a window **-1-**
Entering a window **-2-**

Switching behaviour – time dimension

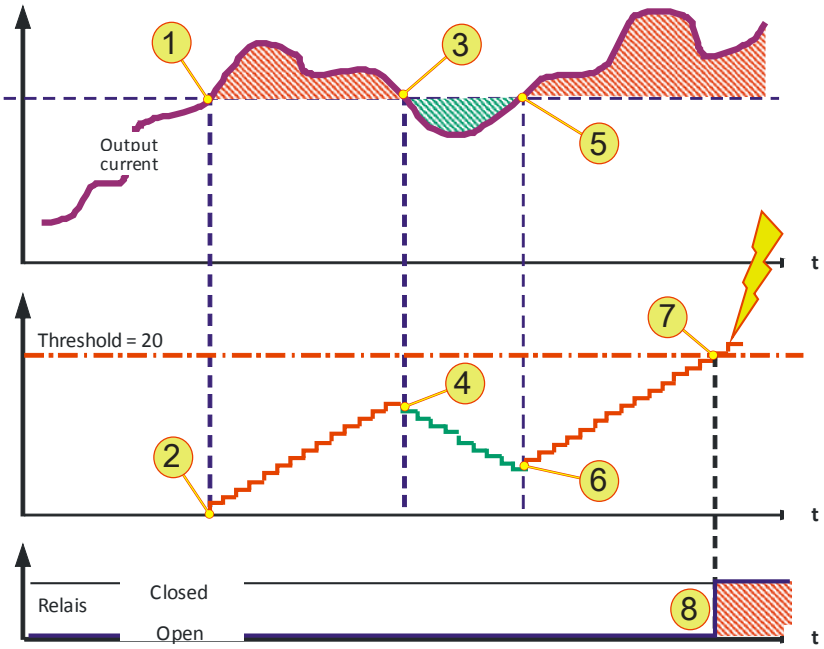

Fig. 42 Explanation of the VLS example (time dimension)

Along with the consideration of the dimension stated above, parameters can be set for the behaviour over time. The switching behaviour for the selected relay is also defined by various (timers) counters that evaluate the VLS state of the TopCon power supply.

The following explanatory example from Fig. 42 assumes the active-to-inactive delay = 20 ms the hysteresis set = 0 V.

The current curve exceeds the threshold **-1-**, as a consequence it is in the active range. The active counter now counts up, as per the limit value set, (“inactive-to-active delay”) **-2-**.

In this example the current drops back below the (lower) hysteresis threshold **-3-.** From this point in time the counter counts down **-4-**. From point **-5-** the monitored current increases again over the upper hysteresis value and the counter counts up again **-6-.**

Once the counter has reached the limit value set (as per the delay parameter) **-7-**, the required relay is closed or opened depending on the configuration **-8-.**

This process is setup similarly for the opposite direction using the “active-to-inactive delay” counter.

3.3.7.2. Programming VLS in TopControl

The VLS function is currently not available for systems in the following categories for reasons of modified hardware and software requirements:

- ReGen
- ResACT
- ACLF

Version

VLS can be programmed using the TopControl application supplied (from V4.01.35).

The data are then transferred directly to the TopCon power supply. VLS then operates independent of the TopControl application, i.e. continued connection to the PC is not necessary.

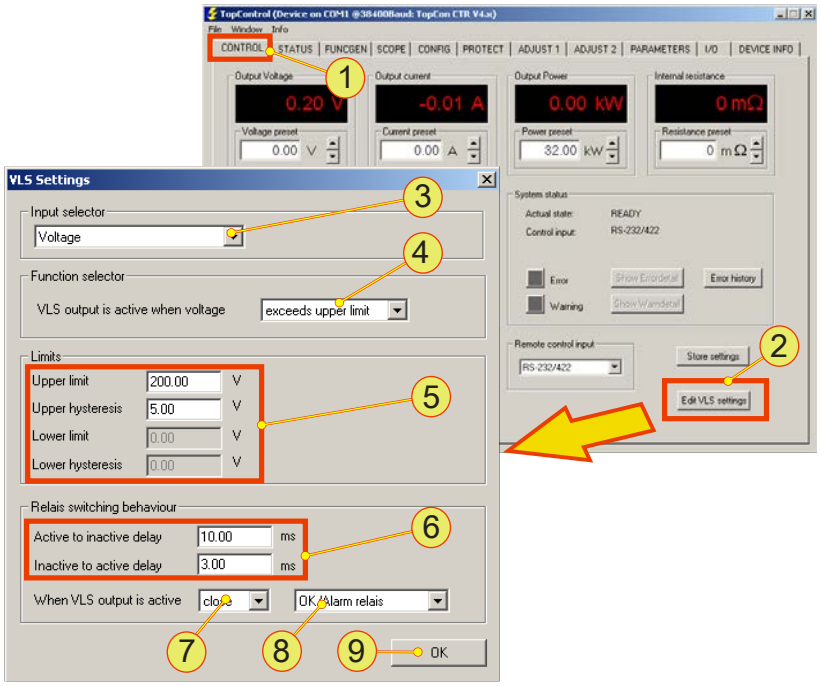

Fig. 43 The **"VLS Settings"** window is opened via the **<CONTROL> -1-** tab and the **<Edit VLS settings> -2-** button.

Window - VLS Settings	
3	**Input selector,** list box "None VLS deactivated" VLS function is switched off → All text boxes are grey, no entries can be made "Voltage", "Current", "Power" Related text boxes can be edited →The units change depending on the selection made
4	**Function selector,** "VLS output is active when voltage" list box Defines the range in which the relay is activated. The following options are available: Exceeds upper limit – Exceeding a threshold Falls below lower limit – Dropping below a threshold is inside window – Entering a window is outside window – Leaving a window
5	**Limits,** text boxes Related thresholds and hysteresis for the selected range. Depending on the selection in **-4-**, different text boxes are activated.
6	**Relais switching behavior,** text boxes The adjustable switching delay between the active and the inactive range helps to ignore brief fluctuations in the output value.
7	**Relais switching behavior,** list box – switching state Selection of whether the relay is to be closed or opened in the active range. The switching state is inverted in the non-active range.
8	**Relais switching behavior,** list box – relay type The following selection is possible: "OK/Alarm" relay (normally open/normally closed), "Warn" relay (normally open), "Run" relay (normally open).
9	**<OK>,** button Closes the VLS window.

Table 52 Window for the VLS function.

4. Options and system options

4.1. Overview

Definition

Regatron considers the term option to cover characteristics that expand the functionality of a TopCon power supply and that can be purchased.

In principle the options can be divided into 3 main groups:

- Hardware options
  Additional hardware that is built into the device, attached to the device, or that can be formed from device combinations (system options).
- Software options
  Functions that are enabled using an enable key.
- Interface options
  Additional hardware interfaces mostly with additional software, or protocols.

In this chapter

In this chapter options are described with a varying degree of detail:

- Options that relate to TopCon power supplies in a multi-unit system are described in a dedicated chapter.
  For further information see chapter 4.4, page 134.
- Frequently procured options are given special attention in this chapter.
- System options, e.g. systems with energy regeneration (Q14) are described in an overview with their primary characteristics. Specific characteristics are published in dedicated system documentation.

The following options are described:

Hardware option	Name	Chapter	Page
Liquid cooling	LC	4.2.1	93
Air filter	AIRFILTER 6U/9U	4.2.1.5	98
Protection of live parts	PACOB	4.2.3	101
Integrated safety relay	ISR	4.2.4	107
Q14 supply and regeneration operation	Q14 ReGen	4.2.5	116
Q14 operation with passive load resistors	Q14 ResPas	4.2.6	118
Q14 operation with active load resistors	Q14 ResAct	4.2.7	120
Q13 operation for low frequency AC	Q13 ACLF	4.2.8	121
Internal resistance simulation	Internal Resistance Extension IRXTS	4.2.9	122
Linear post-processing unit	TC.LIN	4.2.10	124
Specification extensions	Mil spec. ruggedized	4.2.11	126

Table 53 Hardware and system options for TopCon

Software option	Name	Chapter	Page
Function generator	TFE	4.3.1	127
PV simulation Solar array simulator	SAS Control	4.3.2	130
Rechargeable battery management	Akku Control	4.3.3	133

Table 54 Software options for TopControl

Interface option	Name	Chapter	Page
Serial interface, rear side	RS-232 REAR	3.2.4.9	69
Serial interface, differential	RS-422	4.4.4	137
Universal Serial Bus	USB	4.4.5	138
Controller Area Network	CAN/CANOpen	4.4.6	139
Parallel IEC bus, standard 488	IEEE488 with SCPI command set/ GPIB	4.4.7	140
Ethernet	TC.Ethernet	4.4.8	141
RS-232 to Ethernet converter	ipEther 232	4.4.8	141

Table 55 Interface options for TopCon

4.2. Hardware options

4.2.1. Liquid cooling (LC)

As an option Regatron power supplies can be equipped with integrated liquid cooling of the power section.

The advantages of liquid cooling:

- **Noise reduction**
  The majority of the power loss is removed via the liquid cooling. The load on the built-in ventilation is reduced. In addition, the device fans have a programmable fan controller that significantly reduces the speed of the fans.
  The noise emissions are reduced.
- **Greater temperature tolerance**
  The device can be used in areas with a higher ambient temperature if the cooling liquid is correspondingly pre-cooled or is connected to a larger cooling water system.

A power loss primarily occurs in the following device elements:

- **Power semiconductor elements**
  with 90 – 95 % of the total power loss.
  These elements are fastened to a heat exchanger. The heat is removed from the interior of device using a cooling medium.
- **Inductive and resistive elements**
  with 5 – 10 % of the total power loss.
  The heat is dissipated to the environment via a slowly rotating fan built into the rear wall.

Waste heat comparison

By using a water cooling circuit the heat is removed as follows:

- **Via the water cooling circuit**
  Approx. 85 % of the total power loss is removed.
- **Via the ambient air**
  Approx. 15 % of the total power loss is dissipated to the ambient air by components that are not connected to the water-cooled heatsink.

4.2.1.1. Mechanical properties

Dimensions on 6 U devices

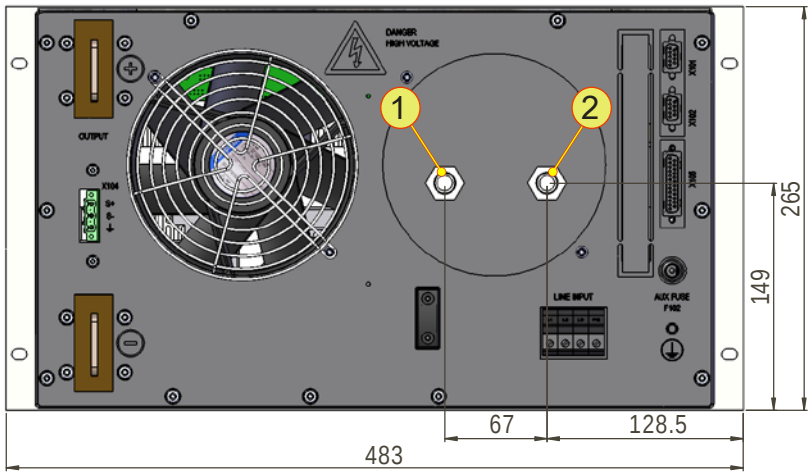

Fig. 44 Position of the hose connection fittings on a 6 U device.

Dimensions on 9 U devices

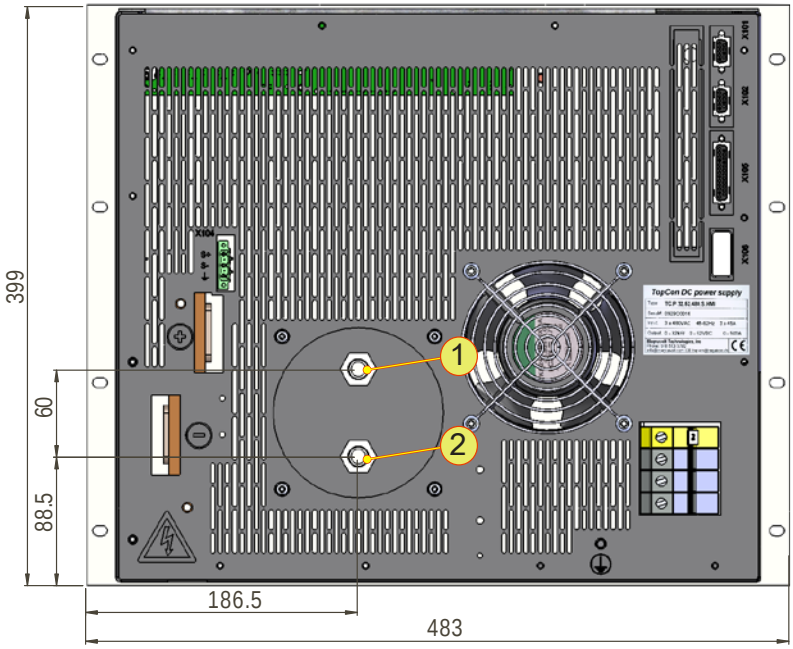

Fig. 45 Position of the hose connection fittings on a 9 U device.

Liquid coolong connections	
1	**Input,** G ½" hose connection fitting
2	**Output,** G ½" hose connection fitting

Table 56 Connections on 6 U and 9 U TopCon power supplies.

4.2.1.2. Characteristics of a water cooling circuit

General information on the heat exchanger

Label	TC.P.10	TC.P.16	TC.P.20	TC.P.32
Connections	On rear side of device, G 1/2“			
Cooling medium (KM)	Purified water, alternatively heat exchanger liquids, non-corrosive			
Heat sink material	EN AW-5083			
KM[1] specific heat capacity	4.19 kJ/kgK			
Thermal rating	0.8 kW	1.3 kW	1.5 kW	2.0 kW
R_{th} (KM-Case) Approx. thermal resistance of the cooling device	< 0.01 K/W			
Recommended flow rate KM	4 – 7 l/min			
Minimum KM flow rate for dT ≤ 10 K, dT ≙ temp. difference between inlet and outlet temp. of the cooling liquid.	2.0 l/min		2.5 l/min	
Maximum permissible continuous outlet temperature KM[2]	40 °C@ 2.5 l/min 50 °C@ 5 l/min			
Maximum permissible inlet temperature KM[2]	25 °C@ ≥ 2.5 l/min 40 °C@ 5 l/min			

Table 57 Characteristics of the liquid cooling.
[1] On the usage of cooling liquids with significantly different specific heat capacity the figures must be modified accordingly!
[2] For other temperature values, please contact Regatron support.

CAUTION **Damage due to condensation!**

Damage in the device due to condensed water is excluded from the warranty.
Reason:

- **Due to cooling liquid temperatures < 15 °C.**
  In case of an ambient temperature of 20 °C and relative atmospheric humidity of ≥ 70 %.

Avoidance:

⇒ Keep the feed temperature at a temperature level > 15 °C to avoid condensation inside the device and on the supply cable.
⇒ In case of doubt contact Regatron support.

Liquid cooling data

In general the quality of normal purified, soft and largely chlorine-free drinking water is adequate.

The installation of fine filters will keep back fine sludge particles.

Your local water utility will be able to provide detailed information on the water quality. For information on the water quality see Table 58, 96

Information on the cooling medium

The quality of the cooling medium will have a long-term effect on the system performance. Avoid the following processes by using suitable measures:

- The deposition of foreign bodies on the heat exchanger surfaces.
- Electrolytic and/or chemical corrosion.
- The deposition of fine sludge.
- Coating with foreign substances and as a result degradation of the heat transfer.

Recommended characteristics of water as a cooling medium

Parameter	Unit	Limit value with single flow[1]
ph-value	-	6 - 8
Total hardness	[°dH][2]	< 15
Carbonate hardness	[°dH][2]	< 6
Non-carbonate hardness	[mmol/l][3]	< 1.60
Carbon dioxide, free	[mg/l]	< 3
Organic substances	[mg/l]	< 10
Algae and fungi	-	Not allowed
Sand and sludge	[mg/l]	0
Sulphate SO_3	[mg/l]	< 50
Chloride CL	[mg/l]	< 30
Undissolved iron Fe	[mg/l]	< 1
Phosphate P_2O_5	[mg/l]	0
Total salt content	[mg/l]	< 3000
Manganese Mn	[mg/l]	< 0.1

Table 58 Recommended water quality with liquid cooling.
[1] The flow is in a closed system
[2] °dH = German hardness figure (= 10 mg CaO/l)
[3] 1mmol/l ≙ 5.6°dH
Hardness figures are dependent on the country and may therefore vary.

CAUTION **Possible damage!**

- Deionised water will result in corrosion.

Avoidance:

⇒ Avoid deionised water completely.

4.2.1.3. Pressure difference/flow rates

The maximum permissible liquid cooling pressure is 4 bar = 4000 hPa.

Standard connection with G ½“

Heat sink with internal pipework, ready for connection of cooling liquid on site at the rear side of the device:

Pressure difference	Flow rate valve[1] with G 1/2 ‘‘
0.02 bar	2.5 l/min.
0.04 bar	3.5 l/min.
0.07 bar[1]	5 l/min.[2]
0.12 bar	7 l/min.

Table 59 List of pressure difference vs. flow rate.
[1] The maximum permissible cooling liquid pressure is 4 bar = 4000 hPa.
[2] Recommended range

Connection with quick-release isolating valves

Heat sink with internal pipework, ready for connection of cooling liquid on site at the rear side of the device plus 2 quick-release isolating valves (on customer request), inside diameter = 6 mm:

Pressure difference	Flow rate quick-release isolating valves
0.06 bar	2.5 l/min.
0.15 bar	3.5 l/min.
0.24 bar[1]	4.5 l/min.[1]
0.38 bar[1]	6 l/min.[1]
0.48 bar	7 l/min.

Table 60 List of pressure difference vs. flow rate with additional quick-release connection.
[1] Recommended range

The pressure drops for on-site feed pipes, manifolds and pressure and flow rate sensors are also to be taken into account. In particular, on the parallel supply of several power supplies an appropriate safety margin is to be included.

4.2.1.4. Filling liquid cooling circuit

By using this procedure you will reduce the formation of bubbles in the cooling system.

1. Only fill the liquid cooling circuit from one end via a cooling liquid connection.
2. Fill the system until the liquid cooling flows out of the other connection.
   The formation of bubble in the cooling circuit is minimised.
3. Connect the device to your cooling circuit.

Fig. 46 Examples for liquid cooling using cooling liquid:
90 ° quick-release isolating valves **-1-** on a 32 kW power supply
Hosing **-2-** and pipework **-3-** on a 32 kW power supply in a device cabinet.

4.2.1.5. Connection of a connection fitting

The G 1/2“ adapter makes it possible to replace the hose connection fitting with alternatives, e.g. quick-release isolating valves.

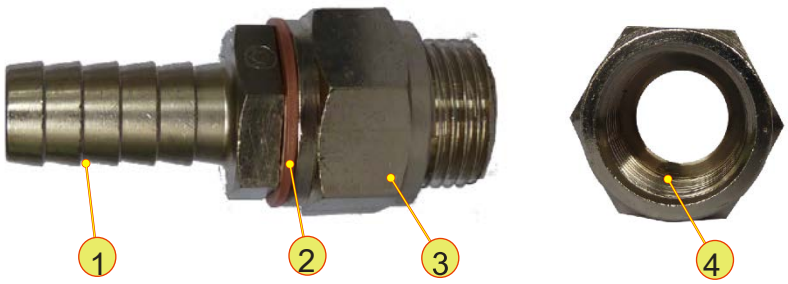

Fig. 47 Hose connection fitting **-1-** with spacer ring **-2-** and adapter -**3-** with nut **-4-**.

Connection parts for a cooling water connection	
1	**Hose connection fitting, G 1/2“** Can be replaced with customer-specific connection systems.
2	**Spacer ring, copper, min. thickness approx. 1.5 mm** (21x26x1.5) Is required to compensate for tolerances on the depth of the thread on the connection fitting and adapter. The spacer ring is not used to seal the connection!
3	**Adapter with nut, G 1/2“**
4	**Thread on the adapter nut, G 1/2“** On undoing and re-connecting the thread must be cleaned of old sealing medium and sealed with new sealing medium LOCTITE® 542.

Table 61 Individual parts for the cooling liquid connection.

CAUTION

Damage possible!

- Due to leaking cooling liquid

Avoidance

⇒ Close the main cooling liquid line to the device before you remove the hose connection fitting.

⇒ Have a container and cloths at hand to be able to collect around 1 – 2 l of cooling liquid.

Remove the hose connection fitting

- On the removal of the connection fitting **-1-** store the copper ring **-2-** in a safe place.
- Free the thread on the adapter nut of the rest of the sealant LOCTITE® 542.

Making a connection

- Slide the spacer ring **-2-** onto the threaded end of the connection fitting **-1-**.
- Apply a generous amount of LOCTITE® 542 to the first three turn of the thread on the connection fitting to seal the connection.
- Screw the connection fitting into the connection and tighten.

Check the system for leaks at 8 Bar for 10 min., as per the standard EN50178.

4.2.2. Air filter (LF)

TopCon power supplies are cooled using air as standard. Even on the utilisation of an LC option (liquid cooling) approx. 15 % (~300 W) of the total power loss is dissipated to the ambient air.

Regatron recommend the utilisation of an air filter for the TopCon power supply, particularly in an environment with a large amount of dust.

For example, fine metal dust can cause lasting degradation of the function of the power supply - and even damage.

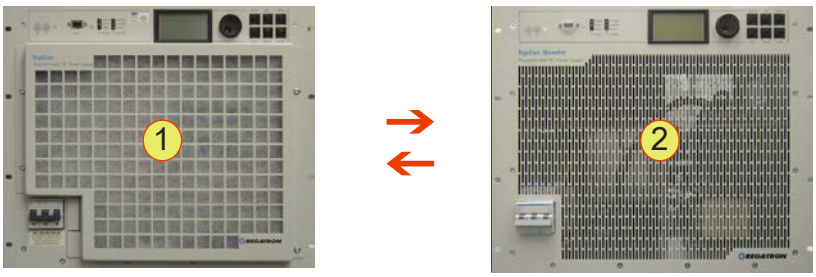

Fig. 48 TopCon power supply 9 U with air filter **-1-** and without air filter **-2-.**

On the usage of filter mats with excessively small pores or in case of excessive soiling, the TopCon power supplies may be further derated.

Air filter sizes

Air filters are available in two versions, depending on the power class of the TopCon power supplies:

- **6 U**
  10 kW, 16 kW devices and TC.LIN
- **9 U**
  20 kW and 32 kW devices

On the usage of the LF option it is necessary to comply with the related maintenance cycles, see chapter 7.1, page 189.

4.2.3. PACOB

The “PACOB” option protects against accidental physical contact if the output current bars are openly accessible on TopCon power supplies. There are PACOB protection variants for the two device sizes:

- Height 9 U:
  Insulating plastic cover
- Height 6 U:
  Insulating plastic sleeve

Insulating plastic cover 9U

The protective cover with its self-retaining screws provides an easy-to-install protection against accidental contact of current bars and increases the safety.

By rated brake points areas of the PACOB housing can be broken out, to adapt the protection against the contact individually to the particular routing.

4.2.3.1. TC.P.PACOB.DC

Rated break point areas

Protection against DC voltage TopCon devices

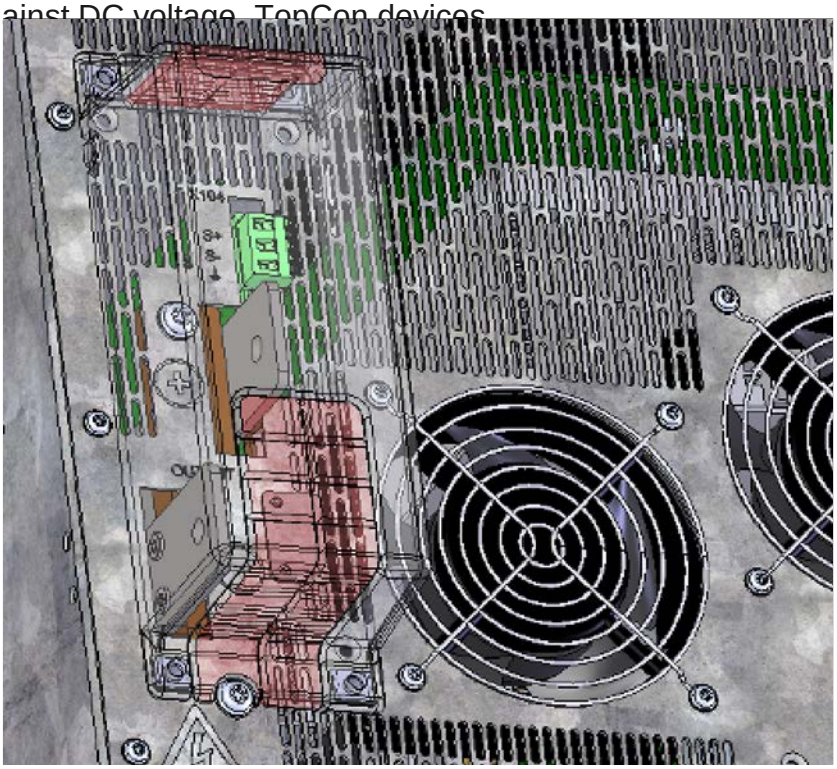

Fig. 49 Red marked rated break point areas of the TC.GSS device .

Mechanical dimensions

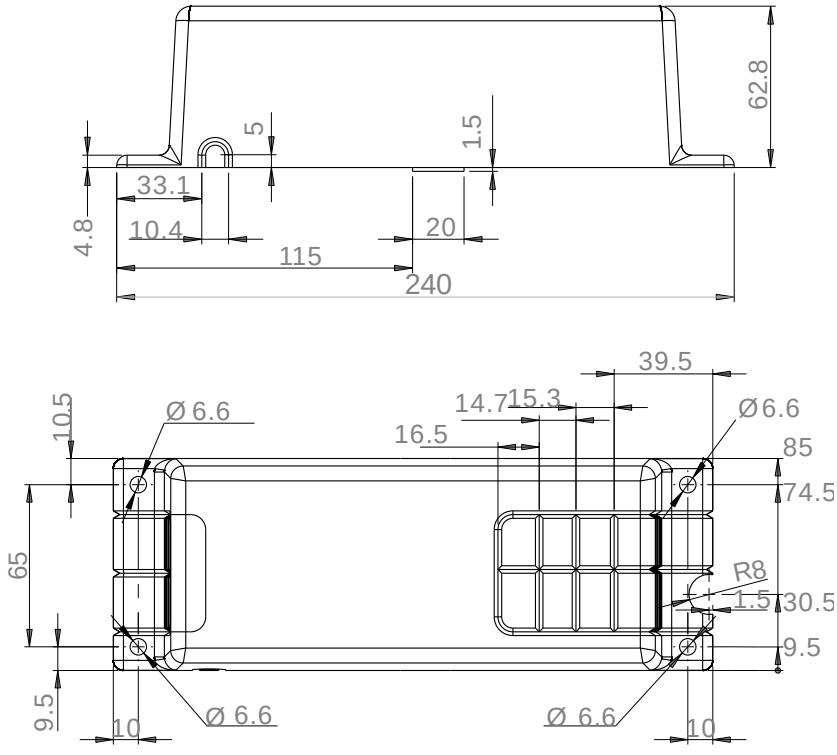

Fig. 50 PACOB dimensions for TC.P devices in mm.

4.2.3.2. TC.PACOB.AC

Rated break point areas

Protection against AC voltage at the AC terminals of TopCon devices.

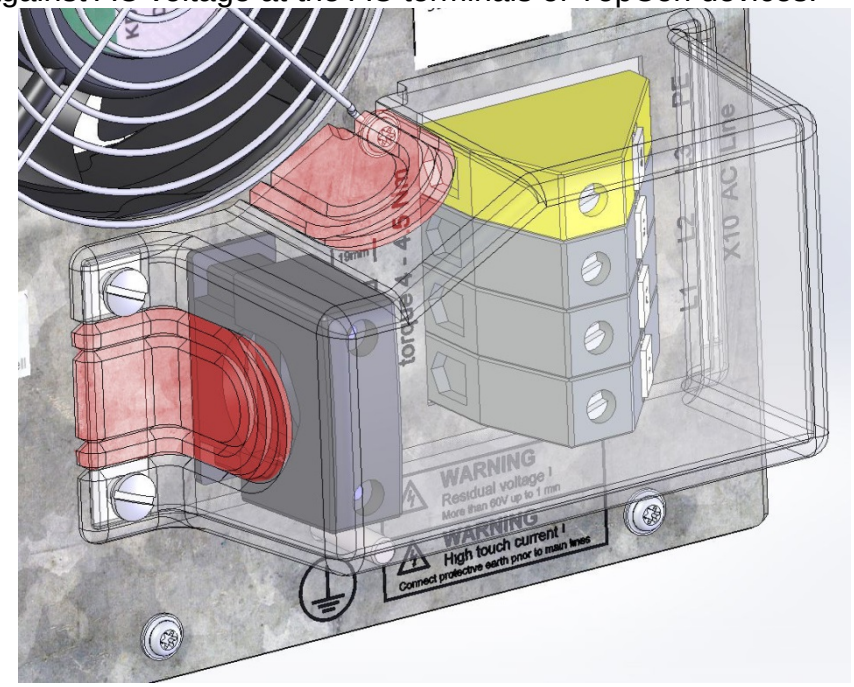

Fig. 51 Red marked rated break point areas of the AC-PACOB.

Mechanical dimensions

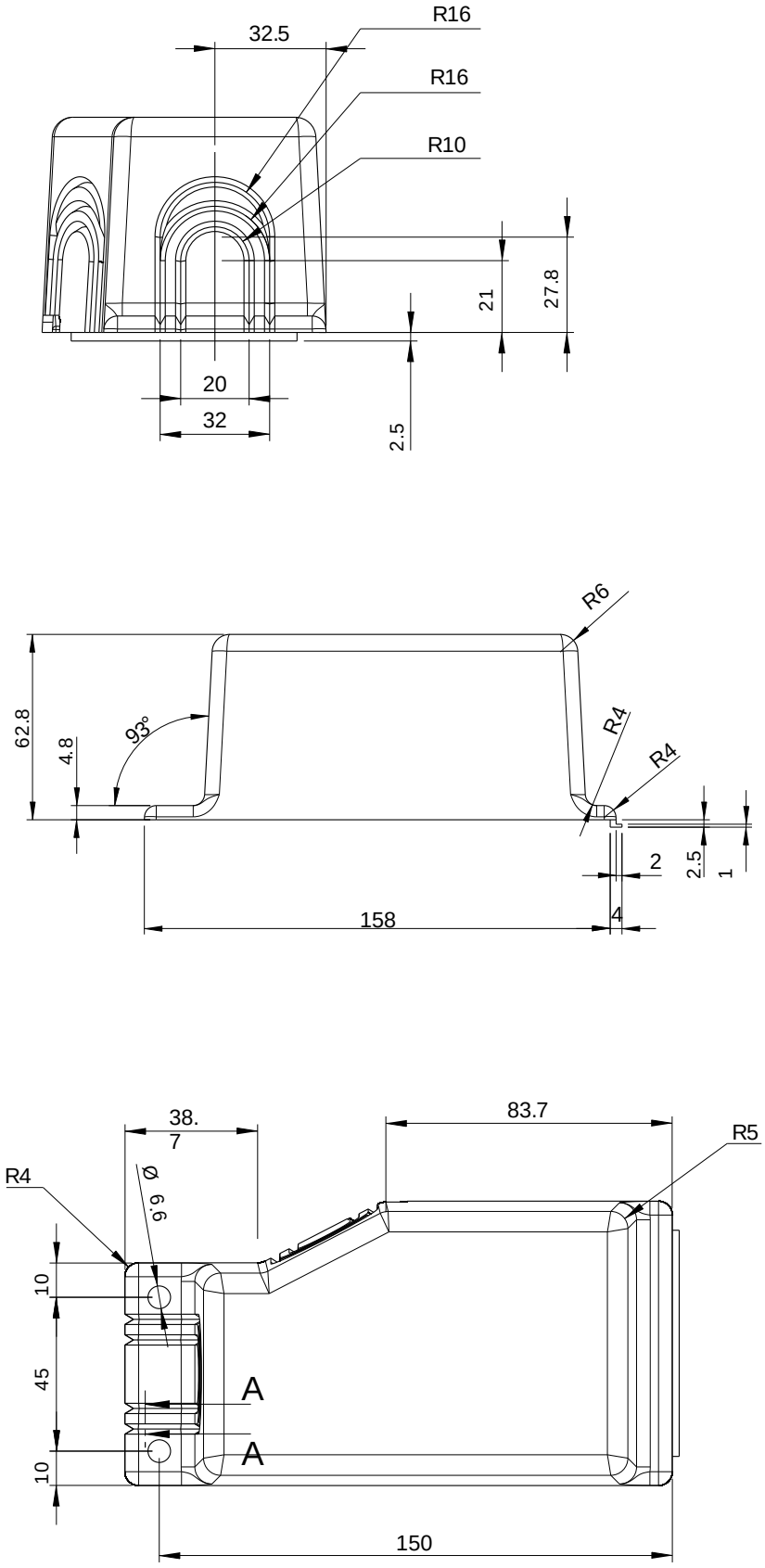

Fig. 52 AC-PACOB dimensions for TopCon devices in mm.

4.2.3.3. Electrical data

Properties	By specifications	Value
Dielectric constant at 50 Hz	IEC 60250	3,1
Electric strength	IEC 60243-1	33 kV/mm
Specific resistivity	IEC 60093	> 10^{13} Ω*m
Creep resistance CTI	IEC 60112	275

Table 62 Electrical properties according to the manufacture´s data.

4.2.3.4. Thermal data

Properties	By specifications	Value
Heat conductivity	DIN 52 612	0,21 W/Km
Max. temperature short time		140 °C
Max. temperature permanently	Heat ageing according to UL746	125 °C
Min. temperature		-100 °C

Table 63 Thermal properties according to the manufacture´s data.

4.2.3.5. Further data

Properties	By specifications	Value
Burning behaviour according to UL94	IEC 60695-11-10	V-2
Transparency		clear-transparent
Raw material		Makrolon 2805 by Bayer (Polycarbonate)

Table 64 Further properties according to the manufacture´s data.

4.2.3.6. Insulating plastic sleeve 6U

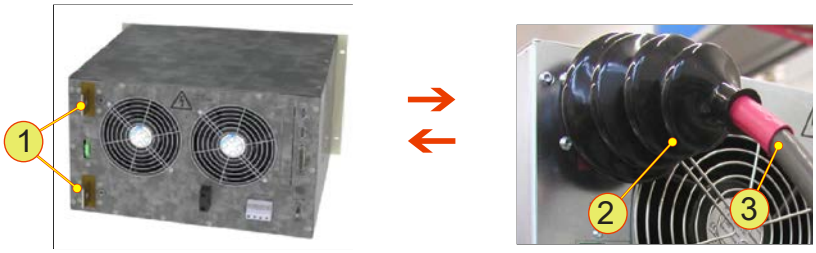

Fig. 53 Protection against physical contact on the power outputs on 6 U devices.

PACOB - components and position	
1	**Current bars** Output on the 6 U TopCon power supply
2	**PACOB protection against physical contact, insulating plastic sleeve** Is fitted over the connected TopCon current bars.
3	**Cable, connected to current bar**

Table 65 PACOB components and position on 6 U devices.

4.2.4. Integrated Safety Relay (ISR)

Definition of applied standard

Applied standard: EN ISO 13849-1:2006

Explanation of the term 'Performance Level PL'

Safety functions of an electrical system can be done according to several so-called safety classes, starting from simple switch-based solutions up to complex and self-monitoring safety systems. The 'Performance Level 'PL' is an indicator specifying how extensively the safety-related parts of a system are performing the task. The most important factors for the PL are:

- Reliability of the used parts within the safety system (**MTTFd**)
- Ability of the system for self-monitoring (**DC_{ave}**)
- Architecture of the safety system

The reliability of used parts is defined by the parameter MTTFd and refers to the conditional probability of failure of the used parts inside each of the respective safety channels. According to the type and number of parts, a number of years can be calculated.

- For 3 years < MTTFd < 10 years, MTTFd is 'low`
- For 10 years < MTTFd < 30 years, MTTFd is 'fair'
- For 30 years < MTTFd < 100 years MTTFd is 'high'

The capability of the safety system to detect malfunctions within the safety system itself is expressed by the parameter DCave. This number is expressed by the %-ratio of:

- number of identified failures which led to an ordinary shut down
- number of all failures, including these not being identified by the system

↳ DC < 60% means DC_{avg} = Null;
(System detects own malfunctions only occasionally)

↳ 60% < DC < 90% means DC_{avg} =' low'

↳ 90% < DC < 99% means DC_{avg} = 'fair'

↳ DC > 99% means DC_{avg} = 'high'
(system detects own malfunctions completely and safely)

The term is derived from the category of the safety system and relates to the type of electro-mechanical/electronic architecture of the safety system. For more details please refer to the regulations EN ISO 13849-1:2006.

If the above explained three terms are given, the Performance Level PL can be determined from the following Abb 1.

As an example: A safety system uses a circuit defined as **Cat 2**. The MTTFd was calculated as to be 20 years -> **MTTFd** = 'fair' and DC = 75% -> **DC_{avg}** = 'low'.

The small triangle within Graph 1 shows the rating of the system as to be **PL c.**

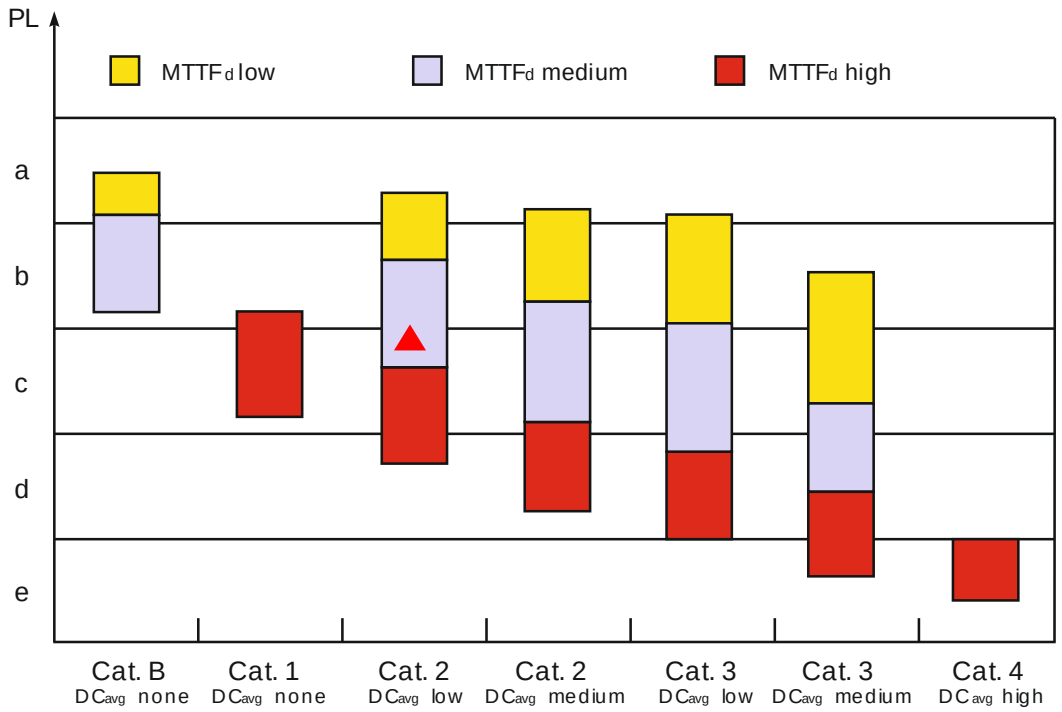

Fig. 54 Relationship between **DC_{avg}**, MTTFd and Performance Level PL

Legende	
PL	**P**erformance **L**evel
$MTTF_d$	**M**ean **T**ime to **d**angerous **f**ailure
DC_{avg}	**av**era**g**e **D**iagnostic **C**overage
Cat.	**Cat**egory

Table 66 Legend

4.2.4.1. General function

TopCon High power supplies TC.P and TC.GSS may be equipped with the Integral Safety Relay option ISR. Fitted with ‘restraint driven contacts’, ISR is connected to external safety switch elements providing safe concepts for emergency shut down of the power supply or system.

As an important feature, ISR is acting directly on the alimentation of the power conversion stages and blocks therefore any energy flow in an emergency case.

Integration of the ISR option is done at the time point of initial manufacturing. A later integration is possible but needs the unit to be returned to the factory.

Function of ISR in a single power supply

ISR is to be connected to the external ‘safety switch loop’ via the X112 interface. If the external loop is opened, the DC-output of the power supply is powered down immediately. In the case of a TC.GSS (bidirectional power supply), the DC output as the AC input stage too are blocked in the same manner. (See also chapters 1.3 and 1.4)

Please note, that an ‘X112 Safety-Shutdown plug’ has to be plugged onto the X112 interface if the external safety loop is not connected. (See chapter 2.2 for details)

Function of ISR in a multi-unit power supply system

A multi-unit power supply system may also be equipped with an external safety shutdown loop using the individual X112 interfaces. Note that all respective units have to be equipped with the ISR option. Breaking the external loop or any fault condition of an individual power supply will immediately shut down the entire system. (Refer to the application examples in chapter 3)

REGATRON power supplies

The above stated principle of operation is valid for TopCon TC.P. unidirectional power supplies as also for the TC.GSS bidirectional series.

4.2.4.2. The function of TopCon TC.P devices

Both ISR safety relays break the low voltage power supply for the primary H-bridge circuit in an independent way. By this, power semiconductors may no longer work and therefore the power transformer is unable to convert energy to the secondary. Because the relays dispose of restraint-driven signal contacts, the state of the relays is routed to the interface X112 in a redundant way.

Refer to the functional block diagram depicted in Picture 2 for details.

Because of two independent acting safety relays it is possible to reach a safety Performance Level of **PL e.**

Performance level vs. operation mode	
Quadrant 1- (Source mode)	**PL e**

Table 67 Performance level vs. Operation mode.

Applicationexamples	
Single safety loop	See on page 113.
Double safety loop	See on page 114.
With ext. Safety building block, double loop	See on page 115.

Table 68 Application variants of safety system.

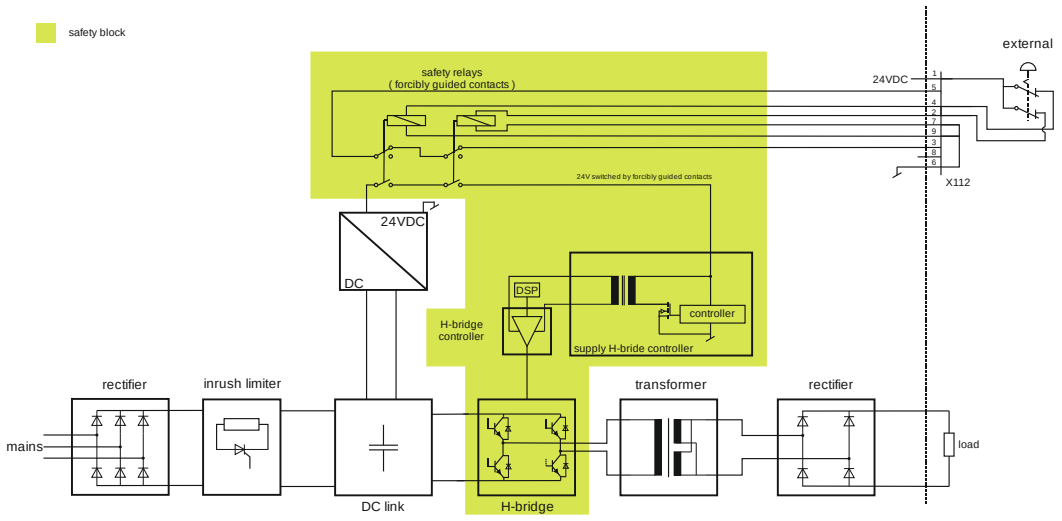

Fig. 55 Functional block diagram of ISR feature in TC.P. units.

4.2.4.3. Interface X112

Please note that interface X112 is available only if ISR option is built in.

D-Sub Buchse
9pol (female)

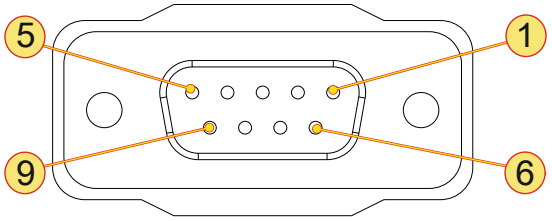

Fig. 56 Pin layout of interface X112, front view

Pin	Signal	I/O	Description
1	**+24VDC**	O	Low voltage internal supply + 24 V_{DC}
2	**RELAY2**[1]	I	Coil a) of ISR relay#2
3	**NC**	I/O	Relay contact NC
4	**RELAY1**[1]	I	Coil a) of ISR relay#1
5	**COMMON**	I/O	Common contact
6	**GND**	O	Low voltage 0 V_{DC}
7	**RELAY2**[1]	I	Coil b) of ISR#2
8	**---**	---	---
9	**RELAY1**[1]	I	Coil b) of ISR#1
Cover	**Shield**	---	Cable screen, tied to earth (PE) internally

Table 69 Interface X112, pin assignment.
[1] Polarity of relay coil pins 2 and 7 resp. 4 and 9 of no importance.

Dummy plug for interface X112

A TopCon power supply equipped with ISR option needs either to be connected to an external safety loop as described above, or alternatively a dummy plug “X112 Safety-shutdown” has to be connected to interface X112. If the interface X112 is left open, the power supply will rest in the ‘Emergency OFF’ state and is inoperative.

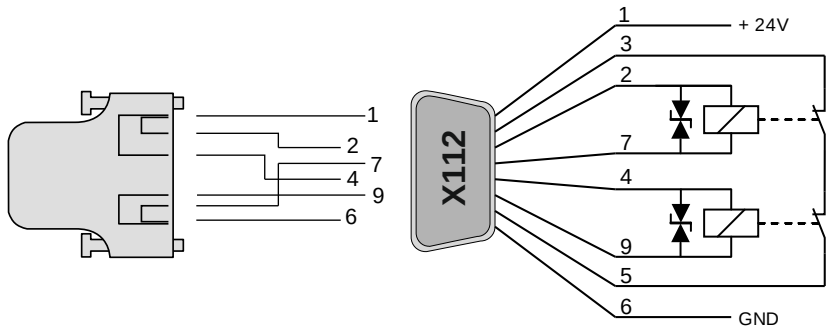

Fig. 57

Adapter for equipment with an X107 interface

Many TopCon power supplies are equipped with the ‘Single channel ISR option X107’. By the aid of a special adapter, X107 ISR equipped units may be operated together with X112 equipped units. Refer to picture 6 for details.

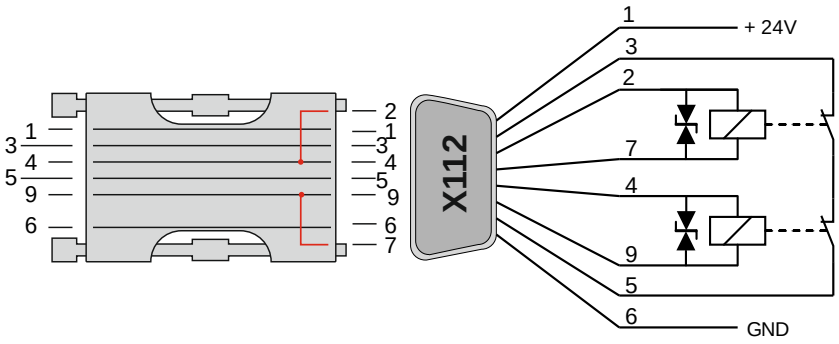

Fig. 58 Adapter for connecting ISR X107 units to ISR X112 units.

4.2.4.4. Application examples

Example 1: Category 1 PL c

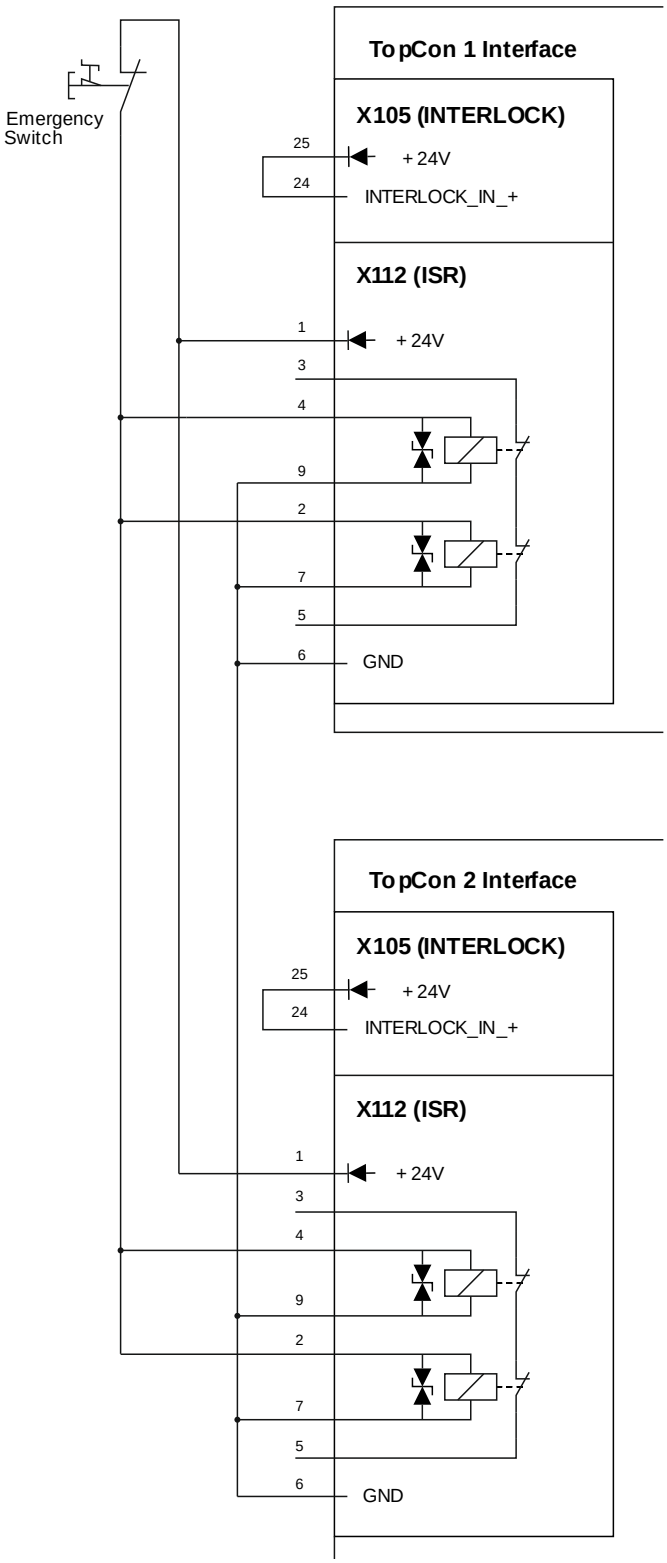

Fig. 59 Wiring diagram using a single pole external safety loop.

Example 2: Category 1 PL c

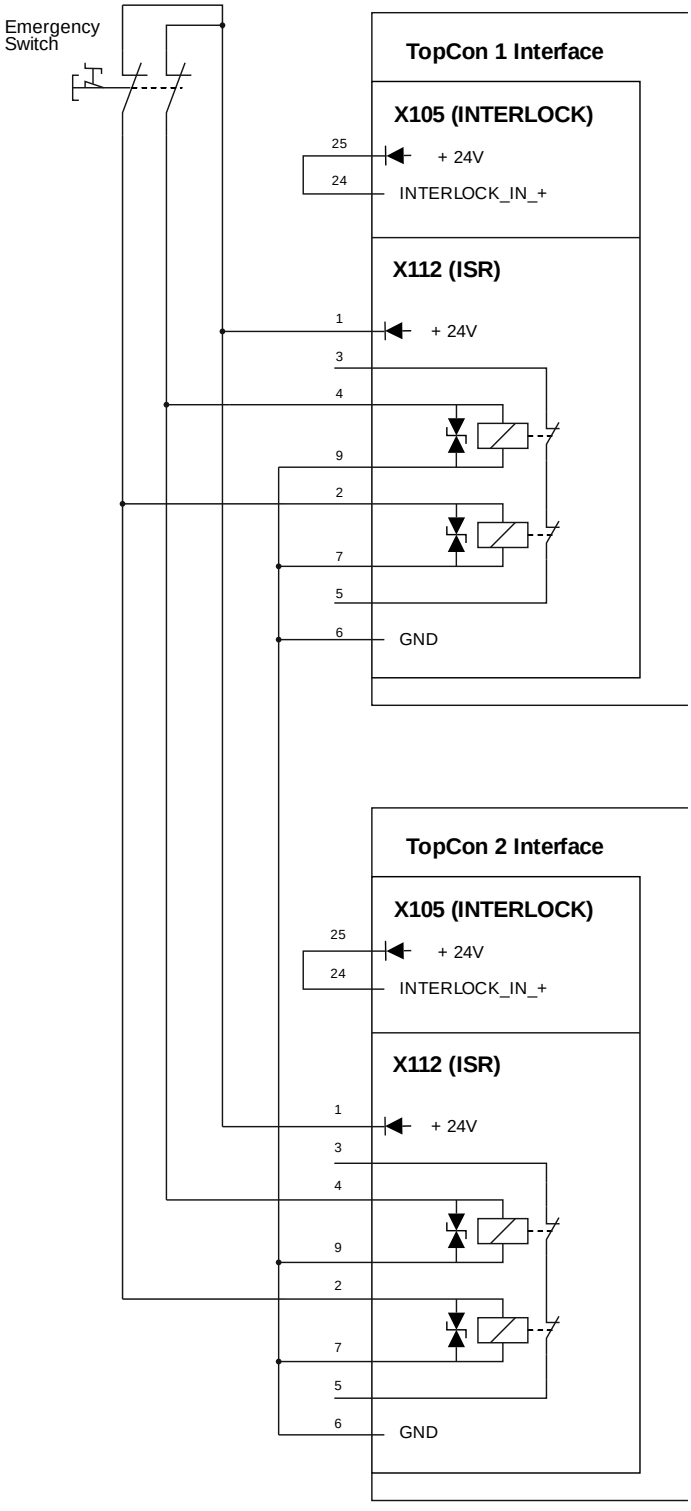

Fig. 60 Wiring diagram using a double pole external safety loop.

Example 3: Category 3 PL e

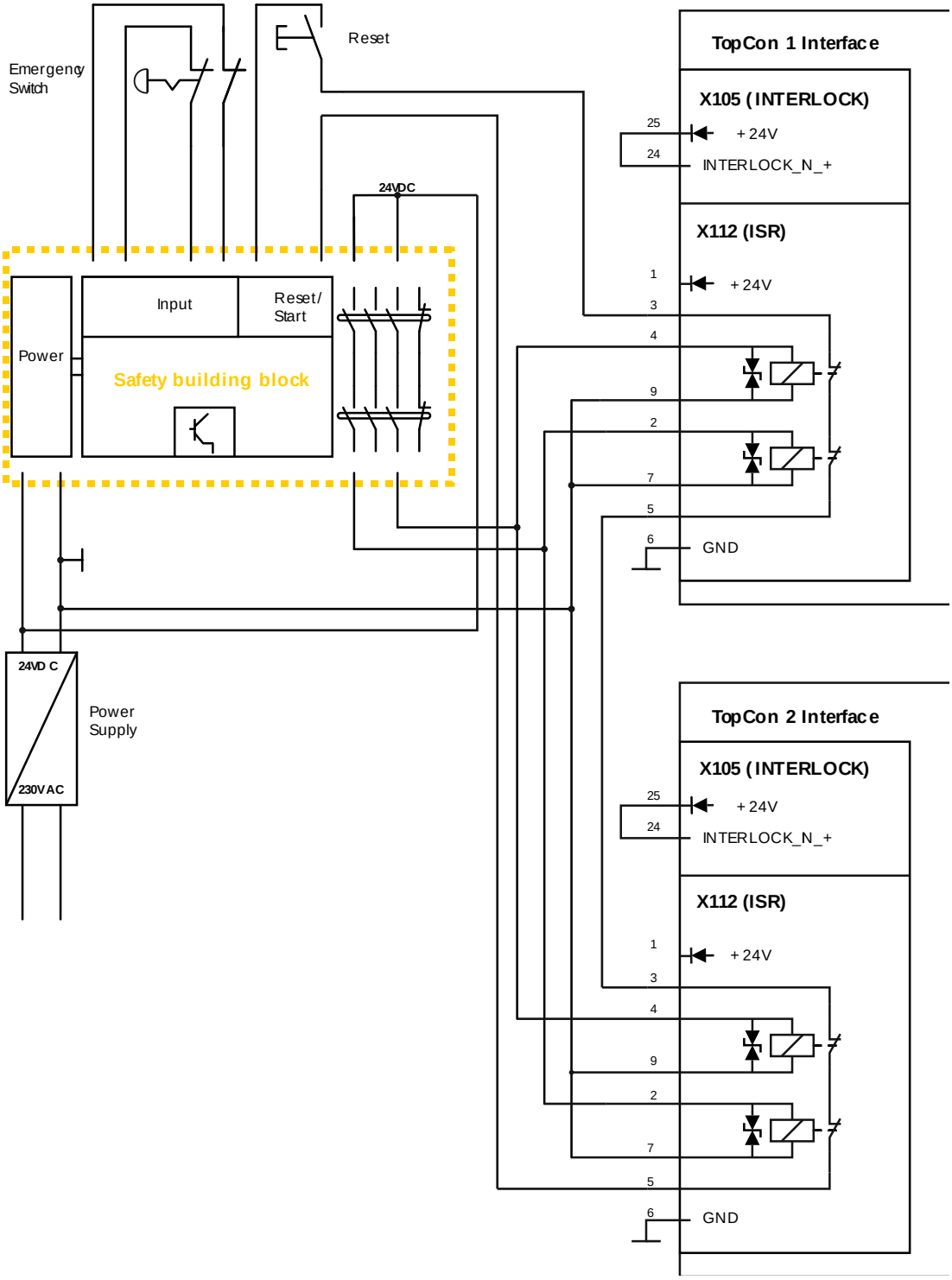

Fig. 61 Wiring diagram using an external safety module, double pole safety loop

4.2.5. Q14 ReGen

Function

ReGen systems are DC power supplies with energy regeneration to the power system that are added to TopCon power supplies. They operate in the quadrants

- Q1 (supply) Energy is drawn from the supplying power system.
- Q4 (regeneration) Energy is returned back to the supplying power system and not converted into waste heat.

ReGen systems exploit the following advantages of the regeneration of energy to the power system:

- The power consumption is reduced. In many cases the saving is considerable.
- There are financial savings.
- Improvement of environmental aspects.

The basic problem

As a rule power supplies based on primary switching cannot absorb any generated or reactive power from the load side.

The solution

In ReGen systems based on TopCon power supplies the two functional units “power supply” and “power regeneration” are connected in parallel (see Fig. 52, 105).

The very good performance of the TopCon power supplies is combined with the very good efficiency of the regeneration section.

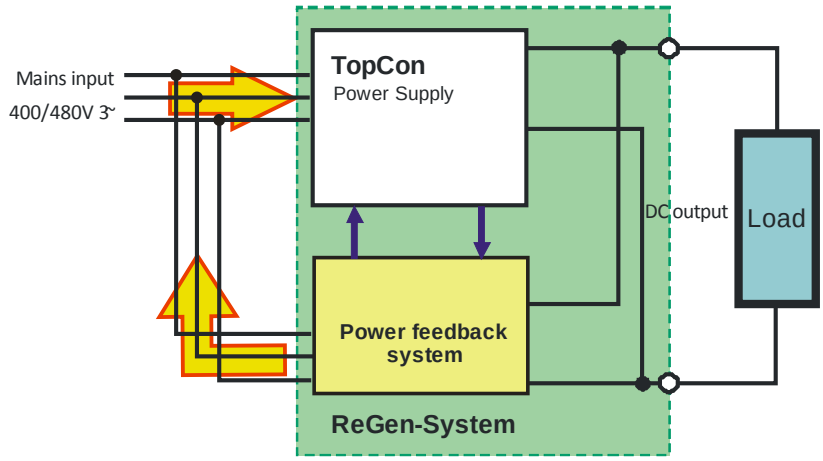

Fig. 62 Principle of operation of a ReGen system.

The signal processors in the TopCon power supply control the regeneration in real time.

Thanks to the new control strategy “Single Authority Control” ambiguities and dead zones in the area of low powers can be reliably avoided.

The high quality of the regenerated power is achieved by:

- Optimal operation of the inverter
- Effective filter technology

The resulting system has very high efficiencies (>95%) both during supply and regeneration.

You can obtain further information from your sales partner and Regatron support.

4.2.6. Q14 ResPas

Function

ResPas is the term used for a class of systems that improve the dynamic properties of the TopCon power supplies. In particular, the energy present in the load can be dissipated more quickly with a ResPas system and therefore permits quicker reactions, even with reactive loads.

In case of an excessively high output voltage the discharge device switches an additional load to the output. This feature can reduce overshooting, e.g. on load shedding.

The discharge device is operated via a binary signal that is sent from the TopCon power supply to the discharge device.

Normally the discharge device can be integrated into the TopCon power supply. However, very high power discharge device resistors must be positioned externally (depending on the load and requirement).

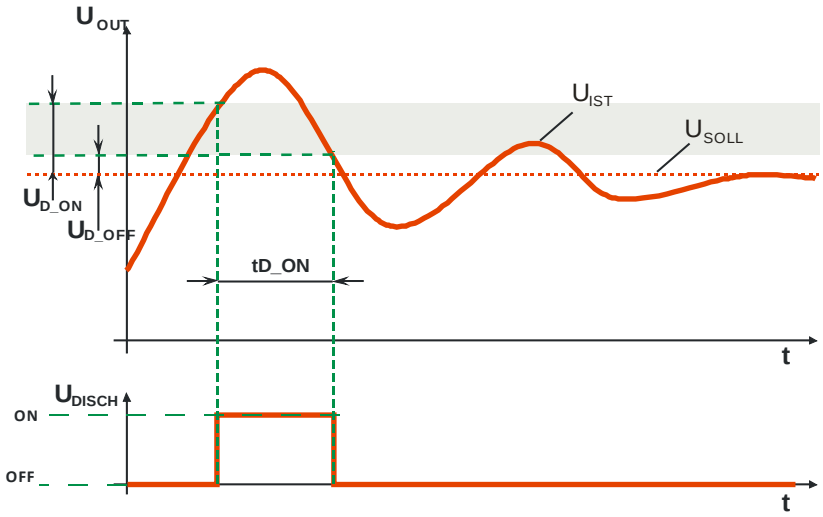

Fig. 63 Sketch of the switching threshold hysteresis of the discharge device with
UD_OFF : Switch-off threshold
UD_ON : Switch-on threshold.

Principle of operation of the software

- Discharge device is activated at: U OUT > UD_ON
- Discharge device is deactivated at: UOUT < UD_OFF
- Overload monitoring resistor

The intervention of the discharge device is signalled by the flashing of the Power LED on the front of the TopCon power supply.

Overload monitoring

The nominal power of the resistor is not allowed to be exceeded for an extended time (approx. 5 s).

The resistor is sized such that at full voltage, 2 – 10-times the nominal power of the resistor is present. This configuration therefore means that only “cyclic operation” is allowed by means of which a pre-defined amount of energy is dissipated at the resistor.

On reaching the amount of energy, the resistor is automatically switched off, even if the overshoot condition is met.

This aspect should be taken into account during the design of the system.

The basic problem

The dynamic operation of loads with reactive properties (in particular with high inductance) will result in the load behaviour only following the TopCon control to a limited extent.

For example, the output voltage will not drop fast enough or may even be increased.

The solution

This undesirable behaviour can be avoided if a Down Programming Unit (DPU) is connected in parallel with the load. The unit is activated if the output voltage/current does not follow the internal control.

Typical usage of the DPU:

In the case of a load with a storage characteristic the output voltage may not follow the specified set values in some circumstances. In this case the electrical energy still present in the system is converted into heat via ballast resistor RB by the DPU.

During this process the amount of energy to be dissipated can be controlled using the DPU switch. As a rule the DPU is operated by the master unit in the TopCon system by means of an analogue signal.

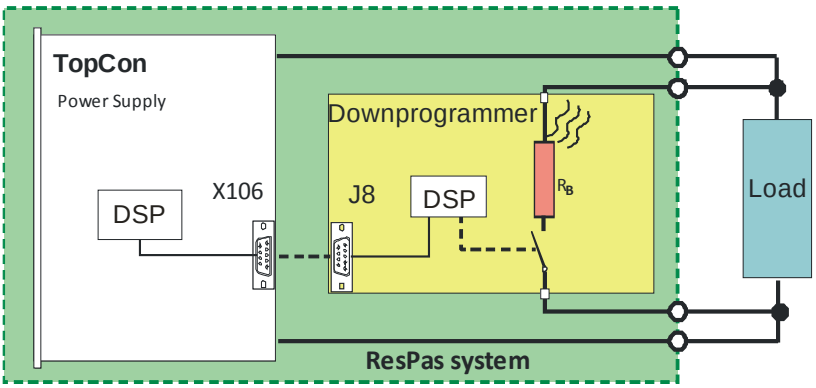

Fig. 64 ResPas: principle of operation of Downprogrammer

The ballast resistors in a ResPas system are designed for larger amounts of power. They have large heat sinks and can even have active cooling in some circumstances. You can obtain further information from your sales partner and Regatron support.

4.2.7. Q14 ResAct

Function

ResAct systems help to expand the system characteristics of TopCon series power supplies.

The basic problem

As a rule power supplies based on primary switching cannot absorb any generated or reactive power from the load side.

The solution

On systems with low voltages and power with simultaneously high system dynamic performance,

the ResACT system operates similarly to the ReGen system. Controlled by the TopCon power supply, a second system (E-Load) “helps” to ensure the power returned from the load (Load) is consumed.

The power is converted into heat.

Compared to the ResPas system, however, the ResAct system also provides the characteristic of a real controller. The ResAct sub-system is controlled by the TopCon power supply.

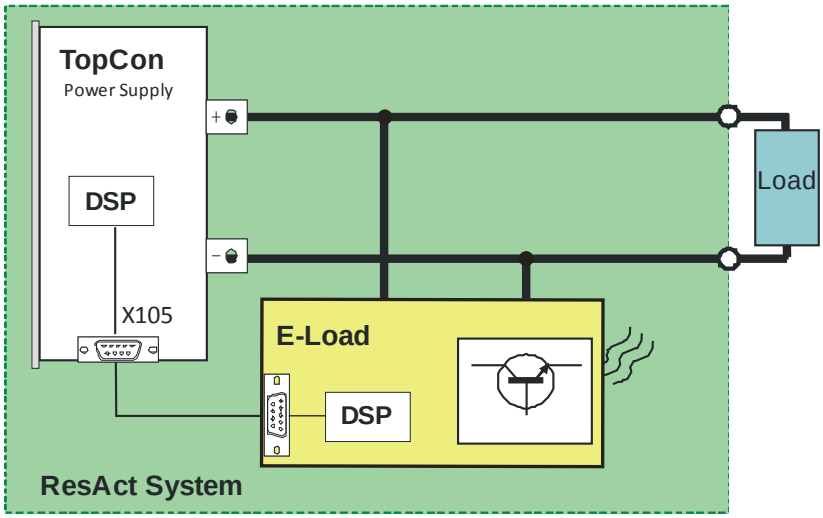

Fig. 65 Principle of operation of the ResAct system.

You can obtain further information from your sales partner and Regatron support.

4.2.8. Q13 ACLF

Function

TopCon power supplies are DC voltage or DC current sources with the ability to operate at high currents. The utilisation of time-dependent functions at low frequencies is typical.

There are application cases in which the characteristics of the TopCon are very appropriate, however the polarity of the output voltage must change.

A practical example of this aspect is a demagnetising workstation that subjects the material to be demagnetised to an alternating, decaying AC field at low frequencies. The ACLF system is intended for this purpose (ACLF = AC Low frequency).

The basic problem

As a DC power supply the TopCon system only provides unipolar voltages at medium powers (at low frequencies). However, there are cases where the TopCon power supply can only not be used because a bipolar voltage source is required. A normal frequency generator can, however, as a rule not provide enough power.

The solution

The ACLF system combines a TopCon power supply (or a multi-unit system, if higher powers are required) with a power inverter.

With this configuration, it is possible to generate and supply to the load bipolar voltages/currents at low frequencies.

Fig. 56 shows the principle of the ACLF system. The downstream inverter makes it possible, e.g., to convert pulsing DC into a bipolar current that is then output to the load.

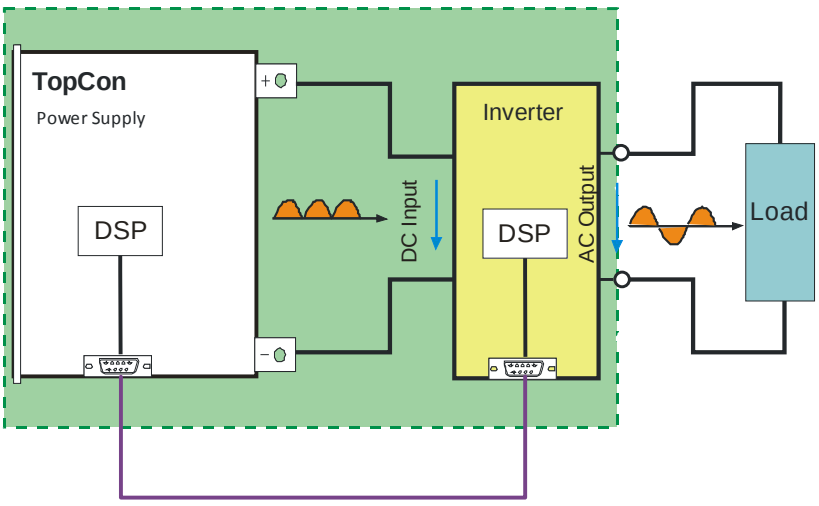

Fig. 66 Block diagram of the ACLF system.
You can obtain further information from your sales partner and Regatron support.

4.2.9. Internal Resistance Extensions (IRXTS)

Function

The TopCon power supply can simulate the static internal resistance of a source.

The basic problem

Due to the digital control, the TopCon power supply does not have any apparent internal resistance.

The solution

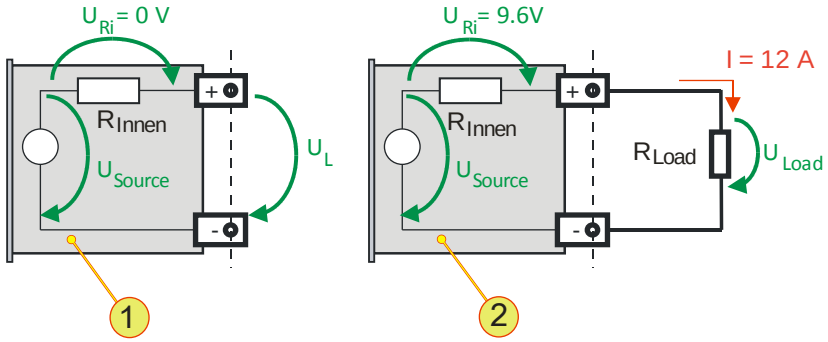

Fig. 67 Internal resistance simulation
-1- TopCon source with no load and internal resistance
-2- TopCon source with load and internal resistance

Example calculation

The TopCon power supply simulates a rechargeable battery with an internal resistance $R_{Internal}$= 0.8 Ω and a no-load voltage U_L= 48 V.

A load current I = 12 A flows, the voltage at the load U_{Load} is reduced by 20 % from U_L

Differentiation between cases - no-load

No-load voltage $U_L = U_{Source} - U_{Ri} = 48\ V - 0\ V = 48\ V \rightarrow U_L = U_{source}$
No-load current I = 0 A

Differentiation between cases - load

Voltage drop $U_{RI} = I * R_{Internal} = 12\ A * 0.8\ \Omega = 9.6\ V$

Load voltage $U_{Load} = U_{Source} - U_{Ri} = 48\ V - 9.6\ V = 38.4\ V$

80 % of U_{source}

Internal resistance extension

Simulation options	Internal resistance [mΩ]
Standard internal resistance	0 to 1000
With option IRXTS	0 to 32000
Customer request[1]	Over 32000

Table 70 Overview of internal resistance simulation options
[1] In consultation with Regatron support

You can obtain further information from your sales partner and Regatron support.

4.2.10. TC.LIN (linear post-processing unit)

Function

The TC.LIN linear post-processing unit contains a powerful DSP, which undertakes the control. Reference value for the control is the voltage present at the load. It is fed via the sense cable both to the TC.LIN and also to the TopCon power supply and is used as the basis for control via PV curves.

During this process the otherwise autonomous TC.LIN is informed only of changes to the characteristic via the CAN bus by the TopCon power supply.

The difference between the output voltage output from the TopCon power supply and the load voltage is used as a controller amplitude reserve for the fast TC.LIN linear controller. Typical values are between 40 V and 50 V.

The TC.LIN operates in principle as a current controller. At very low currents, the TC.LIN switches to the voltage controller mode so that accuracy is maintained also in this area.

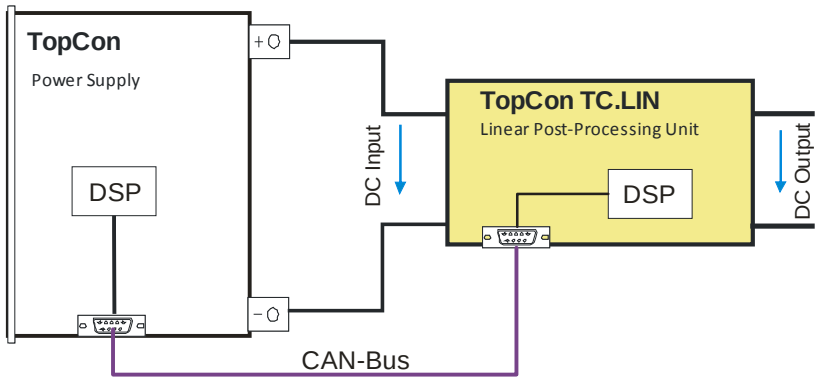

Fig. 68

The basic problem

Some inverter models require even faster dynamic performance for the optimum function of their MPP tracker (Maximum Power Point); this performance is achieved by connecting in series a linear-controlled series controller.

The solution

The TC.LIN contains, along with a highly dynamic linear power stage, a very fast digital controller. These combination of these two modules makes possible the required improvement in dynamic performance.

To address the individual requirements, the following models are available in the TC.LIN family.

Other models with different parameters to the standard models can be built on request. The related modified data will then apply.

Type identifier	Input voltage [V]	Input current [A]	Output current [A]
TC.LIN.SER.26.1000.26	1000	13/26[1]	13/26[1]
TC.LIN.SER.40.1000.40	1000	20/40[1]	20/40[1]

Table 71 TopCon TC.LIN model range
[1] The first value is the “alternative current range” (“half”), the second the standard current range (“full”).

Higher power can be achieved by connecting in parallel in a multi-unit system.

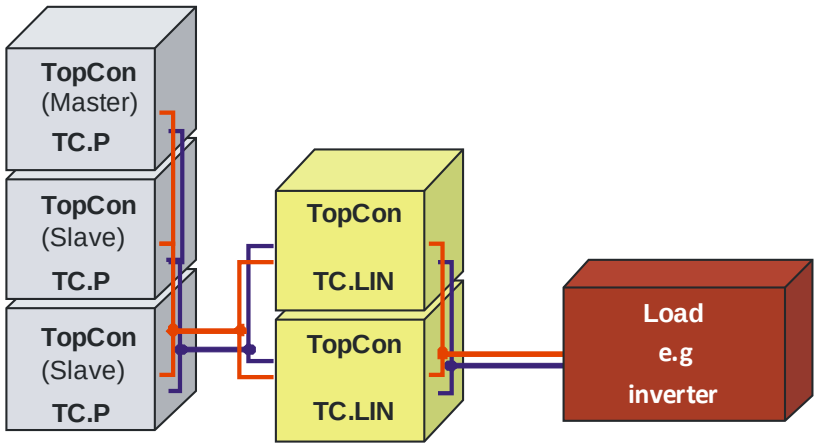

Fig. 69 Power supply/post-processing unit multi-unit system (with load)

In this example 3 TopCon power supplies are connected in parallel. This multi-unit system is connected in parallel to all inputs on the related TC.LINs and their outputs in turn connected in parallel with the load.

4.2.11. Specification extensions (mil spec/ruggedised)

Depending on the required application, modified versions of the TopCon power supply can be built to customer request.

As a result there are to some extent very complex design changes to the device, e.g.:

- Screws secure against loosening.
- Replacement of components with a different specification.
- Replacement of assemblies with a different specification.

The "ruggedized" version of the TopCon power supply

The device is modified such that the specifications for the following tests are met (cf. Table 70):

- Mechanical (single) shock, tests from 3 directions with positive and negative acceleration (test in accordance with IEC 60068-2-27)
- Vibration (in accordance with IEC 60068-2-64)
- Extension of the temperature range (e.g. -40 °C to +55 °C)
- Condensation test (visual tests, function test)

In the case of such requirements or similar requirements, please contact your sales partner or Regatron support.

Example properties of a modified TopCon power supply

No	Short form	Description of the test/result
Mechanical shock		
1	In accordance with IEC 60068-2-27	30 g/11 msec +/- 3 shocks per axis /all 3 axes
Vibration		
2	In accordance with IEC 60068-2-64	Frequency 20 – 2000 Hz Acceleration (dynamic) 0.016 g^2/Hz 10 – 20 Hz → 6 db/oct. 2000 – 4000 Hz → -24 db/oct. Total 6.06 g (eff.) Average test duration 30 min. per axis All 3 axes
Temperature test under effect of load		
3	Hot and cold test	Ambient temperature: 55 °C at 90 % full load up to 180 min Storage temperature: -40 °C Derating of the current above 35 °C
Condensation test		
4	Condensation	Full function in the entire operational range, visible condensation during operation

Table 72 Tests on the ruggedised version

4.3. Software options

4.3.1. Function generator (TFE/TopCon Function Engine)

Introduction

The activated function generator can specify set values for voltage, current and power in the form of pre-defined or user-defined functions for the control of the TopCon power supply.

Here individual function blocks are combined into function sequences that can be triggered by events.

The points on the user-defined functions and the AAP characteristic curves to be used can be created and modified using TopControl or by utilising a function library (DLL).

It is possible to use the “function generator (TFE)” in the demo mode. Within the TopControl application, e.g. sequences of functions can be defined. However, the function curves can only be transferred to a TopCon power supply and used after the activation of this option.

For information on calling defined function sequences for the function generator via the HMI see Table 91, page 176.

Function Block (FB)

A function block can be formed from various base functions for voltage, current and/or output power.

The following functions for which the parameters can be set as required are available:

- Time-dependent standard functions: square, triangle, sine
- Arbitrary time-dependent functions (user-defined)
- Arbitrary functions (AAP, e.g. I = f(U))

Function Sequence (FS)

A function sequence comprises at least one function block. As a consequence a sequence has the following properties:

- Each function block contains base functions (e.g. sine wave with symmetry, offset and possibly exponential decay curve elements)
- The function blocks can be repeated 1 to n-times, or can be defined as continuous functions. In addition, the functions can be given further parameters, e.g., a pause between the repetitions.

- In the case of several reference values within a function sequence, several function blocks can be active at the same time.

↳ The shortest function block defines the duration of the function sequence.

↳ The pause time and the number of repetitions apply equally to all function blocks within a function sequence.

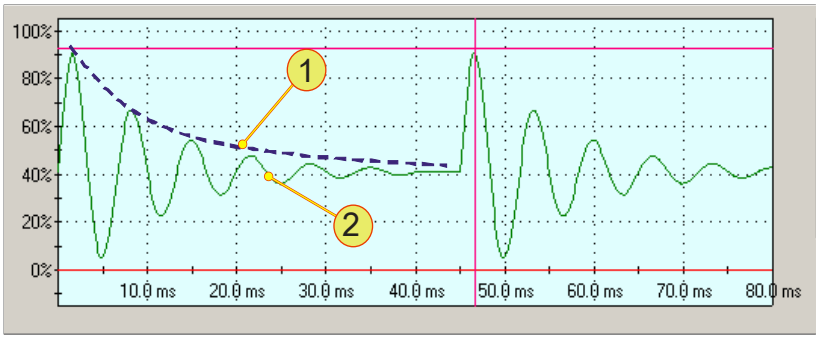

Fig. 70 Example of the capabilities of the function generator.
-1- Exponential envelope, specified in the TFE
-2- Result: a sine wave function that decays correspondingly -1-.
In the example 2 repetitions have been defined.

The following events (“Trigger mode”) can trigger a function sequence:

- VOLTAGE ON (“Voltage on”)
  As soon as the output power is activated at the output of the power supply.
- Manual triggering (“Manual”)
  Manual triggering is possible ¡n the TopControl application or with the aid of the HMI/RCU.
- Analogue interface X105 (“High level on X105/19”)
  If there is a high level on pin 19 of the interface.

Definition of reference values prior to a trigger event

The nature of the trigger can be specified in the TopControl application and HMI/RCU. Up until the trigger event, the set values specified by the active interface apply, e.g.:

- RS-232 interface
  Set values defined via the TopControl application.
- HMI/RCU
  Set values defined via HMI/RCU.
- Analogue interface X105
  Set values defined via the analogue interface.

Definition of reference values after the completion of a function sequence (“After Function Sequence finished”)

After a function sequence has been completed, a reference value can be defined as follows:

- “ VOLTAGE OFF” (“Voltage off”)
  The device output is electrically isolated.
- Actual reference values are retained directly from the function block (“Hold level”).
- From the active set value interface.
  Set values are defined via this interface.

Maximum number of function sequences in the TopCon power supply:

- Up to 256 **time-dependent standard function sequences**.
- In the case of **arbitrary time-dependent (user-defined) function sequences** the number is dependent on the number of points.
  A maximum of 1000 points is possible.
- In the case of **arbitrary function sequences** (user-defined AAP) the number is dependent on number of points.
  A maximum of 64 points is possible; these points can be distributed unevenly.

The function sequences saved in the power supply can be called via the following interfaces:

- HMI (RCU).
- RS-232 interface.
  TopControl application.
  Using custom programs via function libraries.

The parameters summarised

Setting	Value range – TopControl	Value range – HMI
Base function	Sine, square, triangle, user-defined, AAP	
Amplitude	0...100 %, resolution: 12 bits	
Offset	Standard: 0 – 100 % Resolution: 12 bits Bipolar:-100 % – +100 % Resolution: 12 bits	
Symmetry	0...100 % (only with triangle and square)	
Frequency	0.001 Hz – 1 kHz	0.01 Hz – 320 Hz
Exponential envelope (time constant)	0.1 ms – 100000 s	10 ms – 320 s
Rectify negative amplitude	Yes/no	Cannot be changed, Standard: no
Amplitude polarity	Unipolar/bipolar	Cannot be changed, Standard: bipolar
No. of repetitions of the base function	1 – 65535 or continuous	0 – 32000 (0 ≙ continuous)

Table 73 Possible function generator settings with comparison between TopControl and HMI.

Loading and saving function sequences

All the settings can be saved in the non-volatile memory (flash) and loaded again. It is also possible to set that when the power supply is started (power-up), a previously saved function sequence is loaded automatically. Several function sequences can be saved. 64kB of memory are available for this feature. Without user-defined curve shapes, up to 256 function sequences can be saved. In the case of user-defined curves (4 bytes per point) the number reduces accordingly.

The function sequences are saved in a sequence number (1...1000) that can be selected and can be called again using this number. It is also possible to call the function sequences from the HMI. On saving a function sequence via TopControl it is also possible to give an arbitrarily defined name (up to 31 characters) as well as the date and time.

Restrictions and information

The function generator makes it possible to specify complex set value curves. For the output values on the power supply to also be able to follow these set value curves, the following points are to be noted:

The gradient limiters

(can be adjusted in the TopControl application on the <CONFIG> tab → Slopes)
are also active during function generator operation. If, e.g., steeper edges are defined in the function generator, it may be necessary to increase these slope values.

Small control parameters prevent fast control movements.

(can be adjusted in the TopControl application <CONFIG> tab → Controller)

The control parameters depend heavily on the load. In the specific case the current or voltage curve should be checked using an oscilloscope or the Scope function integrated into TopControl to optimally adapt the control parameters.

In addition, it is to be noted that a TopCon power supply in the basic version cannot absorb any energy from the load side, i.e. in case of set value steps the control time constant is dependent on the load impedance.

Negative set values

can only be processed in combination with an AC-polarity reverse bridge or Q14 system (see options chapter 4.2, page 93). A TopCon power supply without AC-polarity reverse bridge interprets negative set values as zero.

4.3.2. Solar Array Simulator (SAS) - SASControl

Function

The function generator for the TopCon power supply is switched to the AAP mode with a function I = f(U) and can behave like a solar panel in accordance with this function.

By overlaying on another AAP characteristic curve, the effect of solar irradiation and temperature on the solar panel can be simulated. During this process it is possible to “softly” overlay linearly from one AAP characteristic curve to another.

The solar array simulator can be used for photovoltaic simulation (PV simulation).

The basic problem

On photovoltaic installations the energy from light is converted into electrical power. The DC produced is fed back to the grid via an inverter.

(Conversion of the DC from the solar panel to 230 V 1~- or 400 V 3~ AC.)

During inverter production and development the TopCon power supply can be used as a solar panel simulator for testing inverters.

The solution

Modules required for this usage

- TopCon Quadro power supply
- SASControl option

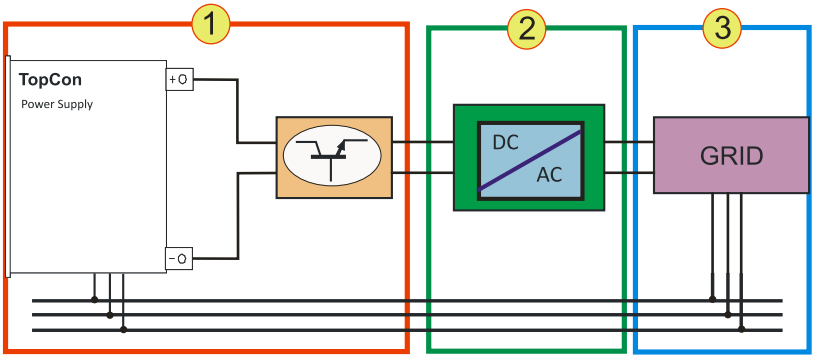

Fig. 71 Usage of the TopCon power supply as a test stand

Test stand - modules	
1	**TopCon power supply with TC.LIN** The TopCon simulates a solar panel with its function generator TFE. The TC.LIN helps to improve the dynamic performance of the system, during the process greater accuracy is required.
2	**Test object: inverter**
3	**Grid** The grid can be real or also be a simulation so that the test object can be operated in an environment that closely represents reality.

Table 74

Improvement of dynamic performance using the TC-LIN linear series controller

A further improvement in the dynamic performance of the system is provided by the usage of the downstream TC.LIN linear series controller. The linear series controller communicates with the TopCon power supply. While the TopCon power supply defines the signal “coarsely”, the TC.LIN modifies the output signal with high dynamic performance and accuracy (5 µs cycle time, 14.5-bit resolution). The combination of the TopCon Quadro power supply and the TC.LIN linear series controller can be used very flexibly and at the same time at high powers for the realistic simulation of small to medium solar panels.

This functionality is largely controlled from the TopControl application. Alternatively the functionality can be controlled via the DLL for custom programs.

4.3.3. Akku-Control – rechargeable battery maintenance charging curves

Research and development on environmentally friendly vehicle concepts is closely linked to the ability to store or temporarily store electrical energy. Electrochemical and also capacitive stores have specific applications – however a common feature is the highly dynamic usage of storage during vehicle operation.

To test the resilience of modern storage systems in relation to charging/discharge cycles and microcycles, bidirectional power supply systems are required that can apply to the stores the loads due to the cycles that occur during vehicle operation as well as boundary loads.

In the context of sensible energy management, the regenerative energy that is produced must be fed back to the supply system with high efficiency. This statement applies in general only at higher loads. On small energy stores it is often sensible to discharge using a dissipative load, because energy recovery to the grid is only economical from higher quantities of energy.

The characteristics for the rechargeable battery management in the Regatron software Accu-Control are:

- Feature for charging and discharging a rechargeable battery via constant current or constant power.
- Largely arbitrarily programmable charging/discharging cycles e.g. standard curves or specified values for different rechargeable battery types.
- 8-channel long-term data acquisition for current, voltage, power, temperature (up to 4 external temperature channels), etc..
- Adaptive sampling of the measured values, with larger curve changes the measuring frequency is increased automatically (can be configured as required).

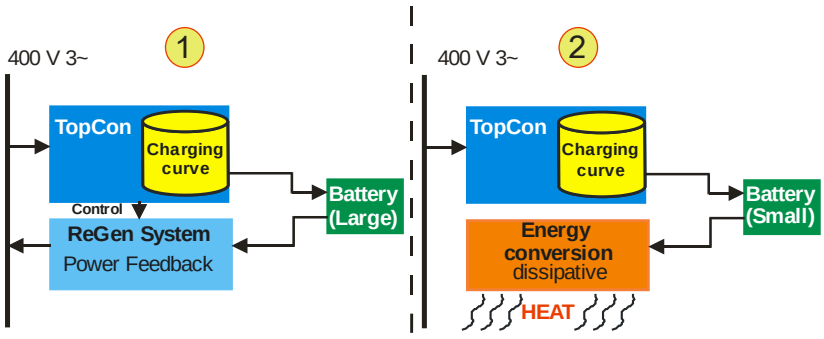

Fig. 72 Overview of “Akku-Management” with large rechargeable batteries **-1-** and small rechargeable batteries **-2-**

4.4. Interface options

4.4.1. Functionality as a function of an optional interface

	CAN/CANOpen	IEEE488	HMI/RCU	RS-232 REAR, RS-422
Read/write register (low-level function)	X	X	X	X
Read system information	X	X	X	X
Reference values: set/specify	X	X	X	X
Read actual values	X	X	X	X
Read errors/warnings	X	X	X	X
Function generator: standard functions (sine, square, triangle)	X[1), 2)]	X[1), 2)]	X[2)]	X[2)]
Function generator: AAP function → call	X[1), 2)]	X[1), 2)]	X[2)]	X[2)]
Function generator: AAP function → define	–	–	–	X[2)]
SCOPE function	–	–	–	X

Table 75 Overview of dependencies between task category and interface
[1] Increased effort required.
[2] Only in combination with the option FUNCGEN (TFE)..

4.4.2. Overview of possible interface combinations

	Analogue	HMI	RCU	RS-232 REAR	RS-232	RS-422	USB	Ethernet	IEEE488	CAN/ CANOpen	Profibus
Analogue	○P	●	●	●	●	●	●	●	●	●	●2
HMI	●	○P	●	●	●	●	●	●	●	●	●
RCU	●	●	●	●	●	●	●	●	●	●	●
RS-232 REAR	●	●	●	○P	○P	○P	○S	●3	○P	↑	●1
RS-232	●	●	●	○P	○P	○	○ S	●3	○P	↑	●1
RS-422	●	●	●	○P	○P	○P	○S	○P	○	○	○
USB	●	●	●	○S	○S	○ S	○P	○S	○	↑	(○)
Ethernet	●	●	●	●3	●3	○P	○ S	○P	○	○	○
IEEE-488	●	●	●	○P	○P	○P	○S	○	○P	○	○
CAN/ CANOpen	●	●	●	↑	↑	○	↑	○	○	○P	○
Profilbus	●2	●	●	●1	●1	○	(○)	○	○	○	○P

Table 76 Possible combinations of various interfaces

- ● The two interfaces are possible and function together (autonomous).
- ○ The two interfaces are not possible at the same time.
- (○) Not foreseen/possible at the moment.
- ↑ The two interfaces are possible, CAN/CANOpen interface is dominant.
- 1) External Profibus to RS-232 converter.
- 2) External converter (not bidirectional). Functionality must be checked
- 3) External Ethernet to RS-232 converter.
- P) Only one interface is allowed to be physically active
  E.g. A connection is made to the interface to be activated, while the inactive interface must be disconnected.
- S) Only one interface can be activated via the software. The other interface is automatically deactivated.

4.4.3. RS-232 REAR interface – rear side of power supply

Fig. 73 RS-232 REAR interface

Installation location:

The interface is built into the rear side of the device. It can be retrofitted to a device or be already installed on delivery.

Combination with other interfaces

- The RS-232 REAR interface takes over the tasks of the RS-232 interface on the front side of the device.

Technical characteristics

- Type of bus connection: plug, D-Sub 9-pin
- Interface standard: in accordance with EIA-232

For technical data and information on function, see chapter 3.2.4.9, page 69.

4.4.4. RS-422 interface – diagnostics and control connection

Installation location:

The interface is built into the rear side of the device. It can be retrofitted to a device or be already installed on delivery.

Combination with other interfaces

- A maximum of ten RS-422 receivers are allowed to be connected to a transmitter within one transmission device.

Technical characteristics

- Type: designed as D-Sub socket, 9 pin
- Interface standard: ITU-T V.11

Function

The RS-422 interface is used for high speed data transmission over large distances.

The serial data are transmitted as a voltage difference between two corresponding wires without a reference to ground.

For each signal to be transmitted there is one pair of cores that comprises an inverted signal wire and a non-inverted signal wire that are twisted together.

The receiver only evaluates the difference between the two wires such that common mode interference up to 7 V on the transmission cable will not corrupt the data signal.

You can obtain further information from Regatron support.

4.4.5. USB interface – Universal Serial Bus

Fig. 74 USB interface **-1-** in combination with RS-232 REAR interface **-2-.**

Installation of the interfaces

The interface is built into the rear side of the device. It can be retrofitted to a device or be already installed on delivery.

Combination with other interfaces

- The interface is always supplied in combination with the RS-232 REAR interface.
- The RS-232 REAR interface takes over the tasks of the RS-232 interface on the front side of the device.

Technical characteristics

- Type: socket for USB plugs of type B (see Fig. 71 USB interface **-1-** in combination with RS-232 REAR interface **-2-.**)
- Interface standard: USB 1.1

Function

This is a serial interface and corresponds to the functionality of the RS-232 interface. The USB interface is used for the transparent transmission of data and can as a consequence be utilised both using the DLL and directly at the low protocol level.

The USB driver for the PC included must be installed for it to be possible to detect and operate the TopCon power supply from the operating system.

4.4.6. CAN/CANOpen® interface

Fig. 75 CAN bus interface **-1-** in combination with RS-232 REAR interface **-2-.**

Installation of the interfaces

The interface is built into the rear side of the device. It can be already installed in a device on delivery.

Only Regatron can retrofit this interface.

Combination with other interfaces

- The interface is always supplied in combination with the RS-232 REAR interface.
- The RS-232 REAR interface takes over the tasks of the RS-232 interface on the front side of the device.
- An active CAN/CANOpen® interface has a higher priority than HMI/RCU control units connected and therefore implements its commands instead.

Technical characteristics

- Type of bus connection: plug, D-Sub 9-pin
- CANOpen protocol: CiA standard 301 V 4.02

Function

Unlike the internal CAN bus in the device, which is responsible for the internal flow of information in the device and that is supplied as standard, the optional CAN/CanOpen® interface is used for the connection of devices from other manufacturers.

As a real-time system the CAN bus can be used for controlled systems.

The CAN bus is a serial two-wire bus that combines a high transmission speed with the communication protocol CANOpen®. By means of its collision management a lasting communication blockage on the bus is prevented.

The utilisation of the CAN/CANOpen® interface makes it possible to connect the TopCon power supply to a type of communication network in widespread use in industry.

You will find further information in the instructions supplied with the order.

4.4.7. IEEE488 – GPIB (General Purpose Interface Bus)

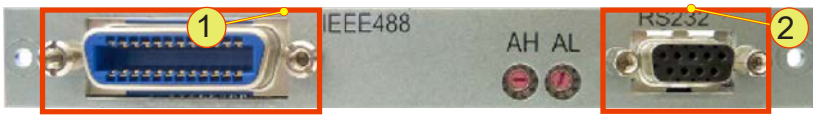

Fig. 76 IEEE488 bus interface **-1-** in combination with RS-232 REAR interface **-2-.**

Installation of the interfaces

The interface is built into the rear side of the device. It can be already installed in a device on delivery.

Only Regatron can retrofit this interface.

Combination with other interfaces

- It is not possible to operate an active IEE488 interface and the RS-232 interface at the same time.
- Combination with other interfaces is not possible.

Technical characteristics

- Type of bus connection: socket, Centronics 24-pin
- SCPI command set: standard IEEE488.2
  expanded with TopCon control commands

Function

Using commercially available Centronics connectors and the IEEE488 interface, TopCon power supplies can be operated independently. During this process specific TopCon control commands are interpreted and executed on the interface board.

Using the IEEE488.2 standard SCPI command set, straightforward connection to other network devices, instrumentation and electrical devices with support for the interface is possible.

You will find further information in the instructions supplied with the order.

4.4.8. TC.Ethernet

Fig. 77 TC.Ethernet interface **-1-** in combination with RS-232 REAR interface **-2-.**

Installation of the interfaces

The interface is built into the rear side of the device. It can be already installed in a device on delivery or retrofitted.

Combination with other interfaces

- It is not possible to operate an active TC.Ethernet interface and the RS-232 interface at the same time.
- Combination with other interfaces is not possible.

Technical characteristics

- Type of bus connection: socket, RJ45

4.4.8.1. Conditions for the Ethernet interface

Standard configuration of the interface card

- DHCP server: the card is configured for the allocation of IP addresses by a DHCP server.
- APIPA: If an address is not allocated by a DHCP server in a specific time window, the card automatically assigns itself an IP address (APIPA).

Crossover cable

The Ethernet interface card cannot switch automatically between a crossover cable and an uncrossed network cable. If the other end does not support Auto-MDI(x), you will need a crossover cable for the installation.

4.4.9. RS-232-to-Ethernet converter

Fig. 78 Converter in the switch cabinet case **-2-** (view of front and underside) and benchtop case **-1-.**

Converter variants

- Benchtop case **-1-**
  without clamping fitting but with feet and 9 V_{DC} power supply socket.
- Cabinet case **-2-**
  with clamping fitting for cabinet rails and 9 V_{DC} power supply terminals.

Combination of interfaces

- RS-232 interface, D-Sub plug 9-pin
- Ethernet 10/100 Mbps interface, RJ45 socket.

Function

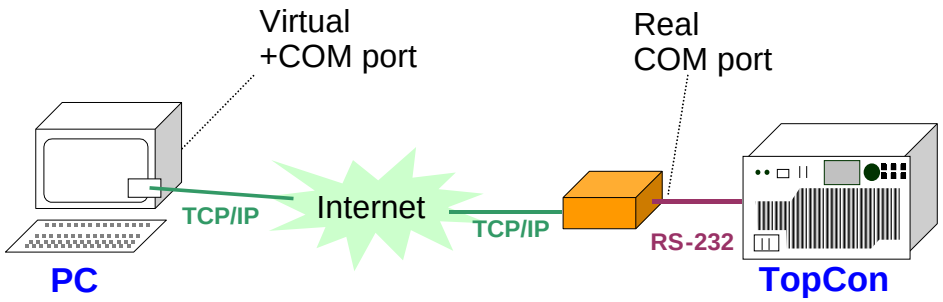

Fig. 79 Sketch of the function of the external Ethernet to RS-232 converter.

The RS-232-to-Ethernet converter (ipEther 232) makes it possible to operate a serial interface (RS-232) from a TCP/IP network. A 10/100 Mbps network is supported.

You will find further information in the instructions on the installation CD supplied with the order.

5. Multi-unit system

5.1. Introduction

Due to the fully digital control of the TopCon power supplies, all control signals are exchanged between the devices without losses within a multi-unit system.

Master/slave system

A multi-unit system can only be made up of TopCon power supplies of the same type (model number).

The devices can be connected together in the following operating modes:

- **Serial**
  To increase the output voltage,
  the outputs of all devices are connected **in series**.
- **Parallel**
  To increase the output current,
  the outputs of all devices are connected **in parallel**.
- **Matrix**
  Some of the systems are connected as a serial multi-unit system, at least two of these serial configurations are connected in parallel.
- **Multiple load**
  Each device supplies **a load** and is not connected with any other device or only to one connection terminal on another device.

In principle the operating modes act on two areas:

- **Load connections**
  The outputs on the TopCon power supplies are connected accordingly in the
  serial, parallel, multiple load or in the matrix multi-unit system.
  The related total output value is distributed evenly over all TopCon power supplies in the multi-unit system.
- **Internal communication**
  All devices in the multi-unit system are taken into account during internal system communication by means of device addressing.
  Along with the TopCon power supplies this aspect also covers the HMI and RCU.

System communication

The system communication in multi-unit systems is ensured by the digital exchange of data (CAN). The wiring is undertaken with individual point-point connections between the devices (modules) as well using the terminating resistors at the two physical ends of the bus structure.

A multi-unit system with max. 8 devices is recommended. Theoretically up to 64 devices can be connected to the bus. From approx. 9 devices the communication is reduced. As a result, the dynamic performance of individual devices cannot be achieved with more than 8 devices.

Here it is recommended to use the **Multi-Rack Controller (MRC)**, for information on the realisation of larger multi-unit systems see dedicated instructions.

Device addressing

The device address comprises an upper address range (AH) and a lower address range (AL).

During the configuration of the related address range, the device type and the master-slave principle play a role, along with the type of configuration.

Master-slave principle

The set values are provided to the master device, e.g. via HMI or the PC using the TopControl application.

The master device passes on the parameters to its slaves via the internal system communication. The individual slave devices in the multi-unit system convert the set values specified into the related output values.

5.2. Load connection on devices in multi-unit operation

Multi-unit system supplied from the factory

The load connection is configured on multi-unit systems supplied from the factory. The minus and plus connections on the individual TopCon power supplies are combined to form a system load terminal that is laid out of the system and to which the load is connected.

Special aspects of the multi-unit system in relation to the safety interlock circuit and the sense function are taken into account.

5.2.1. Sense function in a multi-unit system

Configuration of the sense function

For information on the sense function and the configuration of the single device see chapter 3.2.4.4, page 57.

Serial multi-unit system

In the serial multi-unit system the sense cables are not allowed to be connected! An attempt to activate the related device will result in an error message.

Parallel multi-unit system

The sense function can be used in a parallel multi-unit system. All devices in the multi-unit system must be connected to the sense cable connected and the sense function must be configured in the controller.

Example sense configuration in a parallel multi-unit system with two TopCon power supplies:

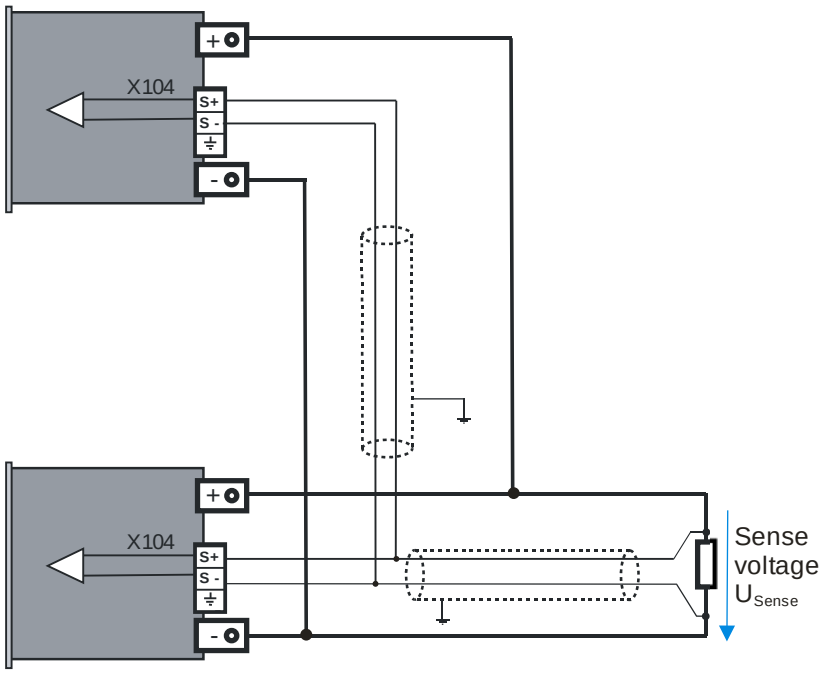

Fig. 80 Circuit diagram for load and sense cables in multi-unit operation

5.3. Internal system communication

5.3.1. Hardware required for the multi-unit system

Allocation of interface using dummy plug

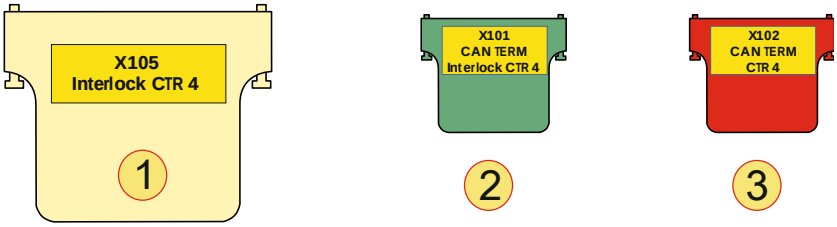

Fig. 29 Schematic illustration of the D-Sub dummy plugs used with their labelling.

Dummy plug	
1	**Interlock connector, D-Sub, 25-pin (dummy plug)** Label: "**X105; Interlock CTR 4"** Is connected on the rear side of all devices to interface X105.
2	**Interlock or CAN-Term, D-Sub, 9-pin (dummy plug)** Label: "**X101; CAN TERM; Interlock CTR 4**" Is connected to interface X101 on the rear side of the device at the start of the CAN multi-unit system.
3	**CAN-Term, D-Sub, 9-pin (dummy plug)** Label: "**X102; CAN TERM;"** Is connected to interface X102 on the rear side of the device at the end of the CAN multi-unit system.

Table 39 Dummy plugs and their labelling.

Allocation of interfaces with the CAN cable

For a wiring diagram for multiple power supplies see Fig. 78, page 147.

5.3.2. Interlock circuit in a multi-unit system

If the interlock circuit is used in a multi-unit system, there are changes compared to operation using an individual power supply. The principles of function and usage with a single device are described in the interlock circuit chapter 3.2.4.8, page 67 and interlock output inhibit chapter 3.3.1, page 73.

So that a multi-unit system can also be operated with a single interlock contact, the interlock circuit for all devices in the system must be supplied from a 24 V auxiliary supply (any device).

Note that the dummy plugs for the interfaces X101/X102 have similar cases, however internally the interlock wiring is different and therefore a differentiation must be made!

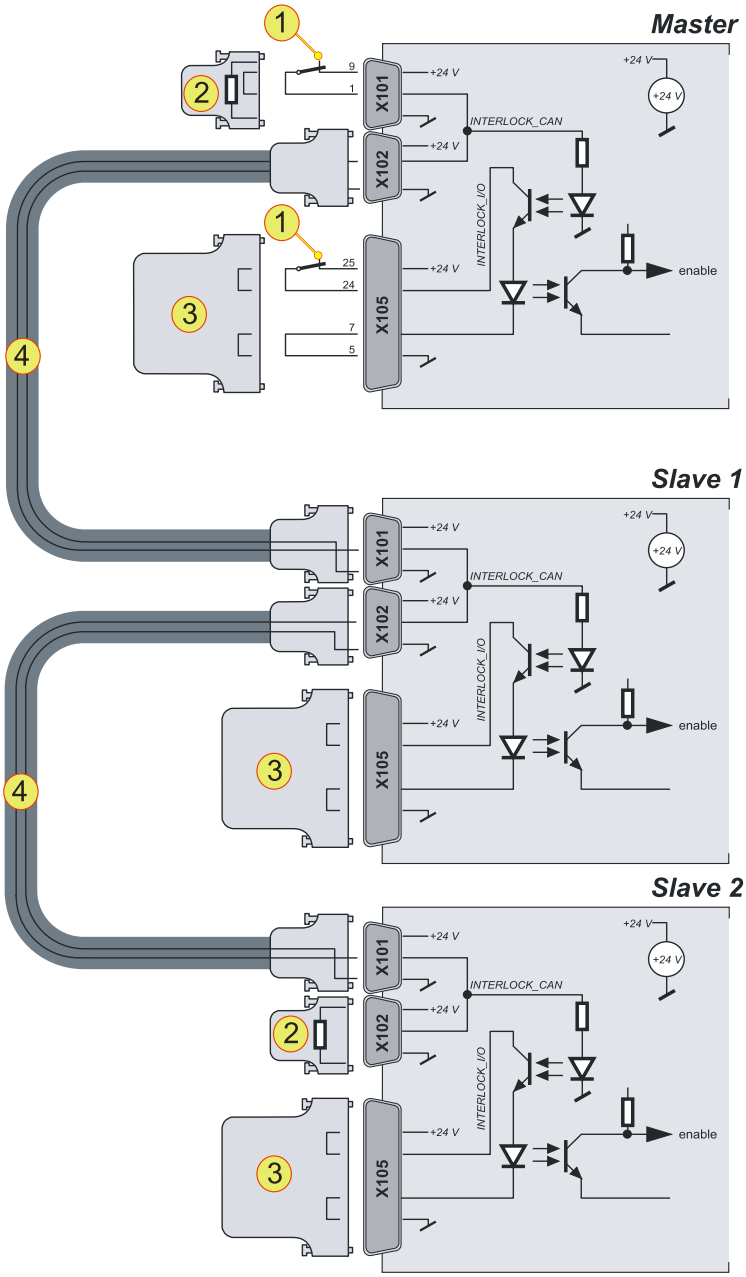

Fig. 81 Interlock connection scheme for TopCon power supplies via the CAN cable and the related dummy plugs.

Interlock modules in accordance with Fig. 78	
1	External EMERGENCY STOP button that can interrupt the interlock circuit
2	Dummy plug “**X101; CAN TERM; Interlock CTR 4**“ Is connected to interface X101 on the rear side so that the interlock circuit is not interrupted. (If there is no circuit -1-)
3	Dummy plug “**X105; Interlock CTR 4”** Is connected to interface X105 on the rear side so that the interlock circuit is not interrupted.
4	CAN cable connects interface X102 on the first device to the interface X101 on the following device.

Table 77 Connection of dummy plugs to the related interfaces in the multi-unit system.

5.3.3. Multi-unit system with TopCon power supplies

5.3.3.1. Master-slave principle on power supplies in the multi-unit system

The set values are provided to the master device, e.g. via HMI or the PC using the TopControl application.

The master device passes on the parameters to its slaves via the internal system communication. The individual slave devices in the multi-unit system convert the set values specified into the related output values.

Limits of a multi-unit system

- Only one master is allowed per multi-unit system.
- Per multi-unit system at full bandwidth maximum number of devices: 8
  Devices such as HMI or RCU also count in a multi-unit system.
- A device address is only allowed to occur once in the multi-unit system.
- Several multi-unit systems can be connected via a Multi-Rack Controller (MRC) to form a large multi-unit system.

Display of the operating parameters for individual devices

The most important operating parameters are sent continuously by the slave devices to the master and can be displayed there, e. g., using the TopControl application.

Errors in the multi-unit system

Control of the state information in the multi-unit system:

- Slave devices follow the state of the master device.
- Each single device (module) can independently enter the “WARN” or “ERROR” state and trigger the entire system to change to this state.
- Acknowledging an error will affect the entire system.

Addressing of master and slave devices

The addresses of multi-unit system devices comprise an upper address range (AH) and lower address range (AL).

The device is defined as a master or slave device depending on the value used for the address.

- **Master device**
  AL: 0; AH: 0
- **Slave device**
  The value for the address is > 0, whether in the AL or AH address range

5.3.3.2. Addressing on power supplies in the multi-unit system

Whether the issue is a single device or a multi-unit system of TopCons, the device addresses are used to allocate the TopCon to its logical position in the multi-unit system

The device address comprises an upper address range (AH) and a lower address range (AL).

During the configuration of the related address range, the device type and the master-slave principle play a role, along with the type of configuration.

Configuration of the addresses via the rotary switch

The device address is configured via the rotary switches. Default values are AH: 0; AL: 0

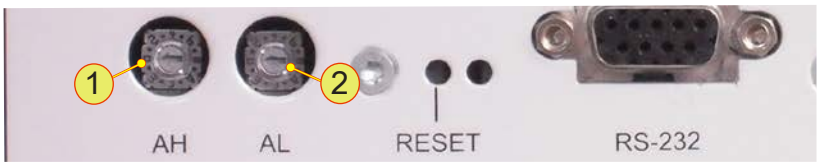

Fig. 82 Rotary switches AH **-1-** for the upper address range
Rotary switch AL **-2-** for the lower address range

Addressing for a parallel multi-unit system

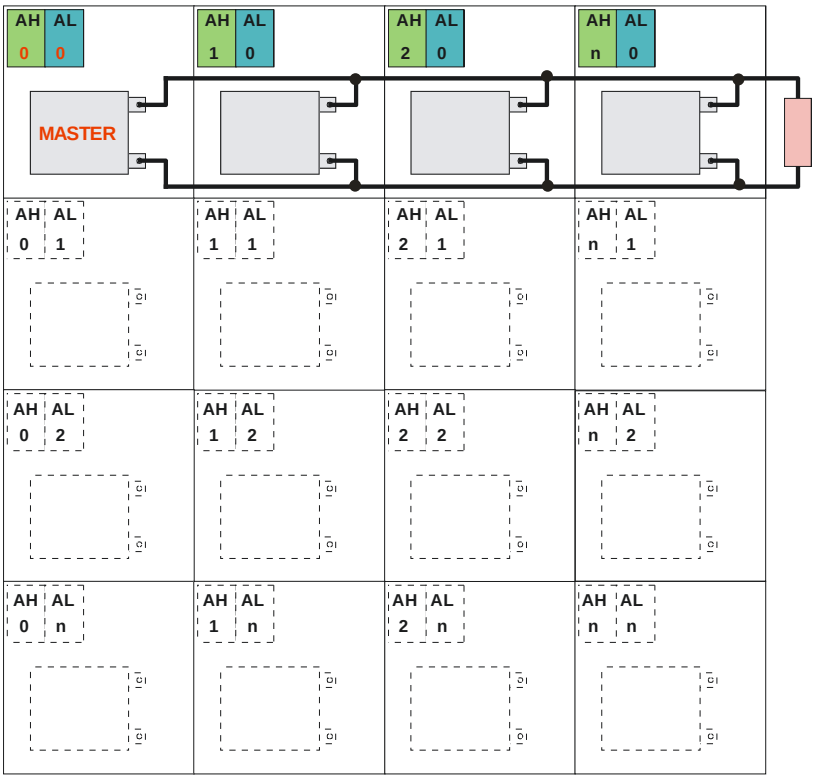

Fig. 83 Example definition for device addresses with 4 TopCon in parallel.

Addressing for a serial multi-unit system

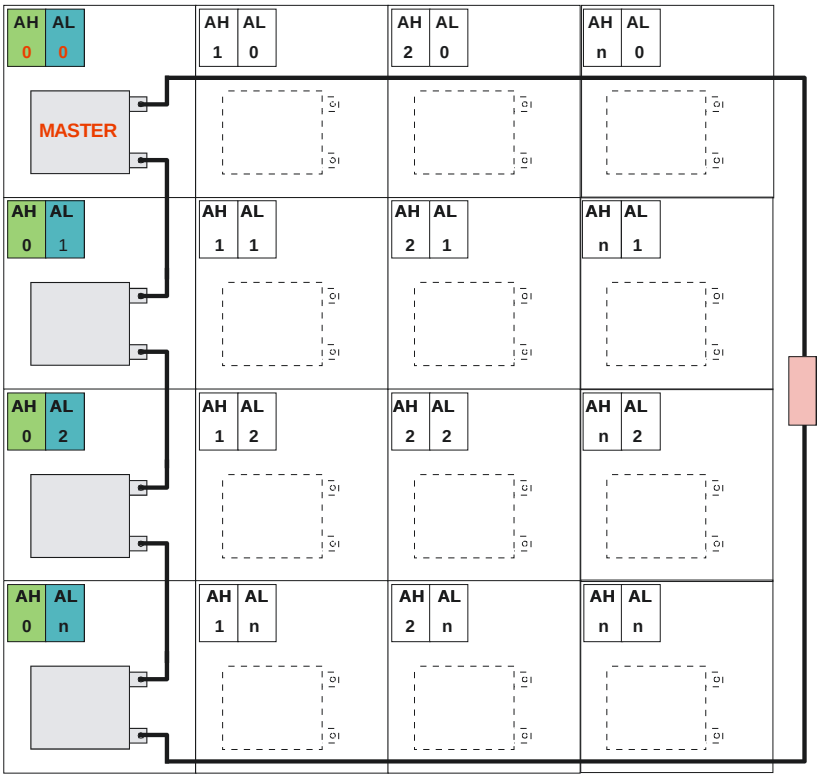

Fig. 84 Example definition for device addresses with 4 TopCon in series.

Addressing for a matrix multi-unit system

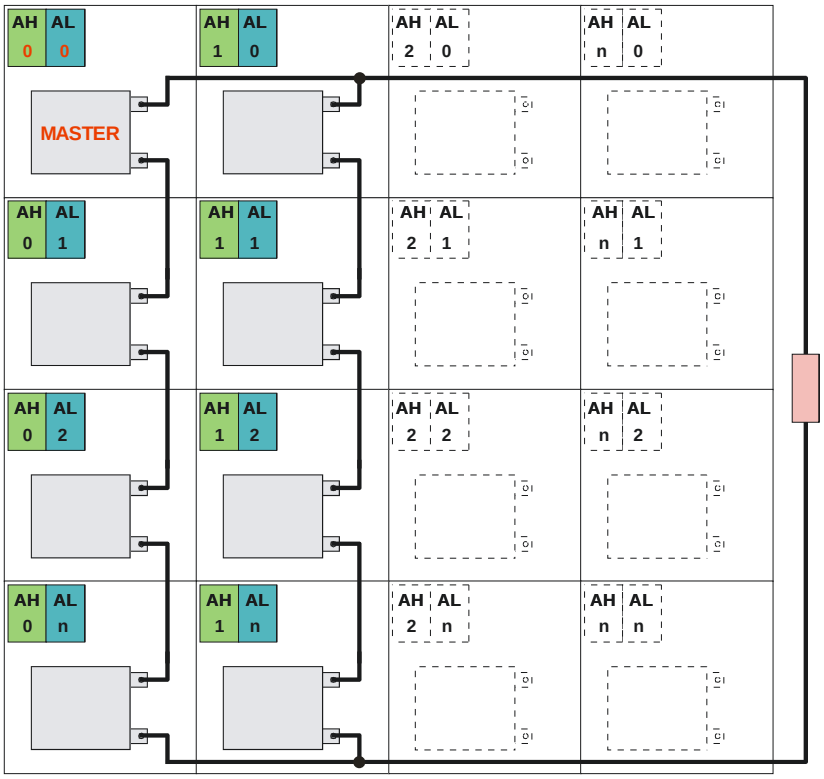

Fig. 85 Example definition for device addresses with 8 TopCon in a matrix.
2 serial strings of 4 devices each are connected in parallel.

5.3.4. ID addresses on several HMI/RCU (option) in a multi-unit system

The optional display and data entry devices HMI and RCU have equal priority.

HMI devices directly installed in the power supply are not necessarily responsible for the display and entry of the data for the device. In principle all HMI devices in the multi-unit system only display the overall system parameters.

5.3.4.1. Master-slave principle for HMI/RCU (option)

Using the master HMI/RCU the parameters for the overall system can be displayed and changed.

Specifications for the multi-unit system

- There can only be one master.
- Each ID number is only allowed to occur once in the multi-unit system.

In case of a single device combination of HMI/RCU and TopCon power supply, HMI/RCU must be defined as the master. This definition corresponds to ID address 1.

5.3.4.2. Addressing with HMI/RCU (option) in a multi-unit system

Whether the issue is a single device or a multi-unit system of TopCons, the device addresses for HMI/RCU are used to allocate the HMI to its logical position in the multi-unit system

ID addresses

- Master HMI/RCU with ID address: 1
- Slaves with ID address: > 1
  Slave 1 = 2; Slave 2 = 3; Slave 3 = 4; etc.

Configuration of ID addresses on the HMI/RCU

Fig. 86 Configuration of ID addresses on HMI/RCU

Opening the settings menu

- Switch on the device -1-.
- Press the <Menu> button -2-.
- Using the JogDial find the
  “HMI settings” -3- menu item and accept your selection by pressing the JogDial.
- Select the “HMI ident number” -4- menu item using the JogDial and accept this selection.
- Select the address ID -5-.
  (Master: 1, slave: > 1)
- Save the HMI settings -6-.
- Repeat the procedure for all HMI/RCUs in the multi-unit system with sequential addressing

5.3.5. Examples for multi-unit system configurations of the hardware

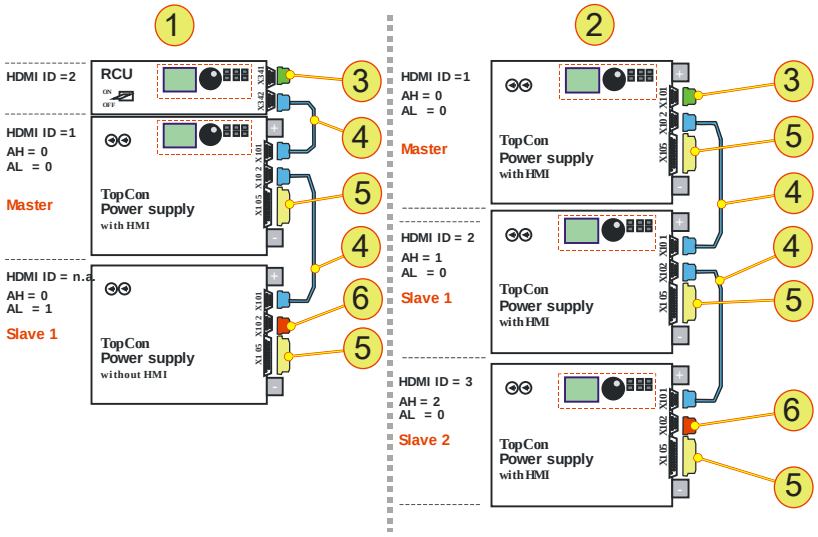

Fig. 87 Examples for systems with corresponding system communication. Master-slave configuration with address specification and hardware configuration

No	Description
1	**2 TopCon power supplies** 1 master device with HMI, 1 slave device without HMI, 1 RCU
2	**3 TopCon power supplies** 1 master device with HMI, 1 slave device 1 with HMI, 1 slave device 2 with HMI
3	**Interlock with CAN-Term** D-Sub, 9-pin
4	**CAN cable** D-Sub, 9-pin, 2 plugs
5	**Interlock** D-Sub, 25-pin
6	**CAN-TERM** D-Sub, 9-pin

Table 78 Description and position of the hardware for Fig. 84 153

5.3.6. Multi-unit system and TopControl application

Only the master is configured in the multi-unit system using the TopControl application.

Necessary conditions for configuration:

- The master device in the multi-unit system must be connected to a PC on which the TopControl application is running.
- CAN connection to all devices in the multi-unit system see chapter 5.3.3.1, page 148.

Procedure for multi-unit system configuration using TopControl

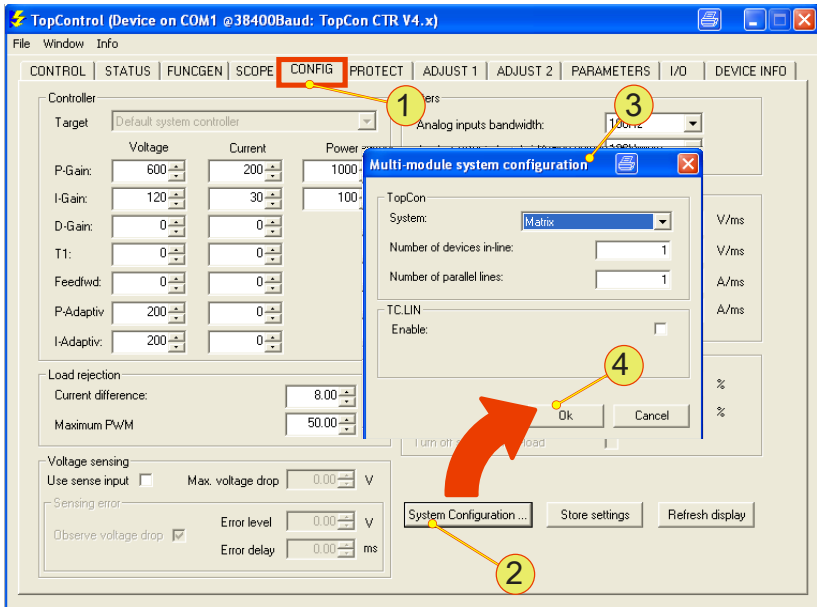

Fig. 88 Setting up multi-unit system using TopControl

- On the <CONFIG> **-1-** tab press the <System Configuration...> **-2-** button.

↳ The “Multi module system configuration” **-3-** window opens.

- Set the parameters for the multi-unit system.
  For further information on the meaning and entry of the parameters see TopControl manual.
- Accept your entries using the <OK> **-4-** button.

↳ A message appears with the rest of the procedure.

- Set up the addresses of all the devices in the multi-unit system, as per chapter 5.3.3.2, page 149.
- Restart all devices to complete the multi-unit system configuration. During this process switch back on all devices within 10 s. The master device last.

6. Operation

6.1. Introduction and overview

The TopCon power supply can in principle be operated in various ways. Here a differentiation is also to be made as to whether the system is operated within a multi-unit system or as a single device.

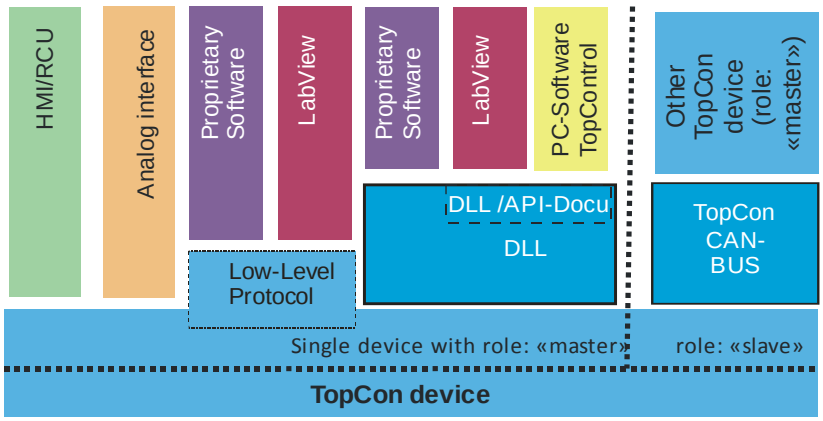

Fig. 89 Overview of the most common operating modes and the resulting options for operating a TopCon power supply.

A TopCon power supply can be operated in the following systems:

- **Single-unit system**
  Single device
- **Multi-unit system**
  - Multi-unit system device as slave:
    Passive receiver (reference values),
    Communication:
    Passing on and receiving the system error status
  - Multi-unit system device as master:
    Active transmitter (reference values),
    Communication:
    Passing on and reception of the system error status.

TopCon as single device or master device

The following interfaces can operate the single device/master device with the following tasks:

- **Analogue interface,** see chapter 6.2, page 157.
  Set value specification for U, I, P and $R_{Internal}$
  Actual value output for U, I
- **HMI/RCU (option),** see chapter 6.3, page 159.
  Set value specification, actual value output,
  start/stop function sequence,
  display errors/warnings, system information
- **TopControl application,** see chapter 6.2, page 184.
- **LabView,** see chapter 6.5, page 185.
  Virtual remote control for base functions available
  Access in principle to all functions in the DLL
- **Proprietary software,** see chapter 6.6, page 188.
  Access in principle to all functions in the DLL,
  using custom software (C/C++, C#, Visual Basic).
  Possibly also access via LabView
- **Slave device in the multi-unit system,** see chapter 5 page 143.
  Passive receiver (reference values),
  passing on and reception of the error status

6.2. TopControl application

6.2.1. Introduction

The user-friendly TopControl application is included with the power supply.

It enables you as the user to communicate with the power supply. The connection is made via the RS-232 serial interface from a PC and its Windows operating system.

The functionality of TopControl includes:

- Switching on/off the output voltage.
- Setting the reference/set values.
- Indication of the actual values.
- Indication of warning and error states.
  (Including the error history)
- Indication of further information on the TopCon power supply.
- Software oscilloscope: “Scope”.
  Analysis of various variables (set values, actual values, system state, etc.).

By means of a user concept it is possible to access advanced functionality in password-protected levels:

- Configuration of multi-unit operation.
- Online access to PID control parameters
  Adaptation of the control characteristics of the power supply to the load-specific situation.
- Linear ramp functions.
  Programming of linear ramp functions for voltage activation and set value steps (set value gradient limiter).
- Setting the limit values.
- Adjustment, modification of internal system parameters.
- Reading the version states of the software.
- Firmware update.

On the procurement of the TFE/function generator option the functionality is expanded:

- Function generator for time-dependent function curves
  Complete control of the function generator via user-defined functions U = f(t), I = f(t), P = f(t) and time-dependent set values (incl. import from Excel .csv files)
- Definition of function curves that can be freely selected
  U = f(I), U = f(P), I = f(U), I = f(P), ...
- Curves can be loaded, run, created and saved, e.g. photovoltaic and rechargeable battery charging curves.

Information about the handling of the software TopControl see the related software manual.

6.3. HMI and RCU

6.3.1. Case designs

The HMI and RCU are available in three different forms

Fig. 90 Installation forms for the control unit (HMI/RCU)

Case designs for HMI/RCU	
1	**HMI, Human Machine Interface** Directly built into the front panel on the single TopCon power supply
2	**RCU front panel, Remote Control Unit** Built into a system cabinet, as front panel with 2 U
3	**RCU device, Remote Control Unit** Remote Control Unit is built into a dedicated case with 2 U

Table 79 HMI/RCU - different forms

6.3.2. Short description/terminology

Function of the Human Machine Interface (HMI), option

Clear system control is made possible by the indication on the display via text menus. Along with the entry of system parameters, the system status is also output.

HMI devices directly installed in the power supply are not necessarily responsible for the display and entry of the data for the device. In principle all HMI devices in the multi-unit system only display the overall system parameters.

Function of the Remote Control Unit (RCU), option

RCU devices have the same functionality as HMIs, they are a device variant with a dedicated case.

In addition, the RCUs can also have an interlock switch on the front.

Function

As per the analogue interface, using the HMI reference values such as current, voltage and power can be specified, the voltage switched on/off and warnings and errors acknowledged.

In addition, the HMI provides the following features:

- Plain text indication of errors and warnings.
- Error thresholds for overcurrent and overvoltage.
- Adjustment of the bandwidth of the analogue inputs and outputs (set and actual values).
- Linear internal resistance simulation.
- Selection of the active interface (analogue, HMI or RS232).
- Permanent storage of the selected settings
  (HMI specific settings as well as system settings).
- Setting the function and characteristics of the Versatile Limit Switch (VLS).

With TFE (function generator) option:

- Loading/activation of a function sequence in the flash.
- Changing function generator settings
  (Note: user-defined points can only be changed using the Top-Control application)

Multi-unit system

On usage in a multi-unit system, the data are forwarded from the master to the slaves and in this way an entire multi-unit system can be operated from a single HMI unit. Depending on the reference values required, the related data are forwarded via the internal communication interface (CAN bus, X101/X102) to the slaves and automatically implemented there.

In the opposite direction (= from the slaves to the master) various items of information, in particular the error and warning data are forwarded from the slaves to the system master and output there.

HMI devices directly installed in the power supply are not necessarily responsible for the display and entry of the data for the device. In principle all HMI devices in the multi-unit system only display the overall system parameters.

HMI identification

All HMI or RCU must be equipped with a unique identifier (ID). Important for the sequence:

- The identifier sequence must start with 1 (for master)
- The identifier sequence must be contiguous.

6.3.3. Technical data on the HMI

The HMI comprises, as an interface component, inputs and outputs and the support interfaces: communication and electrical power supply.

Technical data on the HMI/RCU	
Communication	**Communication bus** Internal proprietary based on CAN Version: V2.0 B (communication with electrical power supply, RCU via interface X101)
Electrical power supply	**Internal (HMI) or via RCU connection** RCU connection cable (communication and supply cable)
Controls	For further information see Table 79, page 162.

Table 80 Technical data on the HMI/RCU

6.3.4. Operation of the HMI (option)/RCU (option)

6.3.4.1. Controls on the HMI/RCU

Fig. 91 Controls for the optional HMI (or the RCU).

Standard controls (cf. Fig. 10)	
1	**LC display** Indication of the actual device settings and various menus 160x80 pixels, font: black, background: blue-grey constant LED background lighting, contrast can be selected Buzzer
2	**<JogDial>**, rotary selector switch Mechanical rotary encoder with detent and integrated button For the selection of menu items and scaling of parameters
3	**<DISPLAY>**, button Cycles entire main window
4	**<ESC>**, button Leaves the actual window and return to the next level up in the hierarchy. Acknowledges error messages and warnings.
5	**<MENU>**, button Opens the main menu
6	**<ON/OFF>**, switch ON: Green LED illuminated. In the operating state the output value set is present at the device output. OFF: Green LED is off, device output is electrically isolated
7	**<REMOTE>**, switch Change over as to whether the TopCon power supply is to be remotely controlled. Deactivated: Red LED off. HMI is ready for entries Activated: Red LED illuminated. HMI is remotely controlled and indicates the device state
8	**<NEXT>**, button In case of two-page menus for data entry used to jump to next page.

Table 81 Controls on the HMI or RCU.

6.3.4.2. HMI/RCU navigation concept

The basic functions of the TopCon power supply can be controlled fully via the HMI or the RCU.

There are 3 different levels in the navigation within the HMI/RCU

- DISPLAY level
  Indication of the most important system data in main windows.
  On system start the HMI is at the system level. The individual main windows can be opened one after the other using the <DISPLAY> button.
  Individual menu windows are also displayed at the DISPLAY level depending on the option activated.
  For an overview of the DISPLAY level, see Fig. 91, page 165.
- MENU level
  The menu windows have an inverse heading.
  The main menu window can be opened explicitly using the <MENU> button. Each individual configuration window is opened using the JogDial and left again using the <ESC> button.
  For an overview of the MENU level see Fig. 92, page 166.
- DATA INPUT level
  You can open the data input level using the JogDial. A text box is selected by clicking the related cursor position. The value can be changed using the JogDial.

Navigation aids within windows

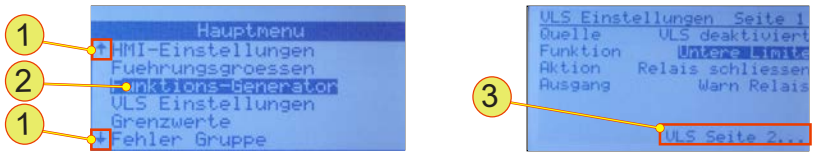

Fig. 92 Window from the DISPLAY level

Navigation aids in windows	
1	**Down/up arrow** The window content is longer than the DISPLAY. The arrow direction indicates the direction of the hidden information. Using the JogDial you can navigate in the required direction.
2	**Cursor** Indicates the actual entry position within a window.
3	**Links** Are mostly in a clearly separate position if there are several pages on a topic or if a window can be left using a navigation item.

Table 82 Navigation within DISPLAY windows

Working with the JogDial (rotary selector wheel)

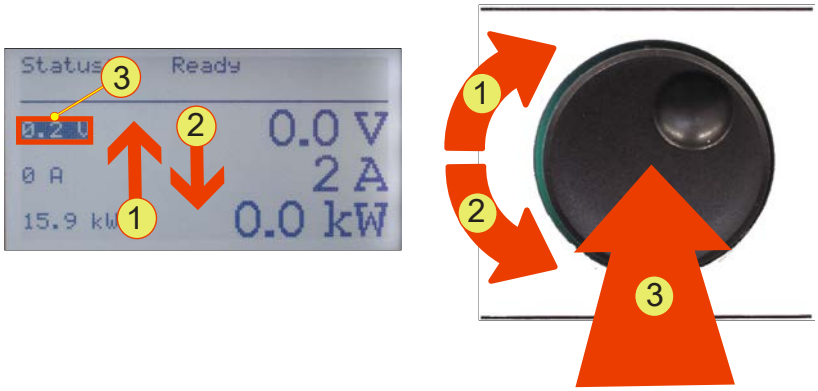

Fig. 93 JogDial for navigating, accepting or setting values

Functions of the JogDial - navigation	
1	**Navigate up** The cursor on the display jumps from one entry to the next entry up as long as the JogDial is turned. On reaching the entry at the top, the cursor jumps to the entry at the bottom.
2	**Navigate down** The cursor on the display jumps from one entry to the next entry down as long as the JogDial is turned. On reaching the entry at the bottom, the cursor jumps to the entry at the top.
3	**Select** By pressing the JogDial once the actual selection (cursor position) is selected. Depending on the selection you can define a value or open a submenu.

Table 83 Navigation using the JogDial on the HMI menus

Functions of the JogDial - DATA INPUT level	
1	**Increase the value** The value is increased as long as the JogDial is turned or until the maximum value is reached.
2	**Reduce the value** The value is decreased as long as the JogDial is turned or until the minimum value is reached.
3	**Accept your entry** The value entered is accepted by pressing the JogDial once and the data input mode is left for the navigation mode.

Table 84 Entry of parameters using the JogDial in individual menu windows

6.3.4.3. Navigation overview – display level

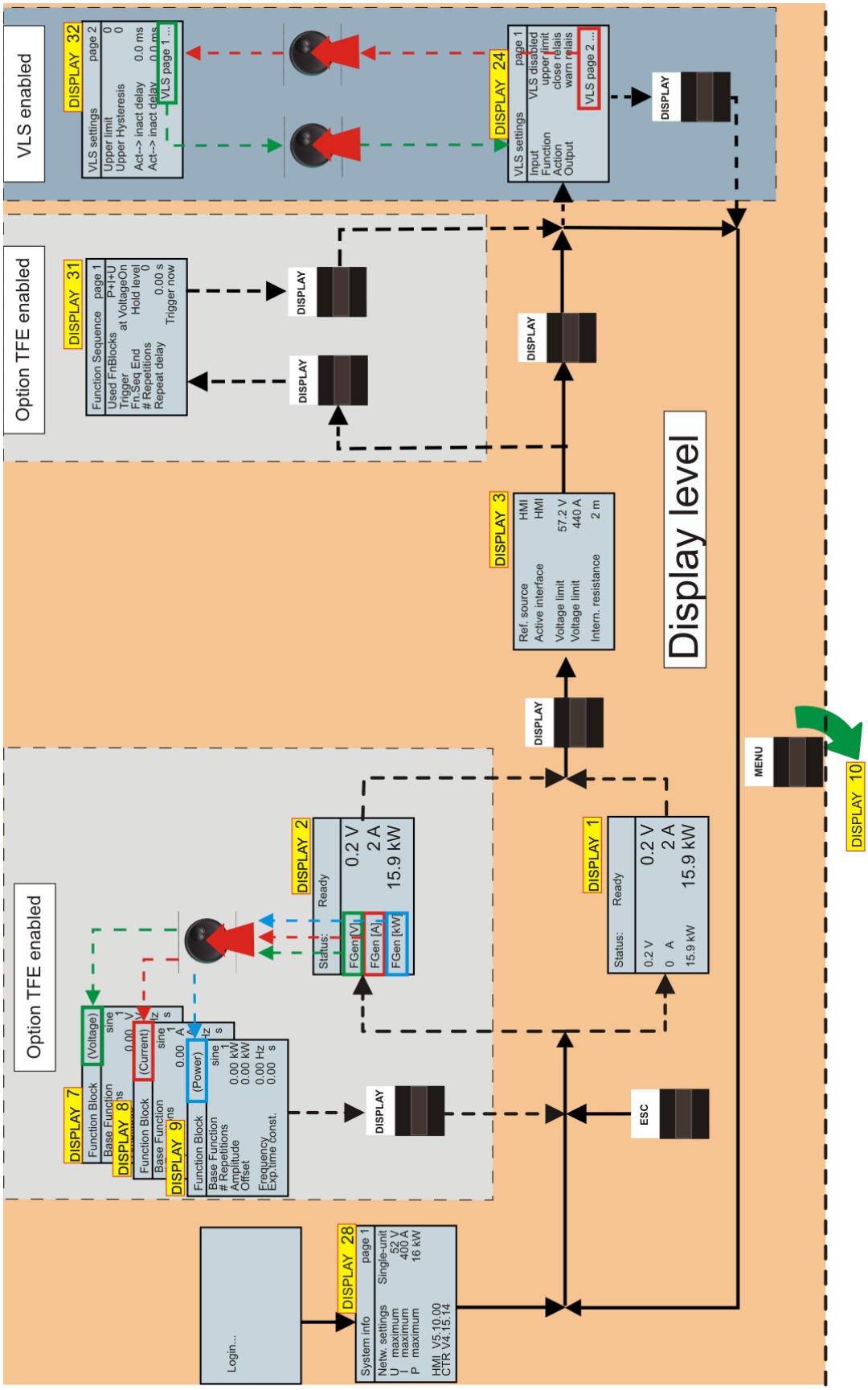

Fig. 94 Overview of HMI operation: DISPLAY level

6.3.4.4. Navigation overview – menu level

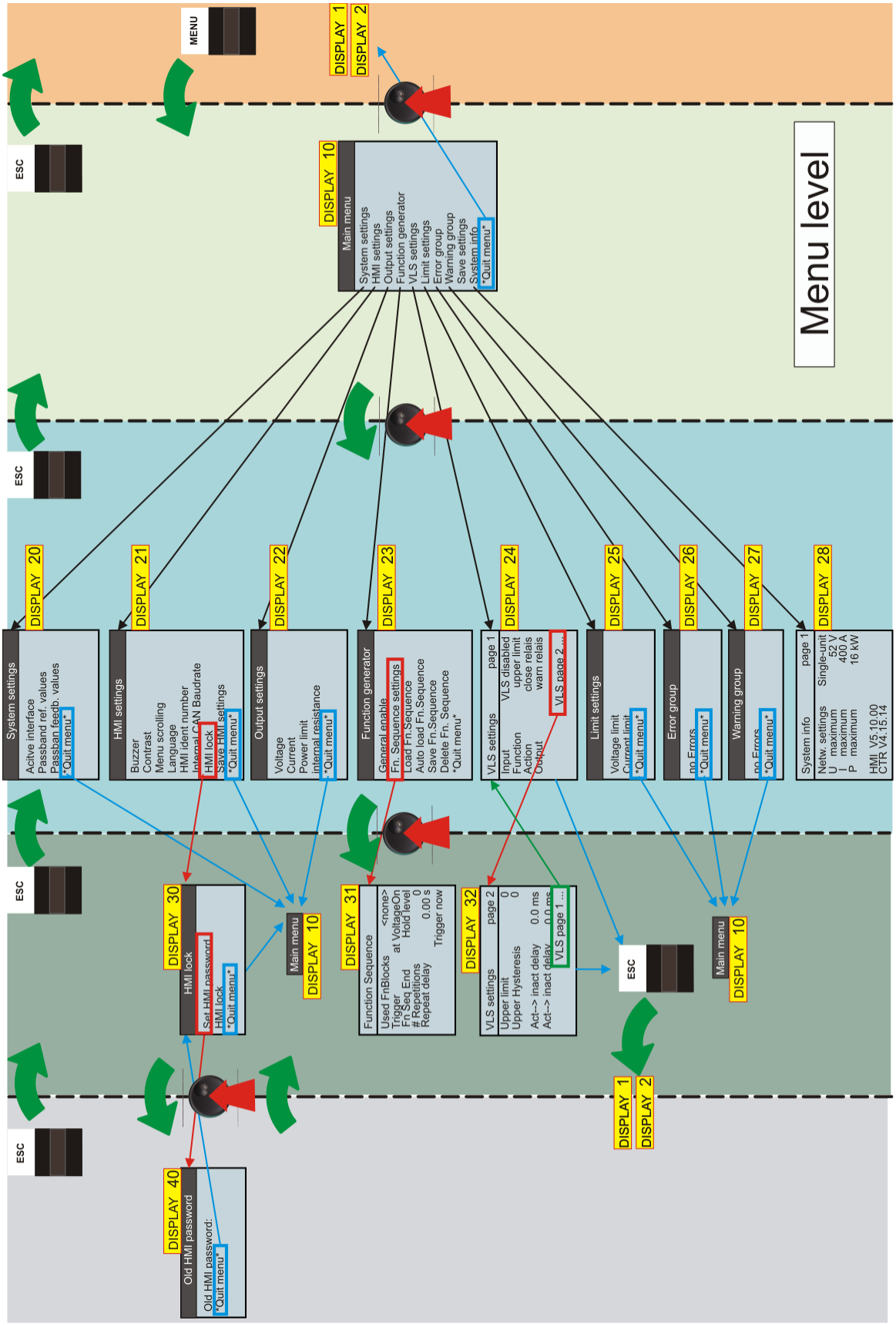

Fig. 95 Overview of HMI operation: MENU level

6.3.4.5. DISPLAY level – windows and their information

During the start process

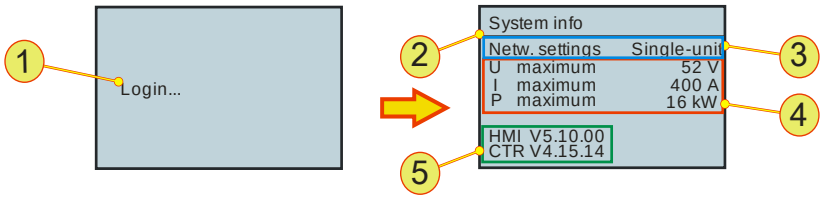

Fig. 96 Login and start information on a single device TP.C.16.52.400.S

Login and system information – DISPLAY 1	
1	**Login,** read-only indication Duration of indication approx. 5 s, while the TopCon power supply is initialised.
2	**System info,** read-only indication Indicates following key system data **-3-, -4-, -5-** Duration of indication approx. 5 s.
3	**Operating mode,** read-only indication Indication of the possible operating modes: Single device Multi-unit system
4	**Device parameters,** read-only indication Parameters for the maximum values that the device reaches in the hardware. Maximum voltage U_{Max}, maximum current I_{Max}, maximum power P_{Max}.
5	**Version information,** read-only indication firmware HMI (Human Machine Interface) CTR (TopCon controller board)

Table 85 Login and device status on starting the system

Main screen

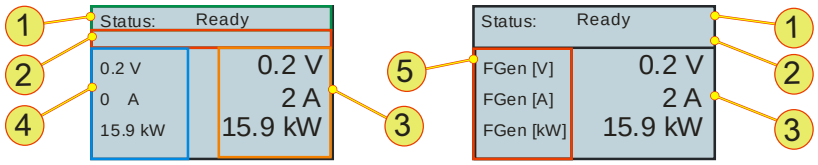

Fig. 97 Main screen without (DISPLAY 1), left, and with enabled and activated TFE option (DISPLAY 2), right

Main screen without/with enabled option TFE – DISPLAY 1, 2	
1	**Status line** The system state is displayed: Ready: Device is ready for operation, the output is electrically isolated and the power semiconductor is inhibited. Running: Device is in operation, the output is providing power. If a load is connected current flows. Warning: Device is still in operation, warning limit is exceeded, an error may be approaching, e.g. over-temperature. Indication: warning in the message bar **-2-.** Error: Device is not ready for operation, the output is electrically isolated and the power semiconductor is inhibited. Indication: error in the message bar -2- STOP: Is generated by the TopControl application on an update to the firmware for the TopCon power supply. The control electronics are inhibited. The output is electrically isolated and the power semiconductor is inhibited. After the update the device must be switched off briefly via the circuit breaker and then switched back on again.
2	**Message bar** Short description in case of error messages and warnings. E.g. “Communication” message if the interlock connector is not fitted.
3	**Actual values** Indication of the actual output values: voltage U, current I and power P.
4	**Set values** Indication of the reference values: voltage U, current I and power P.
5	**TFE display** If the function generator option is enabled and activated, set value **-4-** changes to “FGen”. The change in the indication to “FGen” appears as per the function sequence set. See DISPLAY 23, 31 function generator Fig. 101, page 175.

Table 86 Parameters on the main screen DISPLAY 1, 2

System screen

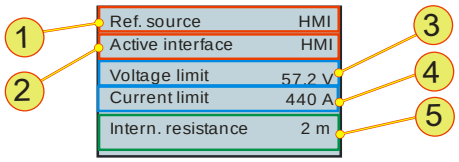

Fig. 98 Parameter entry in DISPLAY 3

System screen – DISPLAY 3	
1	**Ref. source** Indication of the interface that is specifying the set values for the TopCon power supply. (Can e.g. be defined by TopControl.) If a set value source is not defined, the active interface **-2-** is displayed.
2	**Active interface[2],** menu item Selection of the actual interface with which the device is to be operated. The selection has an effect on parameters in the system settings – DISPLAY 20, Table 87, page 171. Possible interface selections: Internal: Is not used RS232[3]: Interface see paragraph 3.1.7.1, page 39. HMI: Human-Machine-Interface Analog: Interface X105, see paragraph 3.1.7.2, page 40.
3	**Voltage limit,** text box [V] Selection of the voltage U_{limit} from which the device indicates an overvoltage error and the output is electrically isolated. Value range: 0 V – 1.1 * U_{Max} ; default: 1.1 * U_{Max}
4	**Current limit,** text box [A] Selection of the current I_{limit} from which the device indicates an overcurrent error and the output is electrically isolated. Value range: 0 V – 1.1 * I_{Max} ; default: 1.1 * I_{Max}
5	**Intern. resistance[1],** text box [mΩ] Default: up to upper value limit 1000 mΩ. As an option the value limit can be extended to 32000 mΩ.

Table 87 HMI screens and menu (selection)
[1] Can be expanded on customer request.
[2] Active interface: defines the active control interface: the message “HMI ist passiv” (HMI is passive) means that the HMI is not the active interface or there is more than one HMI in the system and another HMI has the “master role”.
[3] RS232: the selection of the RS232 menu item activates both the RS232 and also the optional RS422/USB interface. To avoid conflicts it is only allowed to use one interface.

6.3.4.6. MENU level – windows and their information

Main menu

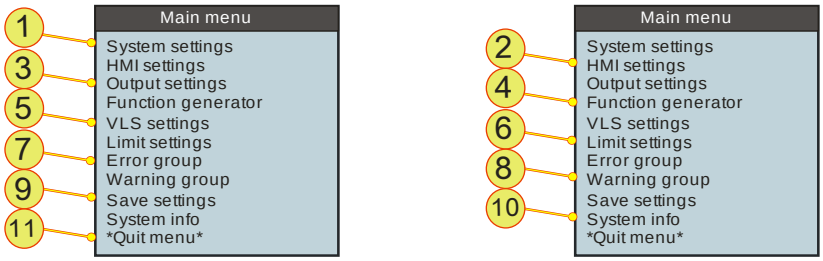

Fig. 99 Main menu DISPLAY10 is used to open windows for entering various options and parameters.

Main menu – DISPLAY 10	
1	**System settings,** navigation item Opens DISPLAY 20, see Fig. 97, page 8.
2	**HMI settings,** navigation item Opens DISPLAY 21, see Fig. 98, page 172.
3	**Output settings,** navigation item Opens DISPLAY 22, see Fig. 100, page 174.
4	**Function generator,** navigation item Opens DISPLAY 23, see Fig. 101, page 175.
5	**VLS settings,** navigation item Opens DISPLAY 24, see Fig. 103, page 179.
6	**Limit settings,** navigation item Opens DISPLAY 25, see Fig. 105, page 181.
7	**Error group,** navigation item Opens DISPLAY 26, see Fig. 106, page 182.
8	**Warning group,** navigation item Opens DISPLAY 27, see Fig. 106, page 182.
9	**Save settings,** menu item All changes made are saved and are available again on the next system start.
10	**System info,** navigation item Opens DISPLAY 28, see Fig. 93, page 167.
11	***Quit menu*,** Return to the DISPLAY level to DISPLAY 1, 2, see Fig. 94 page 168.

Table 88 Navigation items on DISPLAY10 for opening other windows.

System settings

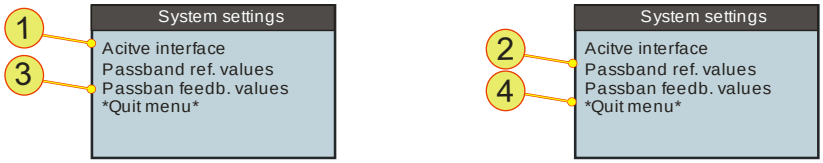

Fig. 100 System settings

System settings – DISPLAY 20	
1	**Active interface**[1,2]**,** menu item Selection of the actual interface with which the device is to be operated. Corresponds to parameters of the same name in DISPLAY 3, Table 85, page 169.
2	**Passband ref. values,** menu item Cut-off frequency for the input filter for the reference values is set. Value range: 0.1 Hz – 1.6 kHz, in 15 steps.
3	**Passband feedb. values,** menu item Cut-off frequency for the output filter for the actual values is set. Value range: 0.1 Hz – 1.6 kHz, in 15 steps.
4	***Quit menu*,** Return one level up in the hierarchy.

Table 89

[1]Active interface: defines the active control interface: the message “HMI ist passiv” (HMI is passive) means that the HMI is not the active interface or there is more than one HMI in the system and another HMI has the “master role”.
[2] RS232: the selection of the RS232 menu item activates both the RS232 and also the optional RS422/USB interface. To avoid conflicts it is only allowed to use one interface.

HMI settings

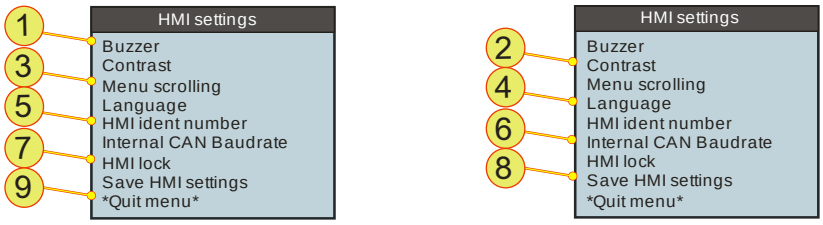

Fig. 101 HMI settings to change the properties of the HMI.

HMI settings – DISPLAY 21	
1	**Buzzer,** menu item Built-in buzzer outputs a tone in case of an error. Selection: On/Off; On ≙ Buzzer tone; Off≙ No Buzzer tone; default: ON
2	**Contrast,** menu item Value range: 0 % - 100 %; 0 % ≙ White; 100 % ≙ Black; default: 35 %
3	**Menu scrolling,** menu item Cursor position reacts as per the direction of rotation of the JogDial. Selection: “Clockwise down”/”Clockwise up” default: “Clockwise up”
4	**Language,** menu item Selection: German/English
5	**HMI ident number,** menu item Value range: 1 – 16; default: 1 (≙ Master)
6	**Internal CAN baud rate,** menu item The transmission rate on the CAN bus is displayed.
7	**HMI lock,** navigation item Open the submenu, see Table 89, page 173.
8	**Save HMI settings,** menu item This menu item causes the HMI settings to be saved immediately. Settings are retained also if the device is switched off in the meantime. The display can be left using the <ESC> button or by confirming again using the JogDial.
9	***Quit menu*,** Return one level up in the hierarchy.

Table 90 HMI settings

HMI lock and setting password

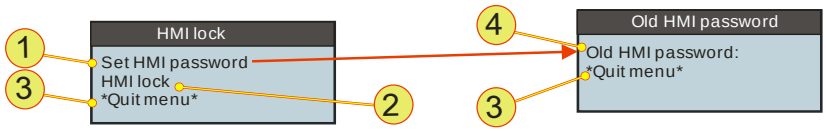

Fig. 102 HMI lock, the HMI can be locked against changes using a password.

HMI lock and setting password – DISPLAY 30, 40	
1	**Set HMI password,** navigation item If you want to define a new password. Open the “Old HMI password” window – DISPLAY 40
2	**HMI lock/HMI unlock,** menu item The HMI can be protected against changes. For the locking and unlocking process, the correct password must be entered at the password prompt. Default password: 0
3	***Quit menu*,** Return one level up in the hierarchy.
4	**Old HMI password/New HMI password** First you must confirm the old password before you can enter a new password. Value range: 0 - 32767; default: 0

Table 91 Locking the HMI using a password.
The password comprises a number that can be selected.

CAUTION **Do not forget your password!**

If you have forgotten your password, it is only possible to set the password with a hardware reset after contacting support.

Avoidance:

⇒ Make a note of your password and keep it in a safe place!

Output settings

Fig. 103 Entry of the output settings – DISPLAY22

Output settings – DISPLAY22	
1	**Voltage,** menu item [V] Specification of the set value for the voltage U_{Set} Value range: 0 V – U_{Max} ; default: 0 V
2	**Current,** menu item [A] Specification of the set value for the current I_{set} Value range: 0 A – I_{Max}; default: 0 A
3	**Power limit,** menu item [kW] Specification of the set value for the power P_{Set} Value range: 0 kW – P_{Max}; default: P_{Max}
4	**Internal resistance,** menu item [mΩ] Specification of the set value for the internal resistance R_{Set} Value range[1]: 0 mΩ - 1000 mΩ; default: 0 mΩ
5	***Quit menu*,** Return one level up in the hierarchy.

Table 92 Entry of the output settings – DISPLAY 22
[1]The value range can be increased as an option. If required, please contact Regatron support.

Function generator

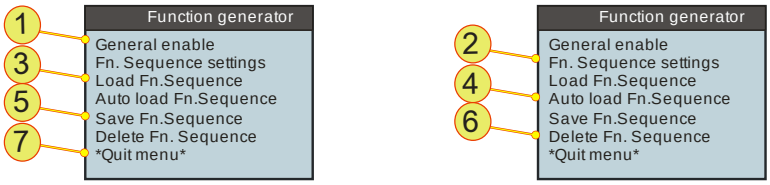

Fig. 104 Function generator – DISPLAY 23

For information on the properties and a description of the features of the function generator see chapter 4.3.1, page 127.

Function generator – DISPLAY23	
1	**General enable,** menu item Function generator is activated or deactivated.
2	**Fn.Sequence settings,** menu item Opens the function sequence window.
3	**Load Fn. Sequence,** menu item The required function sequence number is entered using the JogDial and loaded after acceptance (by pressing JogDial). The process can be cancelled using the ESC button. Value range: 0 - 1000
4	**Auto load Fn.Sequence,** menu item Automatically loads the function sequence given on each powerup. To save these settings permanently, the *Save settings* menu item must be selected on the HMI main menu.
5	**Save Fn.Sequence,** menu item The required function sequence number is entered using the JogDial and saved after acceptance (by pressing JogDial). **Sequence number** does **not exist in the memory**: There is a confirmation on saving **Sequence number** has **already been saved once**: Confirmation prompt as to whether the existing sequence number is to be overwritten. The process can be cancelled using the ESC button Value range: 0 - 1000

The table is continued overleaf.

Function generator – DISPLAY23	
6	**Delete Fn.Sequence,** The required function sequence number is entered using the JogDial and deleted after acceptance (by pressing JogDial). **Sequence number entered exists**: Confirmation of the deletion process Confirmation can be closed using <ESC>. **Sequence number entered does not exist:** Message that the sequence number does not exist Message can be closed using <ESC>. Value range: 0 - 1000
7	***Quit menu*,** Return one level up in the hierarchy.

Table 93 Function generator – DISPLAY 23

Function Sequence

Fig. 105 Settings for the individual function sequences

Function Sequence – DISPLAY 31	
1	**Used FnBlocks,** menu item Function blocks selected here have a direct effect on the indication in the Display mode. (see especially DISPLAY 2). Possible selections: **none:** All function blocks are deactivated. **Voltage**: Voltage function block is active. **Current:** Current function block is active. **Power:** Power function block is active. **U+I:** Voltage and current function blocks are active. **U+P:** Voltage and power function blocks are active. **I+P:** Current and power function blocks are active. **U+I+P:** All function blocks are active.
2	**Trigger,** menu item Event that triggers the function block selected in **-1-**: **VoltageOn**: As soon as device output is switched live **Manual**: Manual triggering via TopControl or HMI/RCU via **-6-.** **Pin on X105:** As soon as there is a high level on pin 19 on interface X105.
3	**FnSeq End,** menu item On continuous repetition **-4-** FnSeq End has no significance. Selection of the output setting that is present on the output after the end of a function sequence: **VoltageOff** The output is electrically isolated. **Hold level** Last set values in the function block are present on the output. **Std. setvalues** The set values on the active interface are present on the output.
4	**# Repetitions,** menu item Number of times a function block is repeated. Value range: 0 – 65000; 0 ≙ Continuous; default: 0

The table is continued overleaf.

Function Sequence – DISPLAY 31 (continued)	
5	**Repeat delay** Waiting time between function block repetitions. Value range: 0 - 650 s; step width: 0.01 s ; default: 0 s
6	**Trigger now,** menu item Manual trigger, starts a function block. (Press the JogDial) Conditions: Trigger **-2-** is set to “Manual”. The device is switched on (voltage on).

Table 94 Function generator – function sequence blocks – DISPLAY 23

VLS settings – page 1

Fig. 106 VLS settings page 1 – DISPLAY 24

VLS settings page 1 – DISPLAY 24	
1	**Input,** menu item Selection of the actual value s to which the VLS function reacts: **VLS disabled:** The VLS function is disabled. DISPLAY 5 and DISPLAY 6 cannot be seen on the DISPLAY. **voltage:** VLS reacts to the actual value for the output voltage. **current:** VLS reacts to the actual value for the output current. **power:** VLS reacts to the actual value for the output power.
2	**Function,** menu item Selection of the thresholds from **-1-** at which the VLS function reacts: **upper limit:** VLS reacts to an upper signal threshold. **lower limit:** VLS reacts to a lower signal threshold. **inside window:** VLS reacts to signals within threshold window. **outside window:** VLS reacts to signals that are outside a threshold window.
3	**Action,** menu item How the switching relay defined in -4- is to be react: **open relais:** The relay is to open when the state set in -2- occurs. **close relais:** The relay is to close when the state set in -2- occurs.
4	**Output,** menu item Which relay is to be operated with VLS. **warn relais, run relais, OK/alarm relais**.
5	**VLS page 2 ... ,** navigation item Continue to page 2 of the VLS settings – DISPLAY32

Table 95 VLS settings page 1 – DISPLAY 24

VLS settings – page 2

Fig. 107 VLS settings page 2 – DISPLAY 32

VLS settings page 2 – DISPLAY 32	
1	**Upper limit or Lower limit,** menu item[1] [V], [A], [kW] Whether the upper limit or lower limit can be entered depends on the function selected on VLS page 1 (DISPLAY 24). See Table 93, page 179. Input range: Voltage[1]: -2*U_{Max} – 2*U_{Max} Current[1]: -2*I_{Max} – 2*I_{Max} Power[1]: -2*P_{Max} – 2*P_{Max}
2	**Upper hysteresis or Lower hysteresis,** menu item[1] [V], [A], [kW] Whether the upper hysteresis or lower hysteresis can be entered depends on the function selected on VLS page 1 (DISPLAY 24). See Table 93, 179. Value range: Voltage[1]: -2*U_{Max} – 2*U_{Max} Current[1]: -2*I_{Max} – 2*I_{Max} Power[1]: -2*P_{Max} – 2*P_{Max}
3	**Act--> inact delay,** menu item [ms] Delay from the active to the inactive state. Value range: 0 ms – 3600 ms; step width: 0.1 ms; default: 0 ms.
4	**Inact--> act delay,** menu item [ms] Delay from the inactive to the active state. Value range: 0 ms – 3600 ms; step width: 0.1 ms; default: 0 ms.
5	**VLS page 1 ...,** navigation item Return to page 1 of the VLS settings – DISPLAY24

Table 96 VLS settings page 2 – DISPLAY 24
[1]Unit is dependent on the source selected on VLS page 1 Table 93.

Limit settings

Fig. 108 Limit settings –– DISPLAY 25

Limit settings – DISPLAY25	
1	**Voltage limit**[1]**,** menu item [V] Value range[2]: 0 V – 1.1* U_{Max}
2	**Current limit**[1]**,** menu item [A] Value range[2]: 0 A – 1.1* I_{Max}
3	***Quit menu*,** Return one level up in the hierarchy.

Table 97 Limit settings – DISPLAY 25

[1] Value at which the device switches to the error state. (over-voltage/current protection)

[2] Maximum value is device-dependent

Warning group and Error group

Fig. 109 Indication of errors – DISPLAY 26 and warnings DISPLAY 27.

Warning group and Error group – DISPLAY 26, 27	
1	Indication of error status**,** ready-only indication and navigation item Message **with no errors**: "no Errors" Not a navigation item, cannot be selected →Quit message using -3-. Message **with error**: <Error group> <Short description> Navigation item, can be selected →Message can be clicked using JogDial. A more detailed error description is displayed.
2	Indication of warning status**,** read-only indication and navigation item Message **with no warnings**: "no Warnings" Not a navigation item, cannot be selected →Quit message using -3-. Message **with warning**: <Error group> <Short description> Navigation item, can be selected →Message can be clicked using JogDial. A more detailed warning description is displayed.
3	***Quit menu*,** Return one level up in the hierarchy.

Table 98 Warning and error indications

[1] For a detailed description and information of troubleshooting please see the warning and error list.

6.3.5. Troubleshooting using the Human Machine Interface (HMI)

6.3.5.1. Acknowledging warning and error messages

If error states occur, the electrical power supply changes to the Error operating state.

The electrical power supply is returned to the Ready state by acknowledging the error messages (**<Escape>** button on the main screen) if the reason for the error has been rectified.

Acknowledging will delete all actual warnings and error messages.

→Prior to acknowledging, all messages in the error and warning lists must be analysed. In particular the error and warning sub-groups provide further, more detailed information on the error or the warning.

6.3.5.2. Error during initialisation

Errors that occur during the initialisation are indicated in a separate window. After the error window is acknowledged, the main screen appears. The electrical power supply is in the Error state and the message Login Error is displayed in the message bar on the main screen. After eliminating the reason for the error, a restart (switch off and on at the circuit breaker) is required:

The following initialisation errors are displayed in an error window.

Error	Reason and correction
“No call for login”	The internal CAN connection cable between device and HMI is not correctly connected. →HMI: contact manufacturer →RCU: check seating of cable connection between RCU and X101 interface, otherwise contact manufacturer

Table 99 Error description, HMI initialisation (login error)

6.3.5.3. Error during operation

The errors that occur during operation are indicated both in the message bar on the main screen and on the Error group menu – DISPLAY. A differentiation is to be made between descriptions for group errors and detail errors. Detail errors are combined into a group error. Only the group error appears in the message bar, the detail errors can be checked on the menu.

For a complete list of all group and detail errors, as well as the warnings, see the manual error list.

The communication errors listed in the following table are initially displayed in a separate window. After the selection knob or **<Escape>** is pressed, the separate window disappears and the message *Communication Error* appears in the message bar on the main menu. The electrical power supply changes to the *Error* operating state.

Error	Reason and correction
CAN controller error	The CAN controller is in the Bus-Off state.
No data received by HMI	The HMI or RCU is not receiving any data. →Check the connection of the connection cable between power supply and RCU →CANTERM terminating resistor fitted to the end of the CAN bus?

Table 100 Error description for HMI errors during operation

In the TopControl application error lists can be further broken down. The error list can also be cleared using the TopControl command “Clear Errors”.

6.3.5.4. Warnings during operation

The warnings that occur during operation are indicated both in the message bar on the main screen and on the *Warning group* menu. A differentiation is to be made between descriptions for group warnings and detail warnings. Detail warnings are combined into a group warning. Only the group warning appears in the message bar, the detail warnings can be checked on the menu.

For a complete list of all group and detail errors, as well as the warnings, see the manual error list.

6.4. Analogue interface

Short description of the analogue interface

The operation of the analogue interface is defined by the pin definition for the analogue interface X105.

Set values can be specified by applying a reference voltage to the inputs for U, I, P, R on the analogue interface.

- **Pin definition** of the analogue interface X105
  For further information see chapter, 3.2.4.7, page 66.
- **Activation** of the analogue interface for remote programming
  For further information see chapter 3.3.3, page 75.
- **Utilisation of the Multi Rack Controller (MRC)**
  Operation of the master devices in several multi-unit systems to form a large multi-unit system.
  For information of the multi-unit system, see chapter 5 page 143.

6.5. LabView: TopCon as a “virtual instrument”

The LabView operating and programming system from National Instruments is a widely used software application for the operation of laboratory equipment. It is often used for control on test stations, as it provides “uniform” operation of different items of measuring and test equipment. The devices are represented in the software as so-called VIs (virtual instruments) and can be combined very easily.

Starting from the TopCon function library (DLL), the necessary functions for addressing the TopCon power supply can be combined using the LabView programming environment. Fig. 107, 186 shows a simple example user interface.

The functions of the TopControl <CONTROL> tab are represented in this VI.

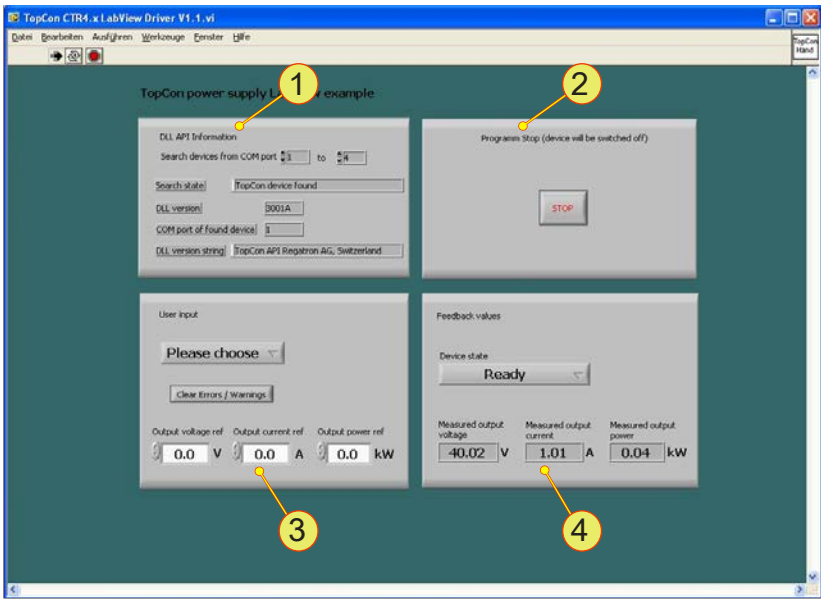

Fig. 110 LabView – view of the virtual instrument VI "TopCon".

LabView – function blocks	
1	DLL API Information, system information for the TopCon power supply such as: →DLL library version used. →RS232 interface COM port actually open to the TopCon power supply.
2	**Programm Stop,** the <STOP> button <STOP> stops the LabView application and electrically isolates the output on the TopCon power supply.
3	**User Input** Set values — Entry of the reference values for current I, voltage U and power P. Switch on/off — Supply power from the output or electrically isolate the output using the <Voltage ON/OFF> list box. Error/warning — Acknowledge errors or warnings using the <Clear Errors/warnings> button
4	**Feedback values,** read-only indication Actual value indication — Actual data on current I, voltage U and power P. Status — State of the TopCon power supply.

Table 101 Description of the function blocks in LabView.

Graphic programming

Unlike text-based programming, in LabView functions are programmed using graphic function blocks.

The DLL functions required are represented in LabView by calls, with parameters that can be set, in the related programming language. There, among other aspects, the related call parameters are defined, input and output values defined and the connection to the DLL established.

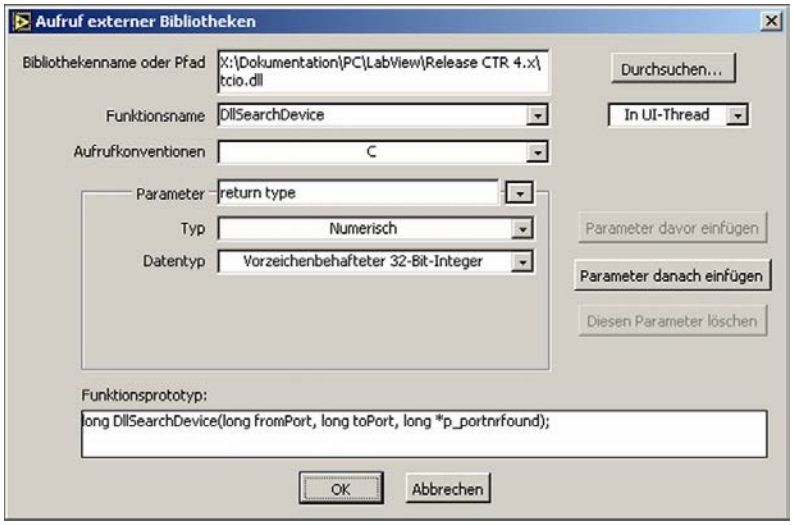

Fig. 111 LabView DLL call that is behind a graphic function block.

6.6. The function library (DLL)

To control a TopCon power supply via external software, data, e.g. actual values etc., can be retrieved from the TopCon power supply or reference values transferred to the TopCon power supply using the DLL function library (DLL ≙ dynamic link library).

Operating systems supported

The DLL is available for the following operating systems:

- Microsoft Windows NT/XP/Vista
- Linux (Suse distribution)
  Using a static function library.

Conditions for using the DLL

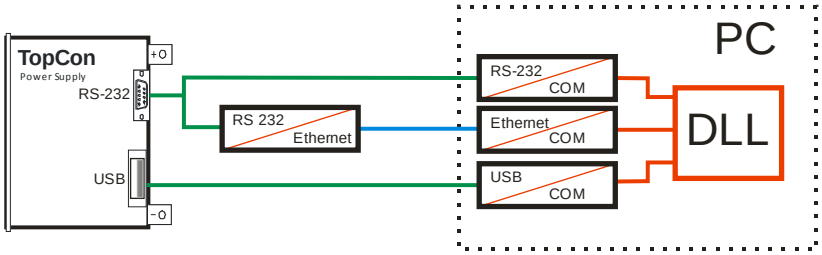

Fig. 112 The function library is always addressed via the COM port (virtual or hardware).

The following options are available:

- RS-232 connection direct to the PC
- RS-232 connection via an Ethernet converter
- USB (option) connection direct to the PC

Programming languages supported/implementation examples

Programming examples are available for the following programming languages:

- C/C++, C#
- Visual Basic
- LabView (see chapter 6.5, page 185)

Additional functionality

This function library is also used by the TopControl application and is subject to continuous further development.

Recently functions on operation and data analysis for the utilisation of the AAP characteristic curve have been integrated in the DLL.

Further information and programming examples for the DLL can be found in the programming manual.

7. Maintenance

Determination of the operating hours

The operating hours represent the time during which the supply voltage is present at the device independent of the operating state.

The number of operating hours is indicated in the TopControl application on the <DEVICE INFO> tab.

7.1. Maintenance of the hardware

In principle the electronics in the TopCon power supply are maintenance-free.

However, the following components require maintenance depending on the number of operating hours:

- Air filter
- Fans
- Electrolytic capacitors.

7.1.1. Air filter (option)

7.1.1.1. Air filter mats

Maintenance interval for air filter mats

The dust filter for the cooling air supplied must be cleaned at regular intervals depending on the degree of soiling.

The maintenance intervals given below are to be understood as general figures and a recommendation, as the actual maintenance interval is heavily dependent on the actual level of soiling in the air.

Degree of soiling of the cooling air	Example environment	Filter replacement (operating time)
Low	Laboratory, test building	**4000 h**
Medium	Workshop without fine metal dust	**2000 h**
Heavy	Construction site or workshop with fine metal dust (e. g. from cutting discs or grinding discs)	**1000 h**

Table 102 General figures for the maintenance intervals for an air filter replacement.

In case of the excessive soiling of the filter mats, TopCon power supplies may be further derated.

7.1.1.2. Ordering replacement air filter mats

Replacement filter mats are included on the delivery of the TopCon power supply with air filters.

Regatron recommends re-ordering the filter mats viledon© P200 from Freudenberg Vliessoffe KG in D-69465 Weinheim with its worldwide offices.

Additional Rucofil P200 filter mats are available from Regatron. If required, please contact Regatron support for re-ordering.

Technical data on the air filter mats

Identifier:	P200 (Viledon filter mat)
Filter class	G2 (in accordance with EN 779)
Fire behaviour: DIN 53438)	self-extinguishing F1 (in accordance with
Temperature-resistant:	100 °C
Weight per unit area	120 g/m^2
Mechanical dimensions:	

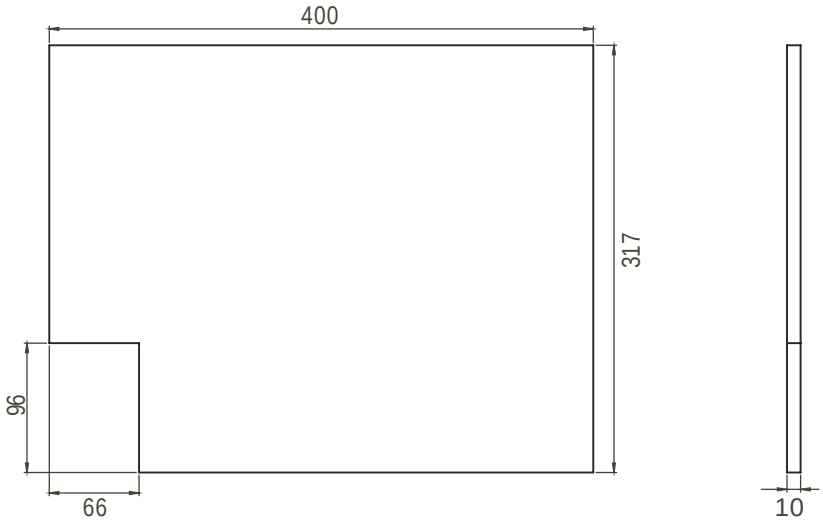

Fig. 113 Filter mat dimensions for 9 U devices.

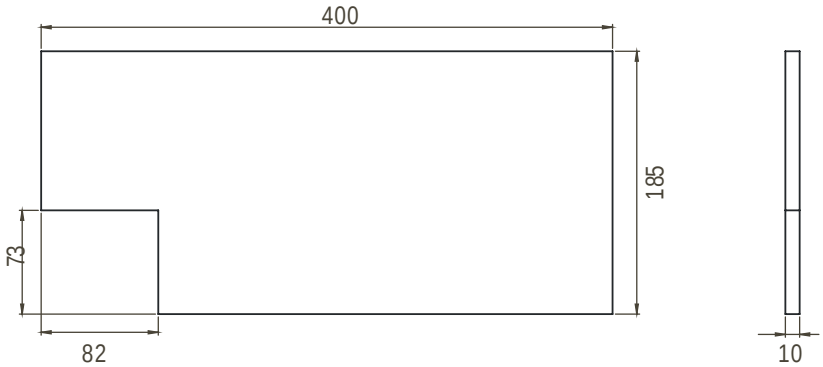

Fig. 114 Filter mat dimensions for 6 U devices.

7.1.1.3. Replacing the air filter mats

Fig. 115 The air filter mounting grille is fixed using 4 fastening screws.

- Remove the 4 fastening screws **-1-** and keep them in a safe place. (M4 x 10, Ecofix TORX)
- Remove the air filter mounting grille **-2-** from the TopCon power supply and dispose of the soiled air filter mat.

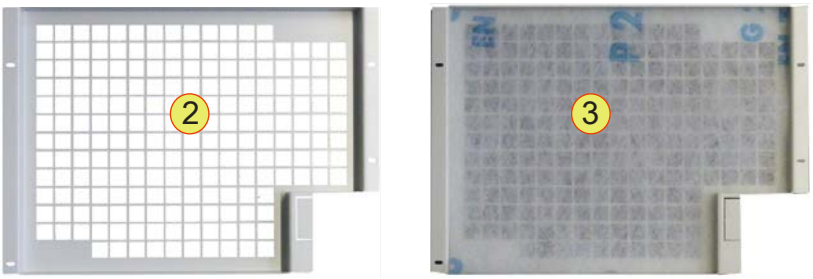

Fig. 116 Empty air filter mounting grille **-2-** and with new air filter mat **-3-.**

- Place the new air filter mat in the air filter mounting grille **-2-** with the **lettering facing upward -3-** (away from the grille).
- Fasten the air filter mounting grille **-2-** to the TopCon power supply using the 4 fastening screws **-1-**.

7.1.2. Fans

The TopCon power supplies contain 1 to 7 temperature-regulated, ball bearing mounted fans to cool the electrical and electronic components.

Life-expectancy – fans	
Life-expectancy per fan with an average ambient temperature of 40 °C	40,000 operating hours

Table 103 Life expectancy of electrical fans.

Depending on the device version, the fans may be visible from the exterior.

Use a torch and check at regular, intervals with the device switched on, whether the fans are rotating.

7.1.3. Electrolytic capacitors

TopCon power supplies have electrolytic capacitors in the DC intermediate circuit.

Life expectancy – capacitors	
Life-expectancy of the electrolytic capacitors with an average ambient temperature of 40 °C	100,000 operating hours

Table 104 Life expectancy of electrolytic capacitors.

7.2. Maintenance of the software and firmware

7.2.1. Version of the TopControl application

The TopControl application is subject to a continuous process of further development.
An update to the latest software version makes it possible for you to use new functions and software improvements.

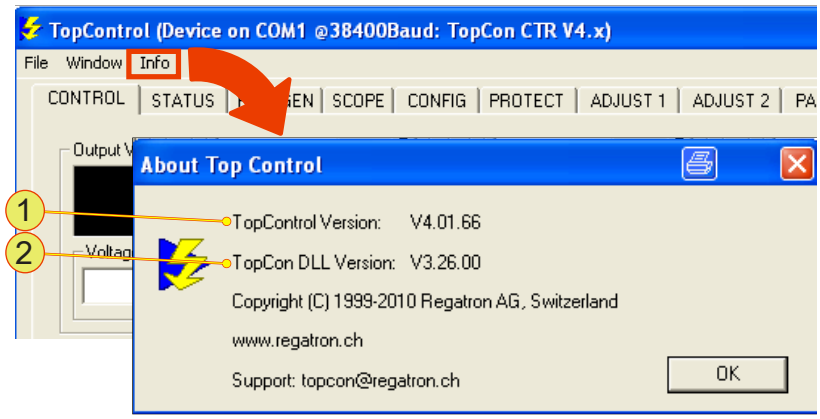

Fig. 117 Indication of the version of the TopControl application.

Using “Info” on the menu bar you can open a window with the actual version of the application **-1-** and the version of the function library (DLL) **-2-**.

Updating the TopControl application

TopControl is supplied with an installation program. Follow the instructions in the installation program, which will correctly install the application on the Windows system.

An older version of TopControl on the computer will be uninstalled first and the new version installed.

If older versions of the TopControl application are not uninstalled automatically, the application must be uninstalled manually. For this purpose use the operating system’s uninstall wizard.

7.2.2. TopCon firmware version

You will find further information in “Determination of the system information” chapter 8.2, page 196.

Updating the firmware versions

CAUTION **Damage can be caused by the following points!**

- If the TopCon power supply is updated unnecessarily, the device may cease to function, as gridfiles and firmware update must match
- A firmware update is not fully completed.

Avoidance:

⇒ Prior to a firmware update, contact support to clarify if an update is necessary.

⇒ Only update the firmware if necessary.
If your application works without problems, an update is not necessary.

7.3. Disposal with due care for the environment

Electrical equipment is too valuable for household waste.

On the disposal of electrical equipment, comply with national laws.

8. Regatron support

You will receive assistance from Regatron support:

- In case of questions on hardware and software, interfaces and maintenance.
- On the procedure in the event of a repair.

Prepare for contacting support!

If you contact Regatron support, you can make the process more efficient with the following information:

- Contact data:
  About your company, your sales partner
- System information:
  Device type, serial number, description of error,
  software versions

8.1. Contact information

If you compile the following information in an e-mail and send this e-mail to support in advance, support will then have this information available already when you ring.

Contact data	
1	**Name of company** The name of your company
2	**Contact person** Your name or the name of the person responsible for the problem in your company with whom further contact will be made.
3	**Contact details** E-mail address, telephone number (extension)
4	**Sales partner or supplier** Name of the sales partners or supplier's company and name of the employee in this company.
5	**Any support number, S 12345678** If you have already received a support number or enquiry number for your problem from support.

Table 105 Important contact information for support.

System information	
1	**Hardware and software information** Software version and firmware version, device serial number or device input and output data for single devices or multi-unit systems.
2	**Description of error** Information that documents the situation and the state of the system using measured results, logs, scope, screenshots and photographs

Table 106 Important system information for support.

8.2. How to contact support

Regatron TopCon support
Feldmuehlestrasse 50
CH – 9400 Rorschach
SWITZERLAND

E-mail: tc.support@regatron.ch

Phone: +41 (0)71 846 67 44
Fax: +41 (0)71 846 67 77

Web: www.regatron.com

8.3. Determination of the system information

8.3.1. Software versions

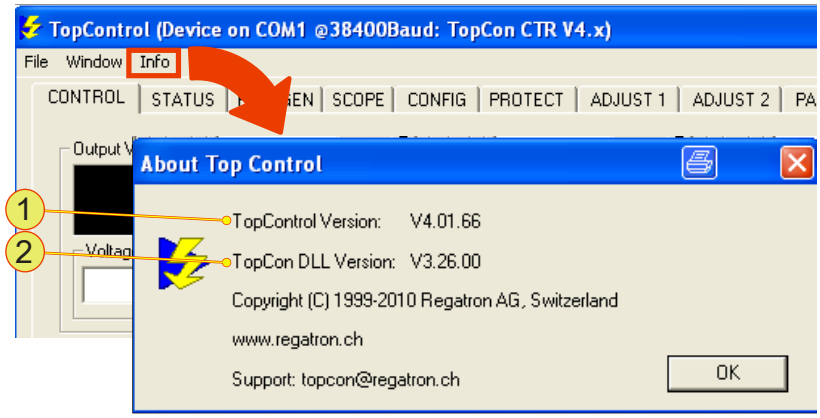

Fig. 118 Indication of the version of the TopControl application.

In the TopControl application, the actual version of the application **-1-** and version of the function library (DLL) **-2-** are indicated in the “About Top Control” window using “Info” on the menu bar.

Provide this information to support as contact information.

.

8.3.2. Firmware versions and device information

Device hardware

Information on the device is to be found on the type plate on the rear side of the TopCon power supply.

Fig. 119 Example - information on the device type, serial number as well as input and output data on the TopCon power supply.

Device hardware and firmware

The <DEVICE INFO> tab contains a large amount of information on individual devices and the multi-unit system, as well as the various firmware versions in the individual device modules.

The best method is to take a screenshot of the <DEVICE INFO> tab and send it to support as part of the contact information.

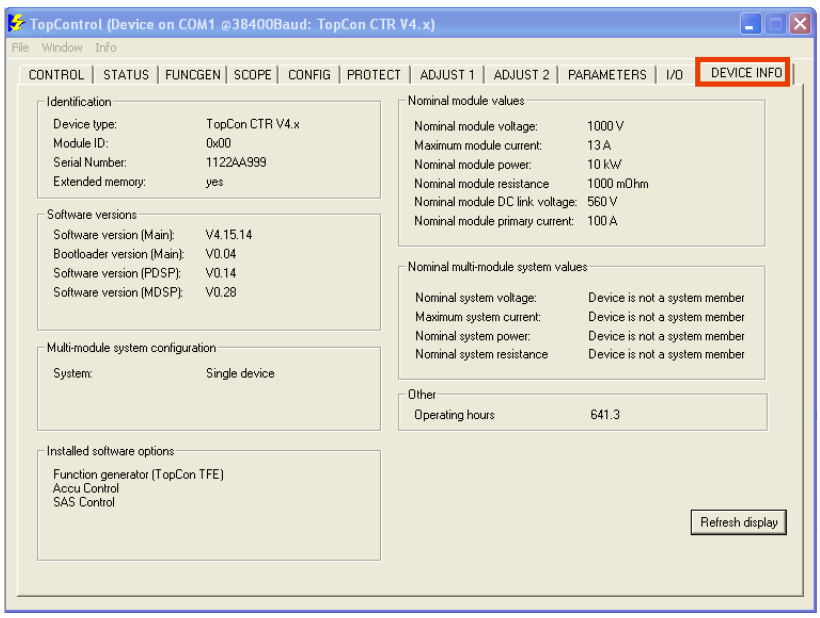

Fig. 120 Example – screenshot of the <DEVICE INFO> tab with all information on device hardware and firmware.

Alternatively, it is possible to read the software versions for the HMI and controller board as well as the operating mode via the display for the HMI.
For further information see 165chapter 6.3.4.5, page 167.

8.4. Enabling software options

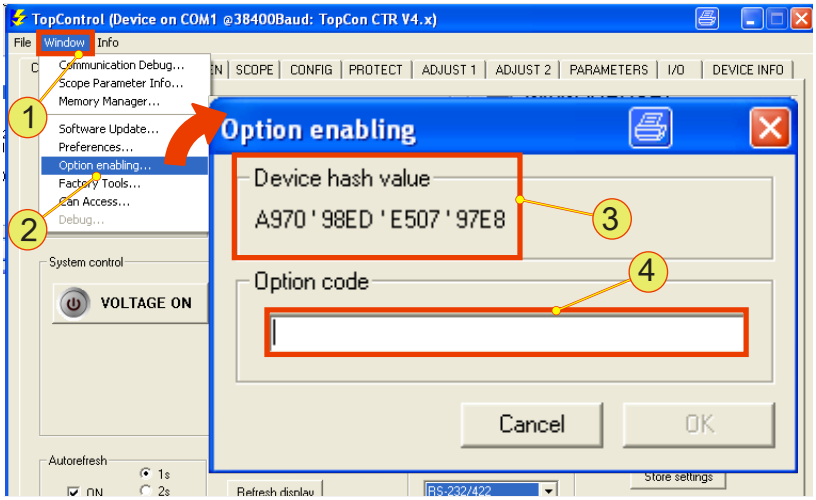

Fig. 121 “Option enabling” window for enabling software options.

Procedure:

- On the menu bar open the “Window” **-1-** menu.
- Click the “Option enabling...” **-2-** submenu item.

↳ The “Option enabling” window opens.

- Send the “Device hash value” **-3-** for the TopCon power supply connected to Regatron support.
- You will receive from support an “Option code” that you must enter in the text box **-4-** as soon as possible.
- Accept your entry using the <OK> button.

↳ The software option has been successfully enabled.

8.5. Producing a standard scope

Using the SCOPE function the following signals can be recorded that are useful for diagnostics by support:

- Input and output signals for the actual values and set values Voltage, current, power etc. (digital and analogue)
- Device-internal parameters, such as temperature, controller signals, system state/error signals, intermediate circuit voltage, transformer current, internal 24V supply, etc.

The procedure is described based on default settings and default signal variables.

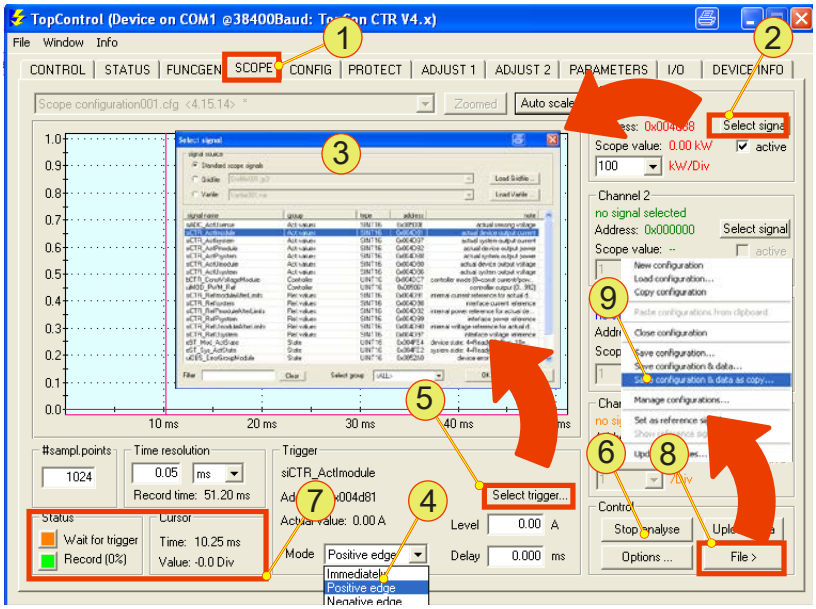

Fig. 122 Overview of the <SCOPE> tab with the controls.

- Open the <SCOPE> **-1-** tab.
- Using the related <Select signal> **-2-** button, select the following default signals variables from the “Select signal” **-3-** window for each channel.

Channel	Variable	Description
1	siCTR_ActUmodule	Output voltage of the single device
2	siCTR_ActImodule	Output current of the single device
3	uiMOD_PWM_Ref	Pulse-width modulation
4	bCTR_ConstVoltageModule	Controller mode

Table 107 Default signal variables for a scope recording.

- In the list box **-4-** select “positive edge”.

↳ <Select trigger…> **-5-** button is activated for the entry.

- Using the <Select trigger…> **-5-** button in the “Select signal” **-3-** window, select the trigger signal.
  (Here in the example: siCTR_ActUmodule)
- Enter the related trigger level.
- Start the scope recording using the <Start analyse> **-6-** button.

↳ The button **-6-** changes function and label to <Stop analyse>.

↳ The indication changes in the “Status” **-7-** group**.**
“Wait for trigger” read-only indication changes to orange.
“Record” read-only indication changes to green.

↳ Storage and indication on the scope are automatic.
(Condition: correctly set trigger parameters)

- Save the scope and data using a folder and name of your choice using the <File> **-8-** button and the “Save configuration & data as copy” **-9-** submenu item.
- Send the scope file as part of the contact information to your sales partner or Regatron support using your e-mail client.

8.6. Device return

Use the original packaging to return the device.

If you no longer have the device packaging at hand, you can order new packaging via Regatron support.

8.6.1. Packaging sequence – standard packaging

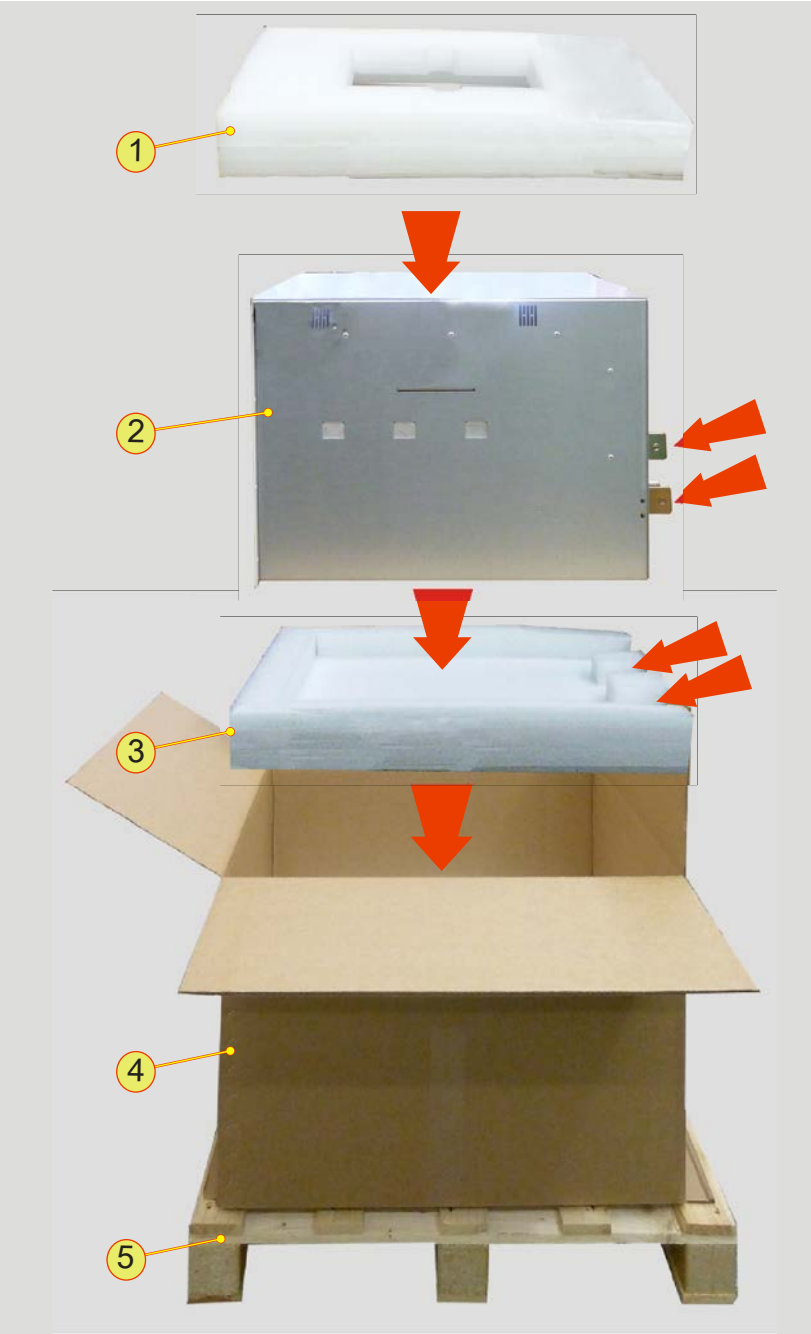

Fig. 123 Arrangement of standard shipping packaging for a TopCon power supply with 9 U.

Elements of the original shipping packaging	
1	**Cover** Upper cover with cut-out for the box of accessories. Varies for 9U and 6 U devices.
2	**TopCon power supply with 9U** 6 U devices are a little lower.
3	**Bottom** Lower protective support with space on the rear side for the current bars on the TopCon power supply. Varies for 9 U and 6 U devices.
4	**Cardboard box** Varies for 9 U and 6 U devices.
5	**Transport pallet,** disposable pallet 120 x 80 mm The cardboard box is firmly strapped to the disposable pallet.

Table 108 Packaging material for standard packaging.

8.6.2. Optional packaging protection

For certain transport routes it can be necessary to protect TopCon power supplies against damage with additional transport protection.

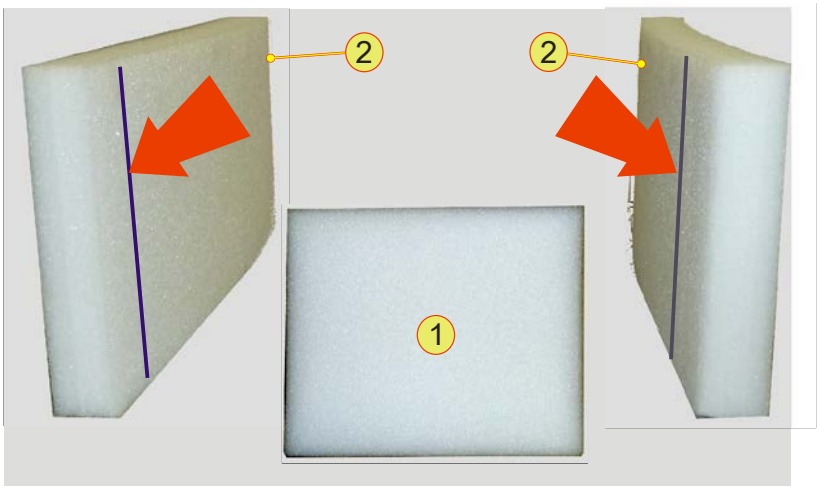

Fig. 124 Additional packaging material.

Optional additional protection	
1	**Device front protection** Provides additional protection for the front side of the device
2	**Side protection** The side protection has slits for the protruding front panel on the TopCon power supply.

Table 109 Additional packaging material.