AUTOMATIC VOLTAGE REGULATORS

UNITROL® 1005

User manual

List of Related Documents

Applicable Standards (3BHS335648 E73)

UNITROL 1000 Control SW manual (3BHS399489 E02)

Voltage droop compensation VDC, Reference Manual (3BHS399489 E03)

Modbus Reference Manual (3BHS358281 E80)

Modbus Address Table (3BHS358281 E81)

UNITROL 1000 Comm-Instruction and PID Tuning (3BHS399489 E01)

Power System Stabilizer functionality (3BHS399490 E01)

CMT1000 PSS Tuning assistant (3BHS399490 E02)

Software revisions

Product Release 6.3xx

DSP Control: 6.3xx

MCU Control: 6.3xx

CMT 1000: 6.3xx

Table of contents

1. Introduction

This document is the user manual for the UNITROL 1005 automatic voltage regulator (AVR) that is used for the excitation of indirectly excited synchronous machines.

Read and understand this document before you do any work on the product.
Before you install or operate the product, refer to Safety on page 13.
You are expected to know the fundamentals of electricity, wiring, electrical components and electrical schematic symbols.

1.1 Intended audience

This document is intended for trained professionals who

- Plan the installation of
- Install
- Operate
- Do maintenance on

UNITROL 1005 automatic voltage regulators.

1.2 Related documents

Refer to the inner front cover.

1.3 Copyright and content information

This document has been prepared and checked with great care. If however it still contains errors, please report them to ABB.

1.4 Generic disclaimer

The manufacturer shall have no obligation hereunder with respect to any product which

(i) has been improperly repaired or altered

(ii) has been subjected to misuse, negligence or accident

(iii) has been used in a manner contrary to the Manufacturer's instructions

(iv) has failed as a result of ordinary wear and tear.

All material in this manual is subject to change without a further notice, manual is intended as non-contractual document.

1.5 Cyber security disclaimer

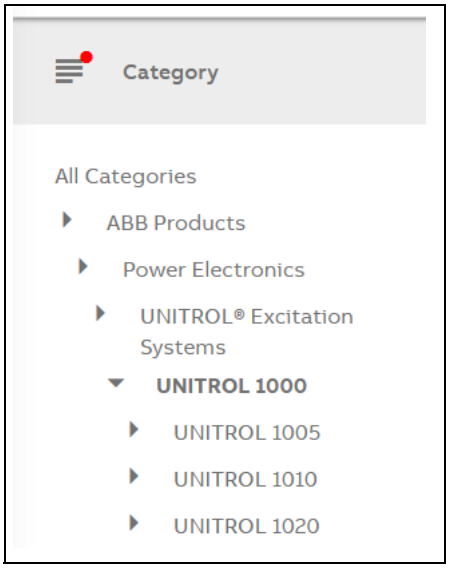
This product is designed to be connected to and to communicate information and data via a network interface. It is customer's sole responsibility to provide and continuously ensure a secure connection between the product and customer network or any other network (as the case may be). It is customer's sole responsibility to establish and maintain any appropriate measures (such as but not limited to the installation of firewalls, application of authentication measures, encryption of data, installation of anti-virus programs, etc.) to protect the product, the network, its system and the interface against any kind of security breaches, unauthorized access, interference, intrusion, leakage and/or theft of data or information. Notwithstanding any other provision to the contrary and regardless whether the contract is terminated or not, ABB, its subcontractors, its and their affiliates and its and their employees are under no circumstances liable for and the Customer shall defend and indemnify said parties from and against any claim for damages and/or losses related to any such security breaches, unauthorized access, interference, intrusion, leakage and/or theft or loss of data or information.

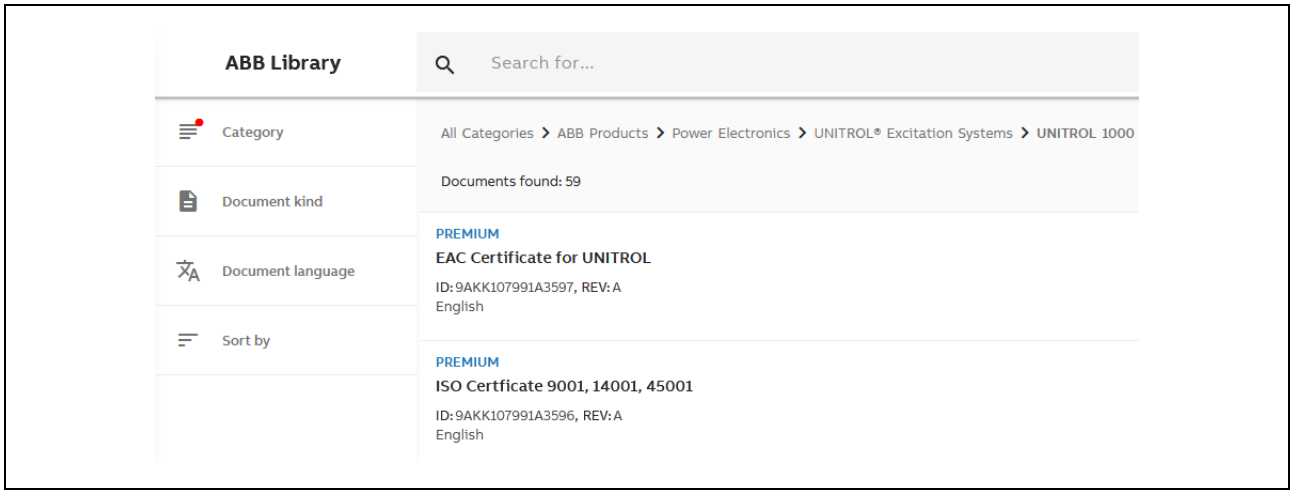
1.6 Documentation, software and tools

You can get access to the latest documentation, software and tools for the AVR on the myABB business portal.

To get access:

1. Go to https://myportal.abb.com in your web browser.
2. Select Log In.
   - If you have an ABB account, you can sign in with your email and password.
   - If you do not have an ABB account, refer to How to register to the myABB business portal on page 9.
3. After you log in, the myABB dashboard opens.
4. On the myABB dashboard, find the myExcitation widget. For information on how to register to the myExcitation widget, refer to How to register to the myExcitation widget on page 9.
5. In the myExcitation widget in the myABB business portal, select GO TO ABB LIBRARY.
6. ABB Library opens in the Category view.
7. In the left-hand menu, select ABB products > Power Electronics > UNITROL Excitation Systems > UNITROL 1000 > UNITROL 1005.
8. You can search for documents by document kind. Click Category to open other filters.
9. Click Document kind. You can select the document kind from a list.





10. You can write a search word in the search box.
11. If necessary, select a document language or sort the results by relevancy or date.
12. Select the documentation, software or tool for your AVR.
13. You can download the documents to your PC.

1.6.1 How to register to the myABB business portal

1. Select Sign up below the LOGIN button.
2. Fill in the registration form.
3. Select Sign up.
4. ABB sends you an email to activate your ABB account.
5. In the email, select ACTIVATE ACCOUNT.
6. You now have access to the myABB business portal.

1.6.2 How to register to the myExcitation widget

1. In the myExcitation widget in the myABB business portal, select GET ACCESS.
2. Fill in the registration form.
3. You now have access to the myExcitation widget.

1.7 Support information

If you have questions, contact your local ABB representative or the manufacturer:

Note! When you call ABB, please give your name, department and phone number. This allows the responsible ABB representative to call back without delay.

ABB Switzerland Ltd
Static Excitation Systems, Voltage Regulators
and Synchronizing Equipment
CH-5300 Turgi / Switzerland

Internet: http://www.abb.com/unitrol

24 h – Hotline for urgent service inquiries: +41 844 845 845

Email contact for questions and UNITROL 1000 support:
unitrol1000.supportline@ch.abb.com

1.8 Terms and abbreviations

Term	Description
AC	Alternating current
AI, AO, AIO	Analog input, analog output, analog input and output
AUTO	Automatic voltage regulation (Auto mode)
AVR	Automatic voltage regulator
Batt	Battery
CAN	Controller-area network
CB	Circuit breaker
CMT 1000	Commissioning and maintenance tool
CT	Current transformer
DC	Direct current
DI, DO, DIO	Digital input, digital output, digital input and output
ESD	Electrostatic discharge
ETH	Ethernet terminal
EXC	Excitation
FCB	Field circuit breaker
FCR	Field current regulation
GEN	Generator
GFR	Ground fault relay (Rotor Ground Fault Protection)
HW	Hardware
IGBT	Insulated gate bipolar transistor
I/O	Input/output
MAIN	Main channel in double channel systems.
MANUAL	Excitation current regulation (Manual mode)
MCU	Micro-controller unit
PC	Personal computer
PCB	Printed circuit board
PE	Protective earth (protective ground)
PF	Power factor
PPE	Personal protective equipment
PS	Power supply

Term	Description
PSS	Power system stabilizer
PT	Potential transformer
PWM	Pulse-width modulation
Q	Reactive power
RDM	Rotating diode monitoring
SM	Synchronous machine
SW	Software
UMAUX	UM auxiliary input measurement
VAR	Reactive power
V/Hz	Volt per Hertz (-Limiter)
VDC	Voltage droop compensation
VM	Voltage matching

2. Safety

Obey the safety instructions in this document when you install, operate and do maintenance on the excitation system. Failure to obey the safety instructions increases the risk of electric shock and damage to the equipment.

DANGER

- **Obey the safety instructions to prevent injury or death, or damage to the equipment.**
- **Read and make sure that you understand the operating and safety instructions before you operate the unit.**
- **If you are not a qualified electrician, do not do electrical installation or maintenance work.**
- **Use personal protective equipment, such as, safety shoes and gloves.**
- **Before you do any work on the system, refer to** Electrical safety precautions **on page** 15**.**

2.1 Warnings in the documentation

This document uses the warnings and notes that follow:

DANGER

DANGER identifies a hazard with a high level of risk that can cause serious injury or death.

WARNING

WARNING identifies a hazard with a medium level of risk that can cause serious injury or death, or damage to the machine.

CAUTION

CAUTION identifies a hazard with a low level of risk that can cause minor or moderate injury, or damage to the equipment.

Note! Notes give important or useful information.

2.1.1 Warning symbols

The symbols in warnings identify the type of warning. Example warning symbols:

	**General warning** – Conditions, other than those caused by electricity that can cause injury or death, or damage to the equipment.
	**Electricity warning** – Electrical hazards that can cause injury or death, or damage to the equipment.
	**Electrostatic sensitive equipment warning** – Risk of electrostatic discharge that can cause damage to the equipment.
	**Hot surface warning** – Risk of injury due to high temperatures.

The equipment can have warning symbols that are not shown here. Obey the warning text of these warnings.

2.2 Requirements for personnel

Personnel involved in installation work and commissioning of the AVR must be trained and know about the residual danger areas according to the local regulations. Refer to Residual danger areas on page 16.

Only authorized maintenance personnel can do maintenance and repair work on the equipment.

The maintenance personnel must know about the emergency shutdown measures and must be able to stop the system if there is an emergency.

The maintenance personnel must be familiar with the accident prevention measures at their workplace and must be trained in first aid and firefighting.

It is the responsibility of the owner to ensure that each person that does the installation and commissioning of the equipment is trained to do so, has a correct education in accordance with the local law, and has read and understood the safety instructions.

2.3 Safety instructions

Obey these safety instructions when you do any work on the equipment:

- Use the device only as specified in the technical data (refer to Technical data on page 97) and when it is fully operational.
- Only trained personnel can install, operate, do maintenance on or repair the excitation system.
- Do not modify the equipment in any way.

2.3.1 Electrical safety precautions

Obey these safety precautions before you do any work on the system:

1. Clearly identify the work location and equipment.
2. Disconnect all possible voltage sources. Make sure that reconnection is not possible. Lock out and tag out.
   - Open the main disconnecting device of the AVR.
   - Disconnect any external power sources from the control circuits before you do any work on the control cables.
   - If you have a permanent magnet generator connected to the AVR, disconnect it from the AVR with a safety switch or by other means.
   - After you disconnect the AVR, always wait for 5 minutes to let the intermediate circuit capacitors discharge before you continue.
3. Protect any other energized parts in the work location against contact.
4. Take special precautions when you are close to bare conductors.
5. Measure that the installation is de-energized.
   - Use a multimeter with an impedance of at least 1 Mohm.
   - Make sure that the voltage between the AVR input power terminals (PWR L1, PWR L2, PWR L3, PWR L4) and the grounding terminal (PE) is close to 0 V.
   - Make sure that the voltage between the AVR output terminals (IE+, IE-) and the grounding (PE) is close to 0 V.
6. Install temporary grounding as required by the local regulations.
7. Ask for a work permit from the person in control of the electrical installation work.

2.3.2 Residual danger areas

When the AVR operates,

- The voltage in the power section can be up to 300 V AC and the short-circuit current is very high.
- The voltage in the control cabinet is > 50 V.

When the AVR is disconnected from power supplies, the large capacitors in the AVR hold a charge for some time. Wait for at least 5 minutes for the capacitors to discharge before you do any work on the AVR.

Warning labels are attached to all of the cubicle doors to warn personnel against opening the doors during operation.

If the device is built into a larger system, additional warning labels are attached to the inside of the cubicle doors and to the covers of the power converter modules.

Consider the residual danger areas when you do any work on the excitation system:

- Danger from live equipment inside the excitation system, if the protective covers are removed.
- Hazardous voltages from the rotor field winding and the secondary side of the excitation transformer.
- Capacitors can still be charged if a power section door is opened immediately after the system is stopped.
- Danger from the main and auxiliary voltages in cubicles when cubicle doors are open.

WARNING

Be careful when you install or replace the AVR. There is a risk of electric shock. The AVR has large capacitors, which can have a charge for a short time after you disconnect the AVR from power.

WARNING

Before you do any work on the AVR, measure to make sure that the input voltage is less than 30 V AC or DC.

2.4 Instructions for emergency situations

Obey the safety instructions in this section for the specific emergency situations.

2.4.1 Firefighting

DANGER

In case of fire, be aware of dangerous voltages, toxic gases and overheating.

All personnel must know the location of fire extinguishers and emergency exits and must be able to operate the fire extinguishers.

Fire extinguishers are carbon dioxide (CO_2) or foam-based:

- Use **Carbon dioxide (CO_2) fire extinguishers** to fight fires in electrical installations. Do not use them on persons.
- Use **Foam extinguishers** to fight fires in non-electrical equipment. You can use them on persons but not on electrical equipment.

If there is a fire:

1. Stop the system.
   Make sure that the operators know the emergency shutdown sequence.
2. Put on a protective mask.
3. Use a carbon dioxide (CO_2) fire extinguisher to extinguish the fire. Do not use foam or water.

2.4.2 First aid measures for electrical installations

DANGER

Do not touch the injured person until the system is grounded. There is a danger of electric shock.
Residual voltage of the rotating machine is present immediately after the system stops.

If there is an emergency:

1. Stop the plant.
   Make sure that the operators know the emergency shutdown sequence of the system.
2. Switch off all power supplies and ground the system.
3. Carefully remove the injured person from the dangerous location.
4. Call for emergency assistance.
5. Provide first aid for electric shock.

2.4.3 Pacemaker

DANGER
Do not stay close to the excitation system. The electrical and magnetic fields of the excitation system can cause malfunctions of pacemakers.

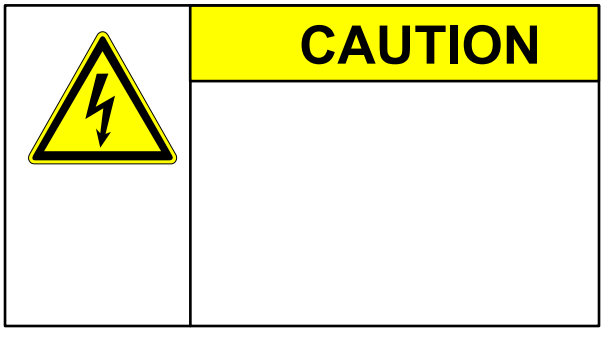
Electrical and magnetic fields can cause interference to pacemakers. It is difficult to predict the sensitivity of pacemakers to interference.

2.5 Danger signs

Danger signs are attached to equipment or locations that have a risk of danger.

The degree and likelihood of such dangers are described by the signal words DANGER, WARNING and CAUTION. The content of the warning sign tells you about the respective situation and the preventive safety measures.

Example signs with the meaning of the signal words:

Sign	Description
	**DANGER, electrical** This symbol identifies imminent danger that will cause life-threatening physical injury or death.
	**WARNING, electrical** This symbol identifies a dangerous situation that can cause serious physical injury or death.
	**CAUTION, electrical** This symbol identifies a possible dangerous situation that can cause moderate physical injury. This signal word is also used for warnings related to equipment damage.

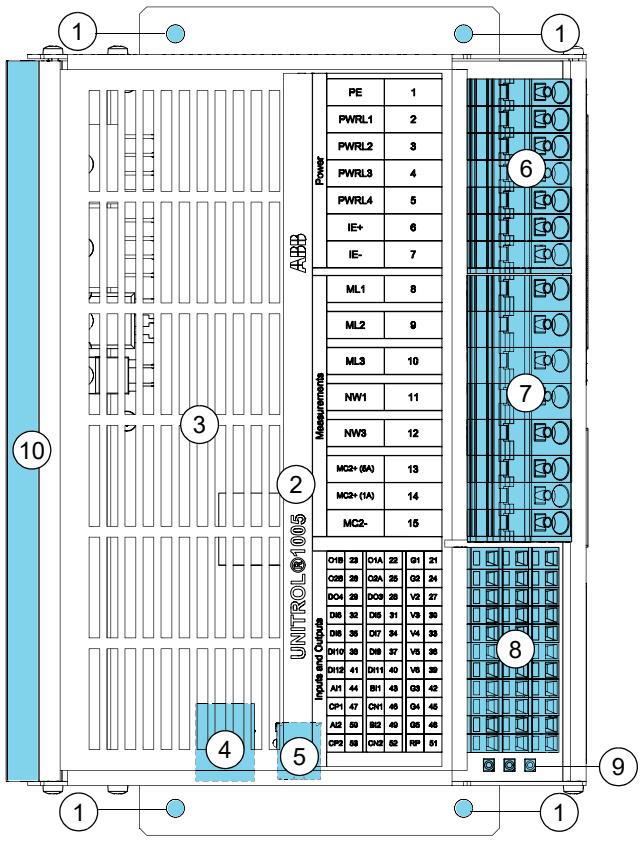
3. Device overview

The automatic voltage regulator (AVR) is used for the excitation of indirectly excited synchronous machines. The AVR can operate as a voltage regulator, a reactive power regulator, power factor regulator or field current regulator, and is designed for excitation currents of up to 5 A nominal.

The AVR has several control modes that depend on the generator state. By default, the AVR is controlled by digital inputs. You can use the commissioning and maintenance tool CMT 1000 on your PC to locally operate the AVR. To operate the AVR remotely, you can use remote access with the Modbus protocol.

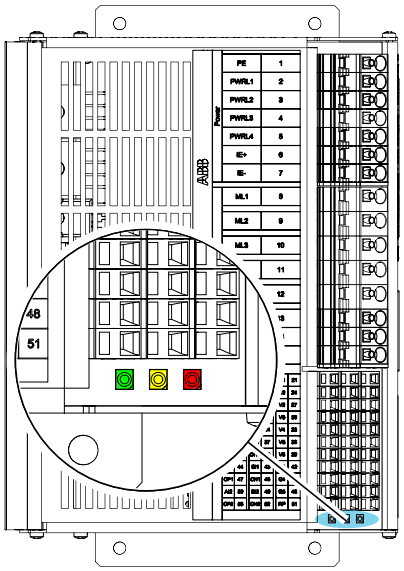
3.1 Hardware overview

This section gives an introduction to the hardware. For more information on the hardware, refer to Mechanical installation on page 22, Electrical installation on page 25 and Technical data on page 97.



No.	Description
1	Mounting holes
2	Unit type designation
3	Front cover
4	Ethernet port
5	USB port
6	Power terminals • Protective earth (PE) • Input power U_{PWR} • Excitation output I_e + U_e
7	Measurement terminals • Network voltage U_{NET} • Machine voltage U_M • Machine current I_M
8	Digital and analog I/Os
9	Status LEDs
10	Heat sink

3.1.1 Status LEDs



Color	Description
Green	**Operating status** ON: Device controller is active Flashes: Device software is active
Yellow	**Excitation status** ON: Excitation is active Flashes: A limiter is active
Red	**Alarm status** ON: An alarm or a trip is active Flashes: • Startup failure • Parameter download failure • Excitation output is blocked

3.2 Control interfaces

To control the AVR, you can use:

- Digital and analog inputs and outputs
- CMT 1000 commissioning and maintenance tool with USB or Ethernet connection
- Remote access with Ethernet or RS-485 connection

For information on access levels and priorities of the operators, refer to Operators and access levels on page 90.

For more information on remote access and Modbus protocols, refer to the *Modbus Reference Manual* (3BHS358281 E80).

3.2.1 Digital and analog inputs and outputs

You can control the AVR with digital and analog inputs and outputs. Digital and analog I/Os have the highest priority by default. You can change the polarity of digital inputs during commissioning only.

3.2.2 CMT 1000

You can operate and control the AVR locally on your PC with CMT 1000 software during commissioning or maintenance work. Use the USB or Ethernet connection. Disconnect the CMT 1000 after you have completed commissioning or maintenance work.

3.2.3 Remote access with Modbus

You can operate and control the AVR from remote locations with Modbus TCP as an application protocol. Use the Ethernet connection for Modbus communication.

The remote access is fully interoperable with CMT 1000. Both interfaces can have monitor access at the same time. The micro-controller unit (MCU) of the AVR automatically gives or denies control access.

Cyber security note: Modbus does not natively guarantee secure communication. Any node able to communicate with the AVR via Modbus can perform unwanted changes or incorrect configurations on such products that can disrupt the intended operation of the AVR and the systems connected to it. It is recommended to limit the Modbus communication within trusted networks and to strictly control accesses to such networks.

3.3 Software overview

The device software of the AVR has control modes for different functions. A set of software options is available for each AVR. For information on the device software, refer to Device software on page 38 and the *UNITROL 1000 Control SW manual* (3BHS399489 E02).

3.3.1 Control modes

The AVR has several control modes, for example:

- Auto mode
- Manual mode
- PF mode
- VAR mode
- Open Loop mode

3.3.2 Software options

You can select a software package that has a default set of software options. To enable more software options, send a password request to ABB. For more information, refer to Software options on page 44.

3.4 Commissioning and maintenance tool CMT 1000

CMT 1000 is a commissioning and maintenance tool for the AVR. You can use CMT 1000 on your PC to set the parameters of the AVR. You can monitor the system with instruments, for example, Oscilloscope, PQ Monitor and History Logger.

For information on CMT 1000, refer to Commissioning and maintenance tool CMT 1000 on page 54.

4. Mechanical installation

This chapter tells you how to mechanically install the AVR. Only trained and certified personnel can install the AVR. Obey the safety instructions in Safety on page 13.

4.1 Product package

WARNING
 **Do not install or use a product that has a damage.**

Contents of the product package:

- UNITROL 1005 AVR
- Special red USB cable that is used to communicate with and to power the AVR. Keep this USB cable in a safe place.
- Quick installation guide
- Test certificate

Open the product package:

1. Carefully open the product package.
2. Make sure that all of the listed items are in the product package.
3. Visually examine the AVR to make sure that it does not have any external damages.
   If the product package has a damage, speak to your local ABB representative.
   Do not use a product that has a damage.

4.2 Installation area

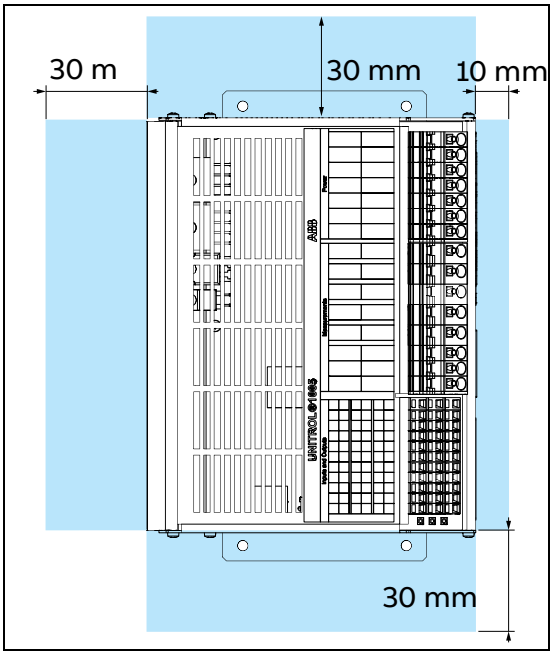
Install the AVR in an indoor area that is dry and dust-free, and that does not contain volatile gases, acid fumes or similar hazards.

Examine the installation area and refer to Technical data on page 97 to make sure that:

- The maximum ambient temperature is in the permitted range.
- The vibration is limited and within the permitted class.
- The ingress protection and pollution degree are suitable.
- The EMC environment is suitable.

4.3 Mechanical installation requirements

- Free space requirements:
  - 10 mm on the terminal side of the AVR
  - 30 mm on the other sides of the AVR
- Make sure that there is sufficient cooling air flow around the AVR.
- Make sure that other devices do not blow hot air on to the AVR.
- The AVR is designed to be installed with suitable hardware to an installation plate.
- Make sure that the frame of the AVR is electrically grounded (PE) to the installation plate with a grounding wire (≥4 mm^2) through a mounting hole. Use toothed washers to get a good electrical ground connection.



4.4 Mechanical installation procedure

WARNING

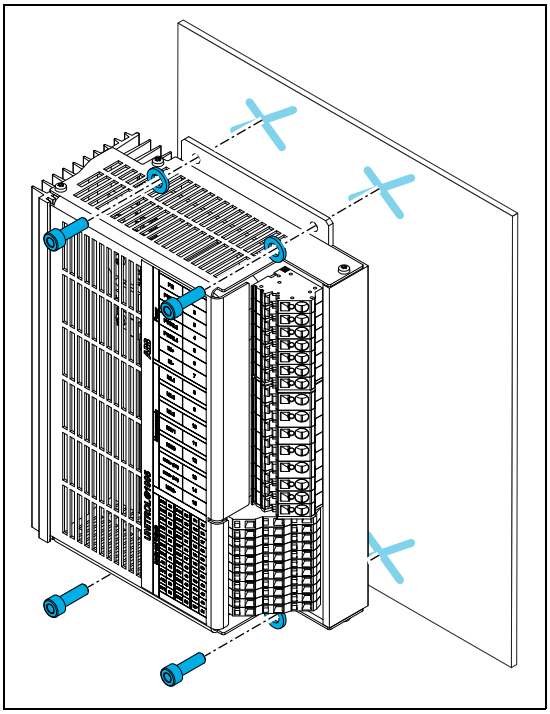
Obey the safety instructions in Safety on page 13 to prevent injury or death, or damage to the equipment.

WARNING

Before you start the installation, make sure that the AVR is disconnected from all power sources.

To install the AVR:

1. Refer to Dimensions on page 97 for the mounting hole dimensions.
2. Make the appropriate holes in the installation plate.
3. Attach the AVR to the installation plate with suitable hardware, for example, M6 screws to a torque of 10 Nm. The mounting holes have a diameter of 6.5 mm.
4. Make sure that there is a good electrical ground connection between the installation plate and the AVR. The installation plate must be electrically grounded (PE).



5. Electrical installation

This chapter gives instructions for the electrical installation of the AVR.

WARNING

Obey the safety instructions in Safety on page 13 to prevent injury or death, or damage to the equipment.

WARNING

Before you start the installation, make sure that the AVR is disconnected from all power sources.

Before you start the electrical installation, read and obey the safety instructions in Safety on page 13. Only trained and certified personnel can install the AVR.

5.1 Electrostatic-sensitive components

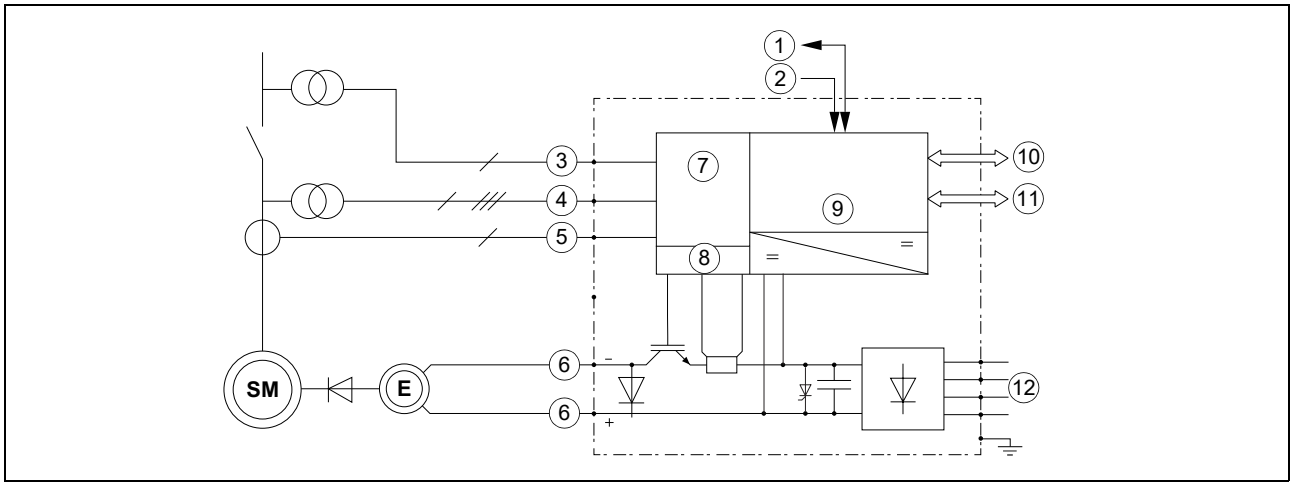
Use electrostatic discharge (ESD) protection when you do any work on printed circuit boards or other sensitive electronic components.

CAUTION

- Use ESD protection such as a wrist grounding strap.
- Hold printed circuit boards only at the edges.
- Put the component on a grounded work surface that has protection against electrostatic discharges.
- Electrostatic discharge can cause damage to printed circuit boards and electronic components.

5.2 Connection diagram

Simplified connection diagram for the AVR.



No.	Description	No.	Description
1	Digital I/Os Maximum cable length 30 m	7	Measurement and control unit (DSP)
2	Analog I/Os Maximum cable length 30 m	8	Power electronic control (PWM)
3	Network voltage measurement U_{NET}	9	Communication micro-controller unit (MCU)
4	Machine voltage measurement U_M	10	USB connection Maximum cable length 3 m
5	Machine current measurement I_{M2}	11	Ethernet connection Maximum cable length 100 m
6	Excitation output I_e + U_e	12	Excitation power supply input PWR L1–L4

5.3 Excitation cabling requirements

The excitation cables refer to the power and measurement cables at terminals 1-15.

The system obeys the emission limits of standard EN 61000-6-4 if the connections for the power electronics supply and the field output use shielded cables that are grounded at each end.

CAUTION
 **Use shielded cables for excitation cables that are longer than 3 m. If the excitation cables are not shielded, there is a risk of electromagnetic interference.**

5.4 Control cabling requirements

The control cables refer to the digital and analog I/O cabling at terminals 21-53.

Requirements for the control cables based on cable lengths:

- <3 m: Grounding is not necessary.
- 3–10 m: Use a twisted-pair cable.
- 10–30 m: Use a shielded cable with one PE connection near the AVR.
- >30 m: Not permitted.

The digital and analog ground is connected directly to the protective earth (PE).

5.5 Cable routing and dimensioning

Make sure that the routing of the excitation cables is not connected with the control cables. Separation of the cable routing is necessary to prevent electromagnetic interference. Refer to Device connections on page 29.

Cable dimension requirements:

Connection type	Cross-section area requirement	
Excitation cables Terminals 1 to 15	0.2–4.0 mm^2	AWG 24 to AWG 10
Control cables Terminals 21 to 53	0.2–1.5 mm^2	AWG 24 to AWG 15

5.6 Grounding (PE) requirements

Connect the AVR to the protective earth at terminal 1 with a 4 mm^2 grounding wire.

Make an additional ground connection through the mounting holes to the installation plate (if it is connected to the protective earth) or with a 4 mm^2 cable to the protective earth.

Make sure that the ground connections are as short as possible.

Additional signal ground terminals are provided for the control cables.

5.7 Inrush current limitation

A high inrush current can occur when you apply supply voltage.

CAUTION
To prevent damage to the AVR, make sure that the inrush current is not > 100 A for 10 ms.

To prevent damage to the AVR from a high inrush current:

Method	Description
Shunt supply	The excitation power is taken from the generator output over a shunt transformer. Use an excitation supply transformer with a maximum power of 3 kVA.
PMG supply	The excitation power is taken form a permanent magnet generator (PMG). The maximum permitted output power of the PMG is 3 kVA.
Auxiliary windings	The excitation power is taken from an additional stator winding of the generator.
DC battery	The excitation power is taken from a battery. Limit the inrush current with a resistor.

5.7.1 External MCB requirements

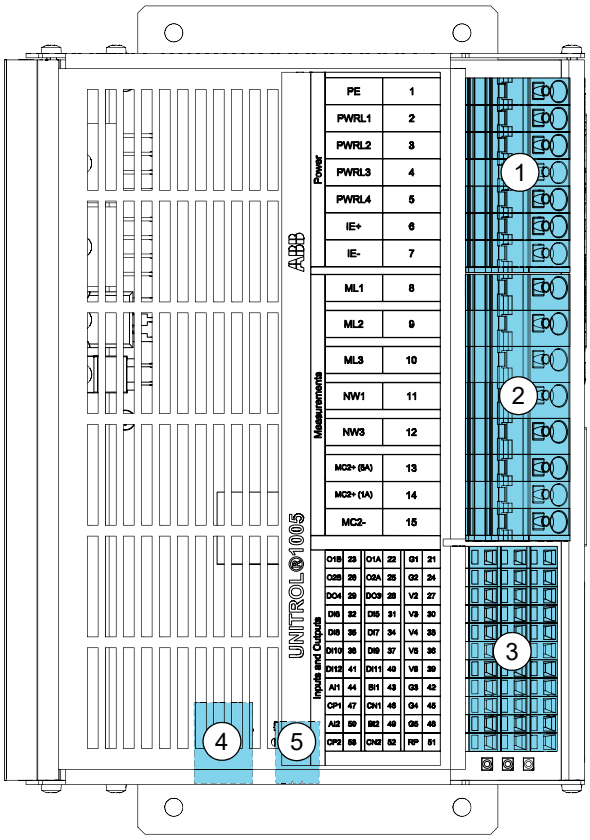
CAUTION
Fuses with > 6 A nominal short-circuit current can damage the AVR.

The AVR has a crowbar firing thyristor. You can set a monitor function that triggers the firing and stops the excitation by tripping the external fuse device.

Use MCB type C fuses with a nominal rating of 6 A.

5.8 Device connections

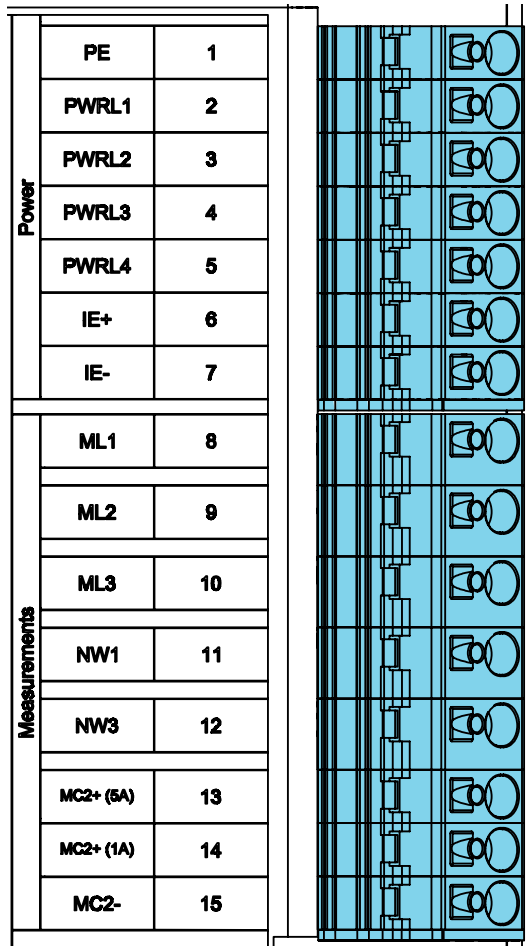
Overview of the AVR terminals and connection ports.



No.	Description
1	Power terminals
2	Measurement terminals
3	Digital and analog I/Os
4	Ethernet port
5	USB port

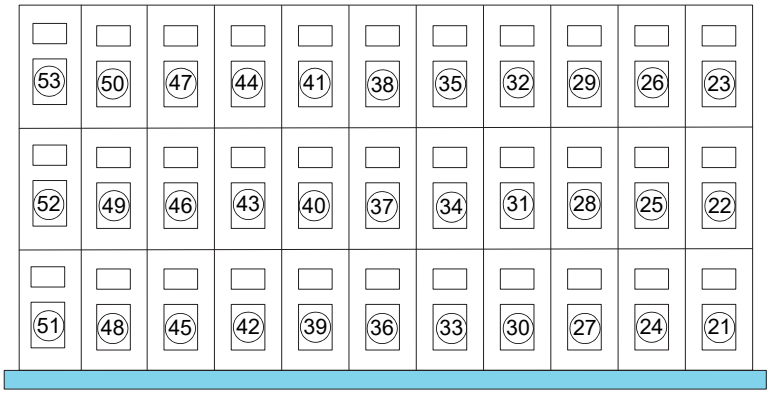
5.8.1 Power and measurement terminals

Terminal descriptions for the power and measurement terminals of the AVR.

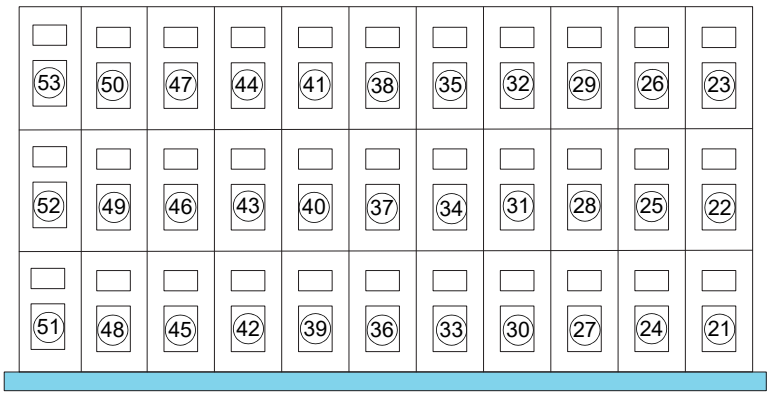
Power and measurement terminals	Type	Ref.	Label	Description
	Power terminals	1	PE	Protective earth
		2	PWR L1	Input power L1
		3	PWR L2	Input power L2
		4	PWR L3	Input power L3
		5	PWR L4	Input power L4
		6	IE +	Excitation current +
		7	IE -	Excitation current -
	Measurement terminals	8	ML1	Machine voltage L1
		9	ML2	Machine voltage L2
		10	ML3	Machine voltage L3
		11	NW1	Network voltage L1
		12	NW3	Network voltage L3
		13	MC2+ (5A)	Machine current 5 A +
		14	MC2+ (1A)	Machine current 1 A +
		15	MC2-	Machine current -

5.8.2 Digital and analog I/O terminals

Terminal descriptions for the digital and analog I/O terminals of the AVR.



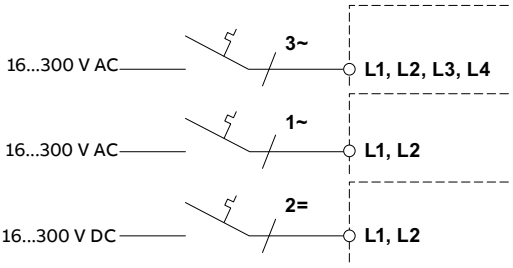
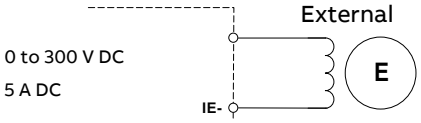
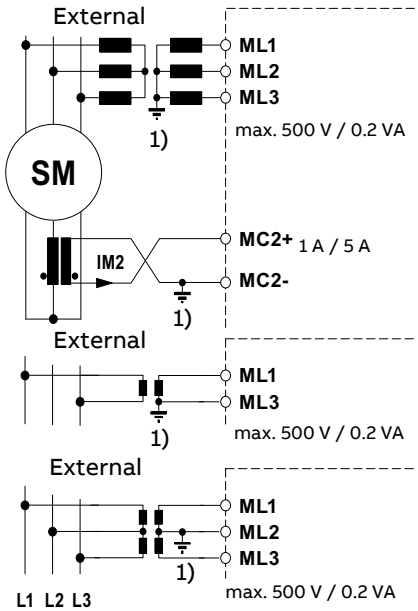
Type	Ref.	Label	Description
Digital I/O terminals	21	G1	GND, connected to PE (PELV)
	22	O1A	Digital output 1, potential-free, positive
	23	O1B	Digital output 1, potential-free, negative
	24	G2	GND, connected to PE (PELV)
	25	O2A	Digital output 2, potential-free, positive
	26	O2B	Digital output 2, potential-free, negative
	27	V2	2 V output, connected to other Vx (PELV)
	28	DO3	Digital output 3 (PELV)
	29	DO4	Digital output 4 (PELV)
	30	V3	24 V output, connected to other Vx (PELV)
	31	DI5	Digital input 5 (PELV)
	32	DI6	Digital input 6 (PELV)
	33	V4	24 V output, connected to other Vx (PELV)
	34	DI7	Digital input 7 (PELV)
	35	DI8	Digital input 8 (PELV)
	36	V5	24 V output, connected to other Vx (PELV)
	37	DI9	Digital input 9 (PELV)
	38	DI10	Digital input 10 (PELV)
	39	V6	24 V output, connected to other Vx (PELV)
	40	DI11	Digital input 11 (PELV)
	41	DI12	Digital input 12 (PELV)

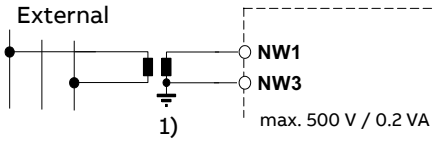
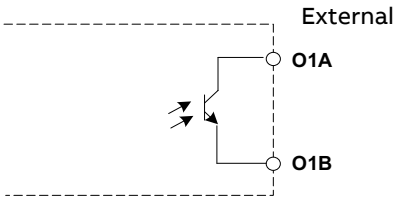
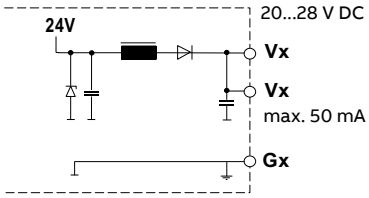
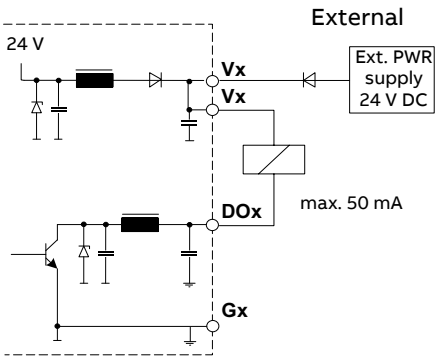
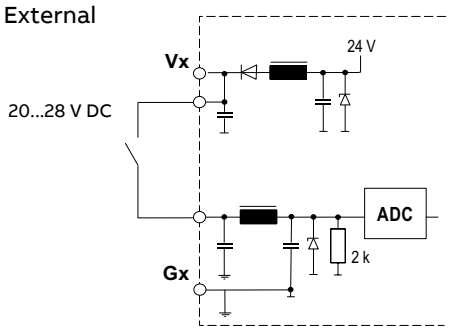


Type	Ref.	Label	Description
Analog I/O terminals	42	G3	Analog ground, connected to PE (PELV)
	43	BI1	Analog input 1, negative (PELV)
	44	AI1	Analog input 1, positive (PELV)
	45	G4	Analog ground, connected to PE (PELV)
	46	CN1	Configuration terminal for 20 mA input (PELV)
	47	CP1	Configuration terminal for 20 mA input (PELV)
	48	G5	Analog ground, connected to PE (PELV)
	49	BI2	Analog input 2, negative (PELV)
	50	AI2	Analog input 2, positive (PELV)
	51	RP	+ 10 V positive reference (PELV)
	52	CN2	Configuration terminal for 20 mA input (PELV)
	53	CP2	Configuration terminal for 20 mA input (PELV)

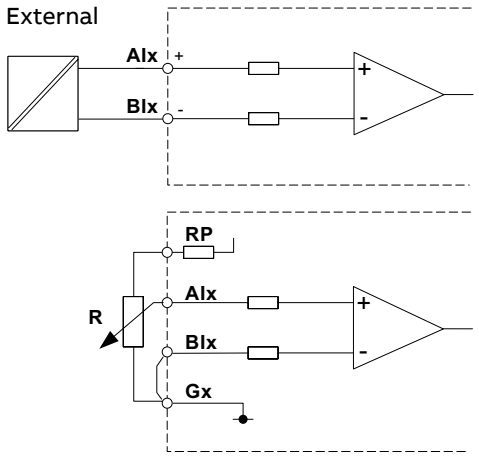
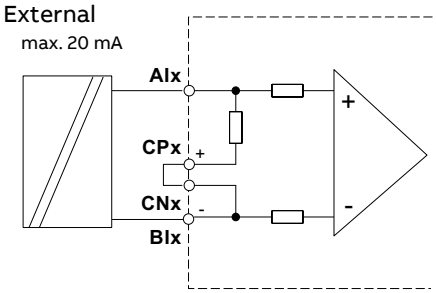
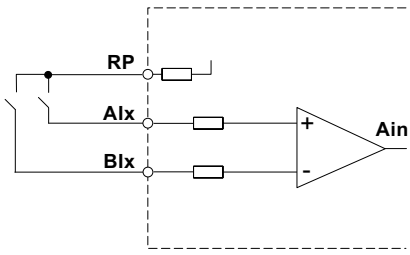
5.9 Terminal and signal data

The table lists the terminal and signal data, and gives a circuit description.

Terminal	Signal	Circuit description
1 = PE	Protective earth	
2 = PWR L1 3 = PWR L2 4 = PWR L3 5 = PWR L4	**Power electronics and control supply U_{PWR}** • Main L1 • Main L2 • Main L3 • Main L4 **Caution! The maximum inrush current must not be > 100 A within 10 ms. Refer to** Inrush current limitation **on page** 28**.** **Note! To get a 6 V AC start level, use L1 and L2.**	Absolute max. values 
6 = IE + 7 = IE -	**Excitation current output I_e** • Exciter current + • Exciter current -	
8 = ML1 9 = ML2 10 = ML3 13, 14 = MC2+ 15 = MC2- 8 = ML1 10 = ML3 8 = ML1 9 = ML2 10 = ML3	**Machine voltage three-phase U_M** • Machine L1 • Machine L2 • Machine L3 **Machine current single-phase I_{M2}** • Machine current + • Machine current - **Machine voltage single-phase U_M** • Main L1 • Main L3 **Machine voltage three-phase with ground U_M** • Machine L1 • Machine L2 • Machine L3 1) You must ground PTs and CTs.	

Terminal	Signal	Circuit description
11 = NW1 12 = NW2	**Line voltage measurement single-phase U_{NET}** • Network L1 • Network L3 1) You must ground PTs and CTs.	
22 = OA1 23 = OB1 25 = OA2 26 = OB2	**Digital output, potential-free** • Digital output, collector • Digital output, emitter • Digital output, collector • Digital output, emitter	
27, 30, 33, 36, 39 = Vn 21, 24, 42, 45, 48 = Gn	**24 V supply for external contacts** • 24 V DC output (maximum 50 mA) • An alternative supply for the internal controller • Digital ground, connected to PE	
28 = DO3 29 = DO4 21 = G1 24 = G2	**Digital output** • Digital output 3 • Digital output 4 • Digital ground, connected to PE • Digital ground, connected to PE **Note! The open collector transistor can switch up to 500 mA peak and 200 mA continuously.**	
31 = DI5 32 = DI6 34 = DI7 35 = DI8 37 = DI9 38 = DI10 40 = DI11 41 = DI12 30 = V3 33 = V4 36 = V5 39 = V6	**Digital input** • Digital input 5 • Digital input 6 • Digital input 7 • Digital input 8 • Digital input 9 • Digital input 10 • Digital input 11 • Digital input 12 • 24 V power • 24 V power • 24 V power • 24 V power	

Note! The internal 24 V supply (V1 to V6) can be loaded with a maximum of 50 mA by all used digital inputs and outputs. If the power consumption is higher, use an external power supply.

Terminal designation	Signal	Circuit
44 = AI1 43 = BI1 50 = AI2 49 = BI2 51 = RP 42, 45, 48 = Gx	**Analog inputs ±10 V DC AIx/BIx** Signal bandwidth 100 Hz +10 V positive reference GND positive reference R = 10 kOhm Input range 0 V to 9.1 V	
44 = AI1 43 = BI1 50 = AI2 49 = BI2 47 = CP1 46 = CN1 53 = CP2 52 = CN1	**Analog inputs 20 mA** AIx/BIx ; CPn/CNn Signal bandwidth 100 Hz **Note! Add a jumper between CPx and CNx to enable a 20 mA input.**	
44 = AI1 43 = BI1 50 = AI2 49 = BI2 51 = RP	**Analog inputs digitally assigned** AIx/BIx Refer to Analog inputs on page 50. **Note! If the two switches are active at the same time, no digital inputs are activated.**	

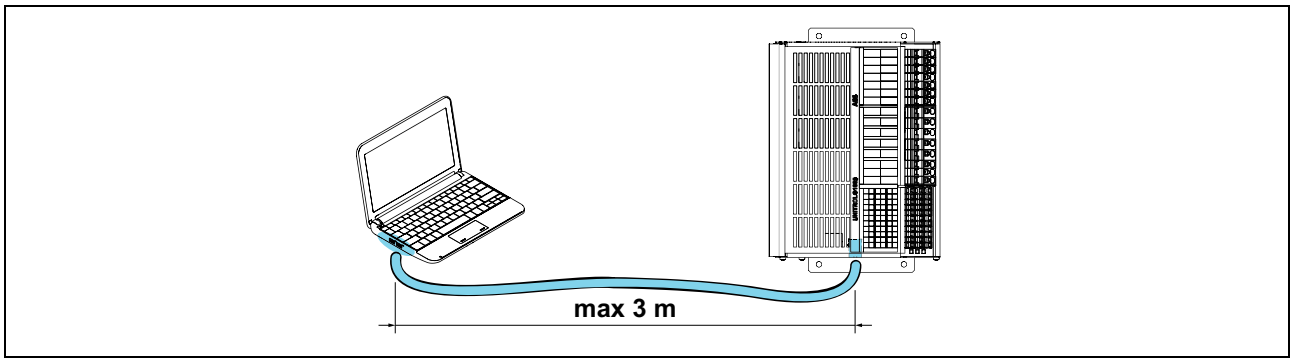
5.10 Communication ports

The AVR has two communication ports that you can use at the same time:

- The USB port connects the AVR to the PC with a USB cable. CMT 1000 uses the USB for communication with the AVR.
- The Ethernet port connects the AVR to a multi-point network. You can use Ethernet for remote access with the Modbus TCP protocol. You can also use the Ethernet port for a direct connection to a PC.

5.10.1 USB port

Use the USB port to connect the AVR to a PC to use the CMT 1000 commissioning and maintenance tool. To connect a PC to the AVR, use the supplied red USB cable. The USB port powers up the control devices of the AVR so you can download or upload parameter files without an additional power supply connection.



Note! Use only the red USB cable that is supplied with the AVR. If you use a different cable, it can cause a communication failure or power supply over USB can be incorrect.

Note! Some options are disabled, when the unit is powered only with the USB cable.

5.10.1.1 Power over USB cable only

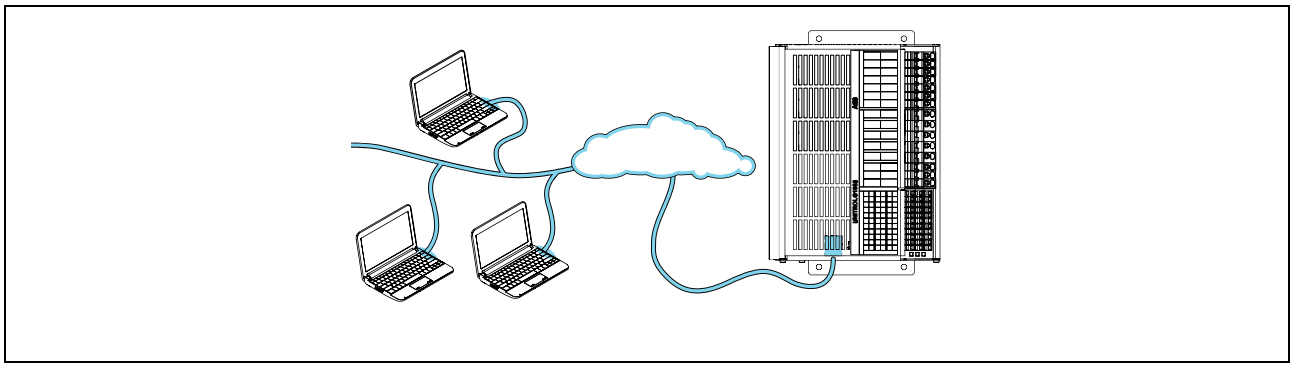
When the AVR is powered only with the USB cable:

- The main window of CMT 1000 shows a yellow error indication on the access level indicator.
- The IGBT power stage is disabled. If the AVR input voltage is < 6 V AC, it is not possible to use the regulators.
- It is not possible to update the software or enable software options.

5.10.2 Ethernet port

Use the Ethernet port to connect the AVR to a multi-point network. You can monitor and control the AVR from a remote location. In an Ethernet network you can use remote access with the Modbus TCP protocol. You can also connect the AVR directly to a PC with the Ethernet connection. It is possible to monitor the AVR from CMT 1000 and a plant control system at the same time.

For information on the Modbus protocol, refer to the *Modbus Reference Manual* (3BHS358281 E80).



6. Device software

This chapter gives a description of the device software: the control modes and setpoints, available software options, and digital and analog I/O signals.

For information on the control features of the device software, refer to the *Control SW manual* (3BHS399489 E02).

For instructions on how to update the device software, refer to Update the device software on page 70.

6.1 Control modes

The AVR has several control modes that you can select. The Channel Follow-up function allows a soft surge-free transition between the control modes (refer to Channel Follow-up on page 39).

6.1.1 Auto mode

- Regulates the terminal voltage of the synchronous machine (U_M)
- Voltage setpoint adjustment by static droop that is based on active or reactive current measurements
- Auto mode is the default control mode

6.1.2 Manual mode

- Regulates the excitation current (I_e)
- Defines the dynamic performance of the I_e limiter

Note! Limiters are not active in Manual mode.

6.1.3 PF mode

- Regulates the power factor of the synchronous machine
- PF setpoint is based on the active power measurement and VAR setpoint
- You can use PF mode for direct or indirect control of the power factor
- Adjust the voltage setpoint to regulate indirect PF

6.1.4 VAR mode

- Regulates the reactive power of the synchronous machine
- Defines the dynamic performance of PQ Limiter
- VAR setpoint is normalized at 1 pu terminal voltage of the synchronous machine
- You can use VAR mode for direct or indirect control of the reactive power
- Adjust the voltage setpoint to regulate indirect VAR

6.1.5 Open Loop mode

- Overrides the excitation output of the AVR
- Set a defined AVR output for commissioning and identification of system data
- The excitation voltage (U_e) is directly defined by the multiplication of the PWM signal with the rectified input voltage of the AVR (U_{PWR})

Note! Limiters are not active in Open Loop mode.

6.1.6 Standby mode

- Standby mode is used only in the redundant channel in a double channel system. Refer to Double Channel (DCH) software on page 52 and the *Control SW manual* (3BHS399489 E02).
- There is no AVR output in Standby mode
- Setpoints and operation points are calculated from the measurements of the redundant channel

6.1.7 Channel Follow-up

When you change between the control modes, the setpoint of the next control mode follows the setpoint of the active control mode. This software feature is called Channel Follow-up. Channel Follow-up ensures that the operation point of the synchronous machines stays correct and surge-free.

For example, when you change from Auto mode to Manual mode, the manual setpoint follows the auto setpoint:

- The ramp rate defines how quickly it is possible to change the setpoint.
- If the new setpoint is within the setpoint limit, you can make a surge-free transition between the control modes.

6.2 Priority of control modes

The priority of control modes defines which signal overrides another signal. Priority 1 is the highest priority. For example, if the digital input “Standby” is active, all other digital inputs of the control modes are ignored.

The priority of control modes:

Generator states			**NoLoad**	**Prim. / Sec. Net**	**Grid**
Control mode	**Remarks**	**Priority**	**GCB open**	**GCB closed Not connected to grid**	**Connected to grid**
Standby	Hot standby (any mode)	1	YES	YES	YES
Sync	Synchronization (AUTO SP)	2	YES	YES[1]	YES[1]
Manual	Excitation current regulation (MANUAL SP)	3	YES	YES	YES
Open Loop	Excitation output regulation (PWM SP)	4	YES	YES	YES
VDC	Voltage droop compensation (AUTO)	5	BLOCKED	YES	BLOCKED
PF	Direct PF (VAR SP)	6	BLOCKED	BLOCKED	YES
VAR	Direct VAR (VAR SP)	7	BLOCKED	BLOCKED	YES
Indirect PF	Superimposed PF (AUTO SP)	6	BLOCKED	BLOCKED	YES
Indirect VAR	Superimposed VAR (AUTO SP)	7	BLOCKED	BLOCKED	YES
AUTO[2]	Voltage control	8	YES	YES	YES

1) Synchronization with a closed generator circuit breaker (GCB) regulates Q to 0 % (unload function).

2) Auto mode is the default. No digital input is necessary for Auto mode.

6.3 Setpoints of the control modes

You can adjust the setpoints in the Setup menu > Setpoints. The control modes have the setpoint parameters that follow:

- Minimum
- Maximum
- Ramp rate
- Initial setpoint

6.3.1 Initial setpoint

An initial setpoint is used:

- At the start of excitation
- If the generator status changes
- When the digital input “Excitation ON” is not active

Control mode	Default initial setpoint	Range of initial setpoints
Auto	100 %	Min SP - Max SP
Manual	0 %	0 - 150 %
Open Loop	0 %	0 - 100 %
PF	1.0	-1.0 - +1.0
VAR	0.0 %	-100 - +100 %

You can set a new value for the initial setpoint of a control mode within the range.

6.3.2 Setpoint with an open GCB

When the signal “Gen CB Closed Status” is not active, all setpoints are immediately set to the values that follow:

Control mode	Final value
Manual	90 % of I_e No load
Open Loop	90 % of 1/Kceil
Auto	100 %

6.3.3 Reset setpoint

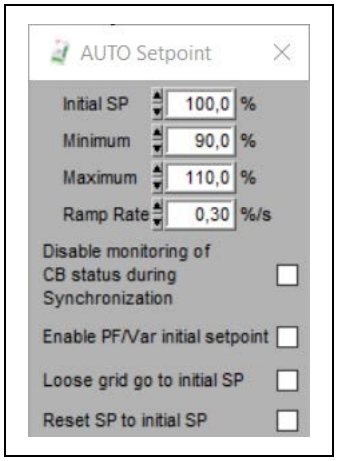
When the signal “Reset Setpoint” is active:

- The setpoint of the control mode goes to the value that follows in accordance with the defined ramp rate:

Control mode	Final value
Manual	I_e No load
Open Loop	100 % 1/Kceil
PF	1.0
VAR	0 %
Auto	100 %

- Or if you select the parameter “Reset SP to initial value”, the setpoint of the control mode goes to initial setpoint (Setup menu > Setpoints > AUTO Setpoint > Reset SP to initial value).

6.3.4 Connect the AVR parallel with the grid



To connect parallel with the grid:

1. Select the necessary control mode (refer to Select a control mode on page 43).
   - PF or VAR mode: select the parameter “Enable PF/VAR initial SP” (Setup menu > Setpoints > AUTO Setpoint > Enable PF/VAR initial SP).
   - Other control modes: the setpoint of the active control mode stays the same.
2. Connect to the grid. Make sure that the digital input signal “Parallel with Grid Status” is active.

6.3.5 Disconnect the AVR from the grid

To disconnect from the grid:

1. If necessary, select the parameter “Loose grid go to initial SP” (Setup menu > Setpoints > AUTO Setpoint > Loose grid go to initial SP). When you disconnect from the grid, the active control mode changes to Auto mode with initial setpoint values.
2. Disconnect from the grid. Make sure that the digital input signal “Parallel with Grid Status” is not active.
3. The control mode changes to Auto mode. The voltage setpoint is adjusted to ensure that the machine voltage stays constant.

6.4 Select a control mode

To select a control mode:

1. Make sure that CMT 1000 has control access.
2. Open the Setup menu.
3. Select Digital I/Os.
4. Select the correct digital inputs to activate a control mode. For example, to activate PF mode, select PF Enable and, if necessary, select Gen CB Closed Status or Parallel with Grid Status. For more information on the generator states and priorities of the control modes, refer to Priority of control modes on page 40.

Control mode	**Digital inputs**								
	Stand by	SYN	Gen CB Closed Status	Parallel with Grid Status	Manual Enable	Open Loop Enable	VDC Enable	PF Enable	Var Enable
Standby	1	X	X	X	X	X	X	X	X
Sync	0	1	X	X	X	X	X	X	X
Manual	0	0	X	X	1	X	X	X	X
Open Loop	0	0	X	X	0	1	X	X	X
VDC	0	0	1	0	0	0	1	X	X
PF	0	0	1	1	0	0	0	1	X
VAR	0	0	1	1	0	0	0	0	1
Auto	0	0	0	X	0	0	X	X	X
*	0	0	1	X	0	0	0	0	0

0 = logical 0

1 = logical 1

X = not relevant

* with droop or compensation

Note! If a digital input is set continuously at logical 1, it is possible to invert it. The digital input is considered as occupied. Refer to Digital inputs on page 46.

5. If necessary, select a digital output signal Manual Active or PF VAR Active. If the green status indicator is on, the selected control mode is active.
6. Open the Tune menu of CMT 1000.
7. Select Setpoint Adjust.
8. Make sure that the correct control mode and generator status are selected in the Setpoint Adjust window (refer to Setpoint Adjust on page 69). If a menu item is shown as gray, it is not possible to activate it with the selected configuration.

6.5 Software options

The device software of the AVRs in the UNITROL 1000 series is based on one source code. A set of software options is enabled by default in each AVR. It is possible to enable more software options that extend the capabilities of the AVR.

To enable a software option, send a request for a password to your ABB representative.

For instructions on how to enable a software option, refer to Enable a software option on page 45.

6.5.1 Software packages

These are the software packages that you can select:

- ECO
- LIGHT

No.	Software option	Description	Package type
1	AVR/FCR/PF/VAR	AVR regulator modes	ECO
2	Limiters	Limiters	ECO
3	Soft Start	Soft Start	ECO
4	Voltage Matching	Voltage Matching	ECO
5	History Logger	Records the last two hours of operation	LIGHT
6	Modbus	Modbus TCP for remote access	LIGHT
7	Rotating Diode Monitoring	Monitoring of rotating diodes on the exciter machine	LIGHT

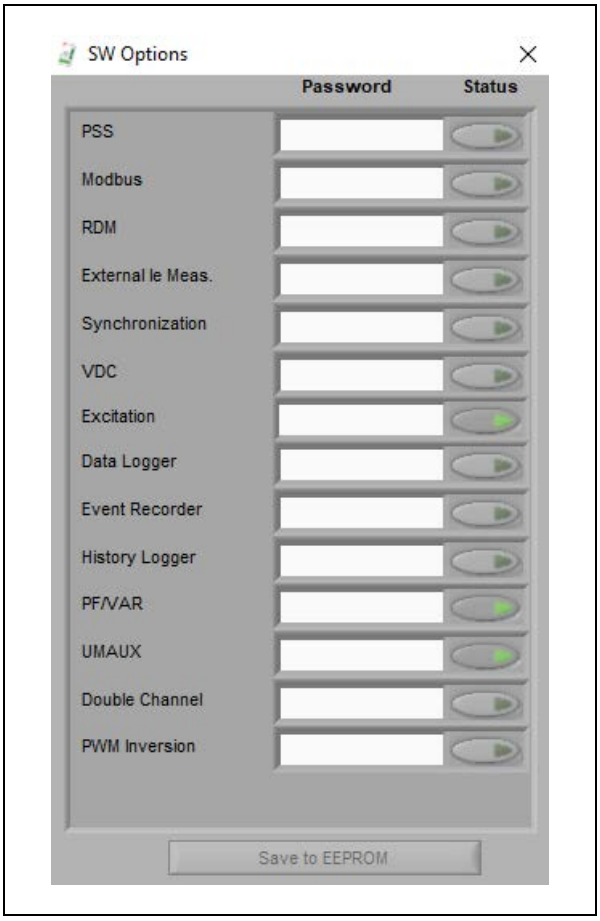
6.5.2 Enable a software option

Use CMT 1000 on your PC to enable software options in the AVR.

Note! It is necessary to have a password for each additional software option. Send a request for a password to your ABB representative. For more information, refer to Support information **on page** 10**.**

To enable a software option:

1. Make sure that CMT 1000 has control access. Refer to Operators and access levels on page 90.
2. In the main menu of CMT 1000, open the File menu.
3. Select SW-Options.
4. Write the password in the white box next to the software option that you want to enable. Press the Enter key on your keyboard.
5. Click the status button on the right.
6. Make sure that the status button next to the white box goes on. If the status button is off, make sure that you write the password correctly.
7. When all of the necessary software options are enabled and the status buttons are on, click the Save to EEPROM button.
8. In the main menu of CMT 1000, open the File menu.
9. Select Write parameters to EEPROM.
10. Start the AVR again.
11. Open the File menu.
12. Select SW-Options.
13. Make sure that the status button is on for the necessary software options. If a status button is off, do the procedure again.



6.6 Digital inputs

Digital input signal	Description
None	**Input not assigned**
Excitation ON	**Excitation ON command active**: • Field Flashing starts, if Off Level > 0 % • Auto mode: Soft Start starts after the Off Level is reached, and increases until the Initial setpoint value of Auto mode. • Other control modes: Initial setpoint • Refer to Initial setpoint on page 41 **Excitation ON command not active:** • All setpoints are immediately set to their initial values and remain fixed there.
Gen CB Closed Status	**Gen CB Closed Status active:** • Activates current measurement • The input signal triggers the ramp up of the Soft Start also if the hold time of Soft Start has not expired. **Gen CB Closed Status not active:** Refer to Setpoint with an open GCB on page 41.
Parallel with Grid Status	**Parallel with grid status active:** • With Gen CB Closed Status on, you can change between PF mode and VAR mode. **Connect the AVR parallel with the grid:** Refer to Connect the AVR parallel with the grid on page 42. **Disconnect the AVR from the grid:** Refer to Disconnect the AVR from the grid on page 42.
Increase	**Increases the setpoint of the active control mode**
Decrease	**Decreases the setpoint of the active control mode**
Reset Setpoint	**Reset Setpoint active:** Refer to Reset setpoint on page 42.
Remote SP Enable	**Remote SP Enable active:** • Enables the setpoint adjustment from an analog input • The setpoint changes in accordance with the defined ramp rate to the selected value  **Note! Set remote setpoints in the analog input section.**
PF Enable	**Activates power factor regulation**
Var Enable	**Activates reactive power regulation**
Manual Enable	**Activates excitation current regulation**

Digital input signal	Description
Open Loop Enable	**Activates the direct control of a power transistor:** Overrides AVR output.
Synchronize	**Activates Voltage Matching:** (Requires the Synchronization software option) The input signal activates Voltage Matching only.
Reset Alarm	**Clears the alarms that follow:** • Supervision Alarm 1 and 2 • Supervision Trip • Switch over • Monitor Alarm 1 and 2
Standby	**Reserved**
RC Fieldbus Block	**Disables the fieldbus communication in local operation:** • All control registers are set to default • Excitation stops if it is controlled over Modbus
External Alarm	**External Alarm input:** Used to detect axillary contacts of the MCBs.
Emergency Excitation Off	**Emergency Excitation OFF command active:** Overrides Excitation ON input signal and Modbus control signal.
Droop2 Select	**Activates Kq2 (Droop) parameters**
Unload VAR	**Regulates VAR to 0:** Command must be active until VAR is at 0.
Remote IO control	**Enables selection of the options that follow:** • True: “Fieldbus write all” enables the override of digital inputs over Modbus • False: It is not possible to override digital inputs over Modbus
Excitation OFF	**Changes the behavior of Excitation ON / Excitation OFF to pulse logic** A pulse from a digital input or from the fieldbus can change the excitation status: • Positive edge of the Excitation ON input signal starts the excitation • If the Excitation OFF input signal is active, the excitation is stopped and blocked

6.7 Digital outputs

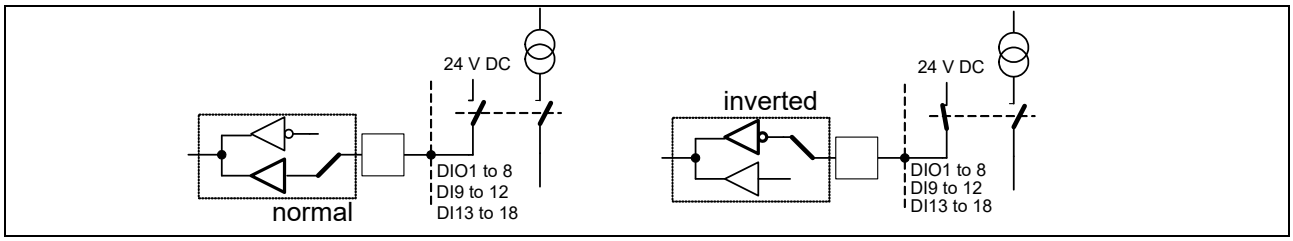
Digital output signal	Description
None	**Output not assigned**
Boost	**Boost status signal is active:** • Boost supports the excitation if there is a short-circuit current or heavy load in the network • Boost is configured to trigger at a defined threshold of the machine voltage • Boost is blocked during Field Flashing and Soft Start
Limiter Active 1	**One of the selected limiters in the limiter matrix activates**
Limiter Active 2	**One of the selected limiters in the limiter matrix activates.**
Field Flashing	**You can activate Field Flashing (voltage ramp up) only if Excitation ON is enabled.** You can start the next Field Flashing only after: • The Excitation ON signal is on • You stop and start the unit again (power on and off) During Field Flashing the excitation output is blocked in all control modes. PWM is forced to 0 %.
Voltage Relay	**Voltage Relay:** • Active: The machine voltage is less than the boost threshold • Not active: The machine voltage is more than the boost threshold plus hysteresis Voltage Relay does not depend on the Excitation ON input signal.
Supervision Trip	**A trip indication that is triggered by monitor functions**
Supervision Alarm 1	**An alarm indication that is triggered by monitor functions**
Supervision Alarm 2	**An alarm indication that is triggered by monitor functions**
Monitor Alarm 1	**An alarm indication that is triggered by monitor functions**
Monitor Alarm 2	**An alarm indication that is triggered by monitor functions**
Monitor Alarm 3	**An alarm indication that is triggered by monitor functions**

Digital output signal	Description
Diode Alarm	**An alarm indication of an open diode** • Detection of an open diode on the rotor of the machine • Depends on the settings for rotating diode monitoring
Diode Trip	**A trip indication of a shorted diode** • Detection of a short-circuit diode on the rotor of the machine • Depends on the settings for rotating diode monitoring
FRT Detection	**An indication of a fault ride through** There is a sudden voltage dip on the network.
ExcON status	**An indication that the excitation is on** If the excitation is blocked internally, the signal is not active. Refer to Power over USB cable only on page 36.
Softstart Active	**An indication that Soft Start is active**

6.8 Polarity and forcing digital signals

You can invert the polarity of each digital input and output port. Each DIO port can be set only as an input or output at a time.

Invert the polarity of DIO ports to force a digital signal.



6.8.1 Force digital input signals

You can set each digital input signal to a predefined value without terminal connections. This process is called forcing.

To force a digital input signal:

- When polarity is set to Normal, the digital input is set to not active
- When polarity is set to Inverted, the digital input is set to active

Note! Do not wire a digital input at the terminal, if you have forced the signal.

6.8.2 Force digital output signals

You can force each digital output signal for test purposes. To force the signal, invert the polarity. It is possible to force a signal also if there is no selected output signal.

6.9 Analog inputs

Analog input signal	Description
None	**Input not assigned**
Auto Remote Setpoint ±10 V / 0 - 20 mA	**External setpoint to Auto mode**
PF Remote Setpoint ±10 V / 0 - 20 mA	**External setpoint to PF mode**
VAR Remote Setpoint ±10 V / 0 - 20 mA	**External setpoint to VAR mode**
Manual Remote Setpoint ±10 V / 0 - 20 mA	**External setpoint to Manual mode**
Open Loop Remote SP ±10 V / 0 - 20 mA	**External setpoint to Open Loop mode**
Common Remote SP ±10 V / 0 - 20 mA	**Common remote setpoint for Auto, PF and VAR modes**
UM Aux ±10 V / 0 - 20 mA	**Additional signal to the summing point of the voltage regulator** Used to measure the transfer function of the excitation system.
VAR Aux Measurement ±10 V / 0 - 20 mA	**Injection signal to the summing point of the PF and VAR regulator**
Ie External	**Reserved for the real-time simulator**
Digital Input 13(+) & 14(-)	**You can use analog inputs as digital inputs**
Digital Input 15(+) & 16(-)	**You can use analog inputs as digital inputs**
Digital Input 17(+) & 18(-)	**You can use analog inputs as digital inputs**
Motor Speed	**Speed input for motor excitation**

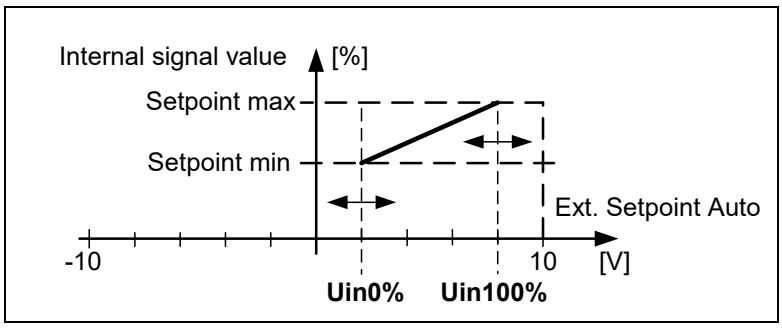
Note! To set an external setpoint from the analog input list, you must also enable the digital input “Remote SP Enable”. Refer to Digital inputs **on page** 46**.**

6.9.1 Voltage level of the analog inputs

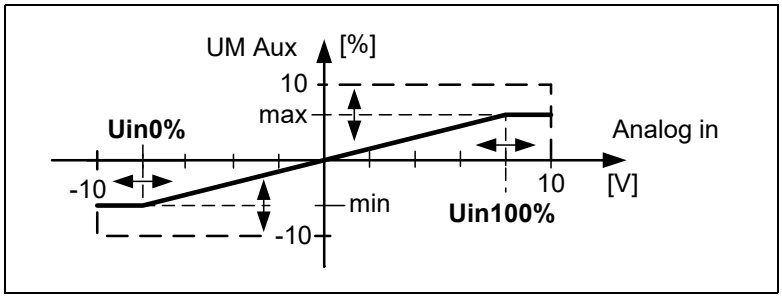
You can set a minimum and maximum voltage level for each analog input.

Analog input signal	Uin0% Minimum input voltage (-10 - +10 V)	Uin100% Maximum input voltage (-10 - +10 V)	Remarks
Auto Remote Setpoint	Auto setpoint min	Auto setpoint max	Refer to Input voltage of an external setpoint on page 51.
PF Remote Setpoint	PF setpoint min	PF setpoint max	
VAR Remote Setpoint	VAR setpoint min	VAR setpoint max	
Manual Remote Setpoint	Manual setpoint min	Manual setpoint max	
Open Loop Remote SP	Open Loop setpoint min	Open Loop setpoint max	
UM Aux	UM Aux min	UM Aux max	Range: -100 % to +100 % Refer to Input voltage to the summing point on page 52.
VAR Aux Measurement	-10 %	+10 %	Range: -10 % to +10 %
Digital Input 13(+) & 14(-)	Set to 2.0 V	Set to 5.0 V	Refer to Requirements for DI13 to DI18 on page 52
Digital Input 15(+) & 16(-)	Set to 2.0 V	Set to 5.0 V	
Digital Input 17(+) & 18(-)	Set to 2.0 V	Set to 5.0 V	

6.9.1.1 Input voltage of an external setpoint

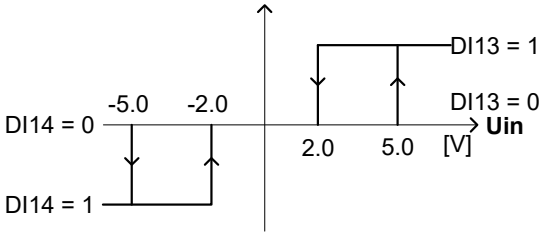


6.9.1.2 Input voltage to the summing point



6.9.1.3 Requirements for DI13 to DI18

Requirements for analog inputs that are used as digital inputs (DI13 to DI18):



DI13(+)	0
DI14(-)	1
DI13(+)	1
DI14(-)	0

Note! Analog and digital inputs must not be active at the same time. If they are active at the same time, DI13 and DI14 are at logical 0.

6.10 Double Channel (DCH) software

Double Channel (DCH) is a software option that integrates supervision or monitor functions and redundant channel support for double channel systems. A double channel system has a main channel and a redundant channel.

Double Channel software is also used for single channel systems in order to force the system into Manual mode or to trip excitation.

For more information, refer to *Control SW manual* (3BHS399489 E02).

6.11 Remote access with Modbus

Remote access is a feature that allows monitoring and control of the AVR with the Modbus protocol. You can use remote access for applications that require a custom user interface or control from a remote location (for example, offshore).

A remote terminal that is set as the Modbus master can get access to an AVR through an Ethernet TCP/IP connection. Up to 10 Modbus masters in parallel can communicate with one AVR to read and write registers (measurements, setpoints and other information) from the AVR. For more information, refer to the *Modbus Reference Manual* (3BHS358281 E80) and *Modbus Address Table* (3BHS358281 E81).

To communicate with the AVR, the remote terminal must get a determined access level in the AVR in accordance with the necessary operation. Monitor access is used for read-only information. Control access is used to read and write registers. For more information, refer to Operators and access levels on page 90.

The electrical connections are described in Communication ports on page 36.

Cyber security note: Modbus does not natively guarantee secure communication. Any node that is able to communicate with the AVR via Modbus can perform unwanted changes or incorrect configurations on such products that can disrupt the intended operation of the AVR and the systems connected to it. It is recommended to limit the Modbus communication within trusted networks and to strictly control access to such networks.

6.11.1 Configuration

Communication between a Modbus master (external device) and Modbus slave (the AVR) is based on the Modbus Slave-ID value. The Modbus Slave-ID value can be a value between 1 and 247, where 247 is the default value.

There is a restriction, if the Modbus Slave-ID value is between 1 and 63 (except 32) and it is the same value as the AVR-ID number for the main channel or AVR-ID number +32 for the redundant channel.

In these situations, the AVR changes the Modbus Slave-ID value to 247 upon restart. You can set the Modbus Slave-ID for remote access between 64 and 247 without restrictions. This is the range that is recommended for most applications.

When you use CMT 1000 directly through an Ethernet connection, the Modbus Slave-ID is a value between 1 and 63. The value depends on the AVR-ID and the channel identification (Main or Redundant), also without the double channel software. When you set parameters with the CMT 1000, you can see the Modbus Slave-ID for CMT 1000 connection in the Modbus Supervision window.

Note! Do not use the Modbus Slave-ID value for a direct CMT 1000 connection as the Modbus Slave-ID for remote access.

6.11.2 Ethernet TCP/IP connections to an AVR

- 1 CMT 1000 connection is possible
- 10 remote access connections are possible

Open the TCP ports that follow:

- Port 5002 (outbound) / 5003 (inbound):
  - Device detection
  - Ethernet scanning
- Port 502 (inbound): Modbus TCP

7. Commissioning and maintenance tool CMT 1000

This chapter gives information on the commissioning and maintenance tool CMT 1000. CMT 1000 is a PC application to adjust the settings of your AVR. Connect your PC to the AVR with a USB or Etherner connection. ABB recommends a USB connection for the initial installation and an Ethernet connection for control use.

For the connection options, refer to Communication ports on page 36 and *Modbus Reference Manual* (3BHS358281 E80).

7.1 Basic features of CMT 1000

With CMT 1000 you can:

- Set parameters and I/O signals
- Adjust setpoint steps
- Monitor and control measurements
- Visualize measurements with an oscilloscope
- Upload and download parameter files
- Do commissioning and PID tuning

7.2 System requirements

The minimum system requirements for the PC:

- Microsoft® Windows operating system
- A Pentium 1 GHz processor or higher
- 512 MB RAM
- 10 GB of free hard disk space
- A display resolution of 1024x768 pixels or more

7.3 Installation procedure

Obey the installation procedure:

1. Download the latest documentation and software from the myABB business portal. Refer to Documentation, software and tools on page 8 for instructions.
2. Install the CMT 1000 software (refer to Install CMT 1000 on page 55).
3. If problems occur, refer to Problems with installation on page 55.
4. When you complete the installation procedure, refer to Starting procedure on page 56.

7.3.1 Install CMT 1000

To install the CMT 1000 software:

1. Make sure that you have the correct revision of the *CMT 1000 software* (3BHS346676). Note that you can open parameter files only with a compatible software revision.
2. Unzip and open the software folder on your PC.
3. Double-click setup.exe to install the CMT 1000 software.
4. Follow the instructions in the installer window.
5. Start the PC again when the CMT 1000 installer tells you to restart. Select Restart in the installer window.
6. Connect the USB cable between the AVR and your PC. Use only the supplied red USB cable.
7. Open the Device Manager of your PC to make sure that the AVR is listed under Ports.
8. If problems occur, refer to Problems with installation on page 55.

7.3.2 Problems with installation

7.3.2.1 USB driver installation

If problems occur with the USB port, install the USB driver:

1. Download *CMT1000 USB Driver* (3BHS346676) from the myABB business portal.
2. Open the software folder on your PC.
3. Double-click InstallUSBdriver.exe to install the USB driver.
4. Connect the AVR with the USB cable to your PC. Use only the supplied USB cable.
5. A message “New Hardware Found” shows on your PC.
6. Click Next until the installation is completed.

7.3.2.2 Changing the firewall settings

If problems occur with the firewall settings, change the firewall settings of your PC:

1. In the main window of your PC, click Start/Window > Settings > Network & Internet > Windows Firewall > Allow an app or feature through Windows Firewall.
2. Select the Exceptions tab.
3. Select Add Port.
4. Enter the Name Scanning and Port number 5002.
5. Select OK to save the changes.
6. Do the same procedure for port 5003.

Note! Speak to your IT department representative, if you are not allowed to change the firewall settings of your PC.

7.4 Starting procedure

It is necessary to set a connection type before communication with the AVR is possible.

Follow the starting procedure:

1. Set a connection type (refer to Set a connection type on page 56).
2. After you have a connection with the AVR, a scanning process starts. Refer to Scanning process on page 57.
3. If problems occur, refer to Failure of the scanning process on page 57.
4. After the scanning process completes, you can start the communication with the AVR. Refer to Communication with the AVR on page 58.

7.4.1 Set a connection type

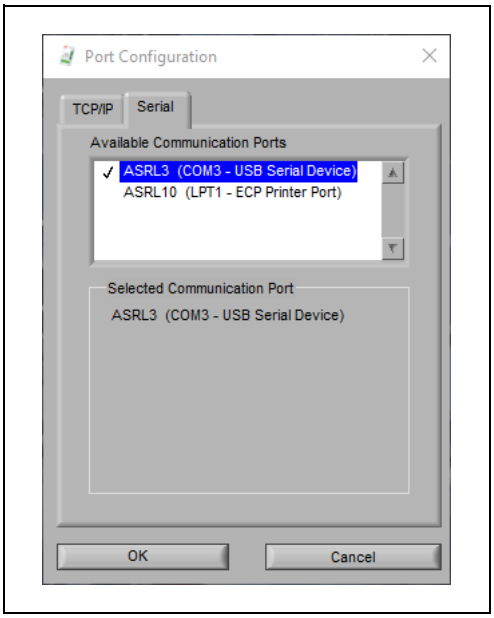
To set a connection type:

1. In the main window of CMT 1000, open the Communication menu.
2. Select Port Configuration.
3. Select a connection type:
   - Select the Serial tab for a connection through the USB port. Refer to Connection through the USB port on page 56.
   - Select the TCP/IP tab for a connection through the Ethernet port. Refer to Connection through the Ethernet port on page 57.

Note! It is recommended to use the USB connection for the installation procedure. If possible, use the Ethernet connection for operation.

7.4.1.1 Connection through the USB port

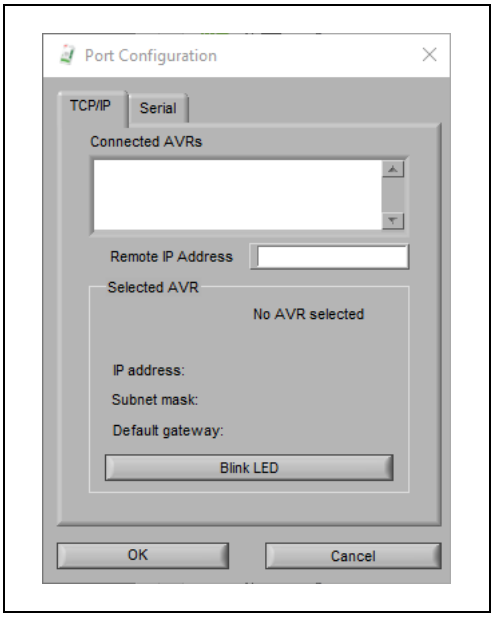
1. Select the Serial tab.
2. In the Available Communication Ports menu, select the applicable communication port.
3. Select OK to save the changes or Cancel to abort the changes.



If you cannot find the applicable communication port (COMx):

- Examine if the configuration of the communication port is correct in the operating system of your PC.
- Examine if another application uses the same communication port.
- Typical settings for a communication port:
  - Base I/O Port address: 3f8
  - Interrupt Request Line (IRQ): 4

7.4.1.2 Connection through the Ethernet port



1. Select the TCP/IP tab.
2. Enter the IP address of the remote terminal in the Remote IP Address field.
3. A pinging process starts automatically. After two seconds CMT 1000 shows a message:
   - If the message “Connection OK” is shown, you can connect the remote terminal to the AVR.
   - If the message “Not accessible” is shown, the connection is not satisfactory. Examine if the configuration and installation of the Ethernet, gateway, firewall and cabling are correct. For configuration, refer to Communication ports on page 36.

   The pinging process operates at intervals of two seconds after the last message is displayed.
4. Click Blink LED to flash the LED on the connected AVR. Make sure that you are connected to the correct AVR.
5. Select OK to save the changes or Cancel to abort the changes.

Note! If CMT 1000 shows a message “In use”, CMT 1000 uses the IP address. You can ignore this message.

7.4.2 Scanning process

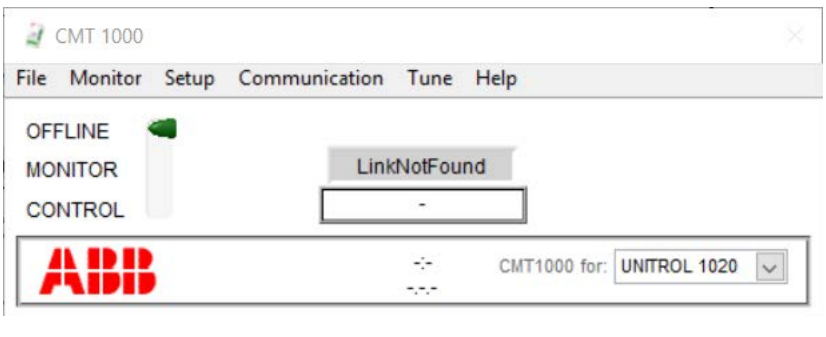
After you set a connection type, CMT 1000 starts a scanning process. CMT 1000 senses an AVR through the related communication port (USB or Ethernet). During the scanning process (some seconds) it is not possible to change the access level.

When CMT 1000 senses an AVR, it shows the AVR-ID and channel identification (Main or Redundant) in the main window.

If CMT 1000 does not sense an AVR, refer to Failure of the scanning process on page 57.

7.4.3 Failure of the scanning process

If CMT 1000 does not sense an AVR in one minute, the main window shows a message Link Not Found. The scanning process continues in the background.



Make sure that the port settings and the hardware connections are correct. Refer to USB port on page 36 or Ethernet port on page 37.

7.5 Communication with the AVR

CMT 1000 has three access levels to connect to an AVR: off-line, monitor access and control access.

You can communicate with the AVR only during monitor access or control access. When off-line, CMT 1000 can only read the AVR-ID and channel identification (Main or Redundant) directly from the AVR.

For more information, refer to Operators and access levels on page 90.

To communicate with the AVR:

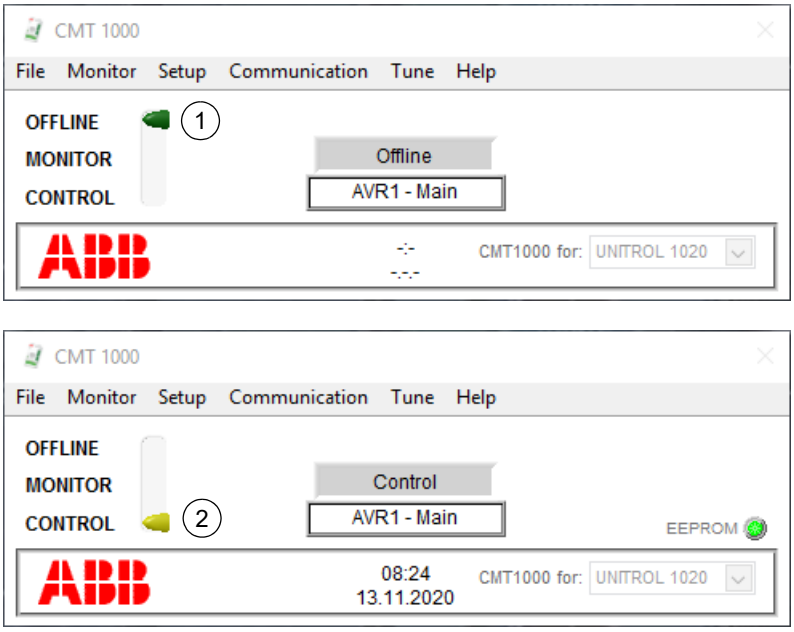
- Change the access level (refer to Access selector on page 58)
- Control the parameter changes (refer to EEPROM status indicator on page 59)

Note! Make sure to examine the access selector and EEPROM status indicator before you upload and download parameter files. Refer to Parameter files on page 73.

7.5.1 Access selector

You can change the access level with the access selector. The color of the access selector changes between green and yellow:

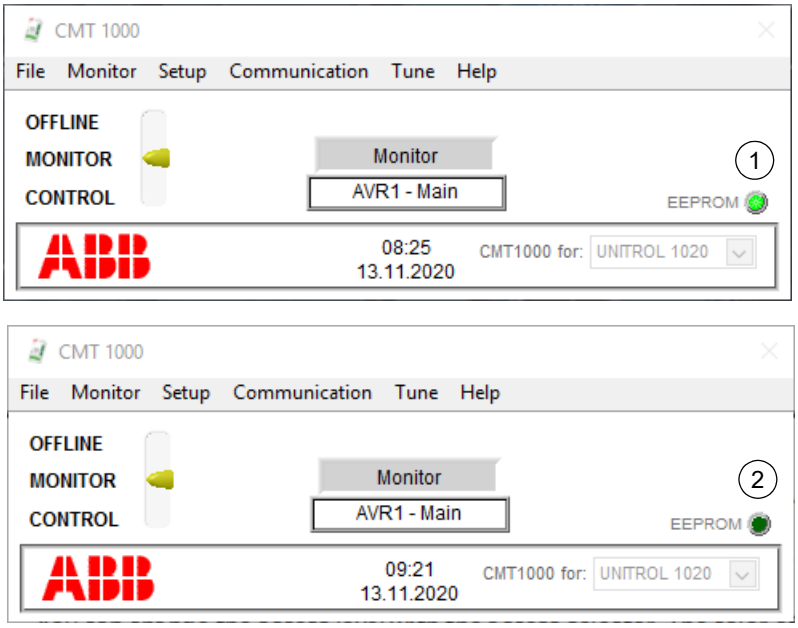
No.	Description
1	Green: • The AVR is fully operational • CMT 1000 is off-line • Or you use CMT 1000 without a connection to an AVR
2	Yellow: The AVR is only powered with the supplied red USB cable, excitation is blocked



7.5.2 EEPROM status indicator

The EEPROM status indicator shows if the parameter values agree in the RAM and in the non-volatile memory (EEPROM) of the AVR. The color of the EEPROM status indicator changes (on and off):

No.	Description
1	ON: All parameter values agree
2	OFF: A minimum of one parameter is changed

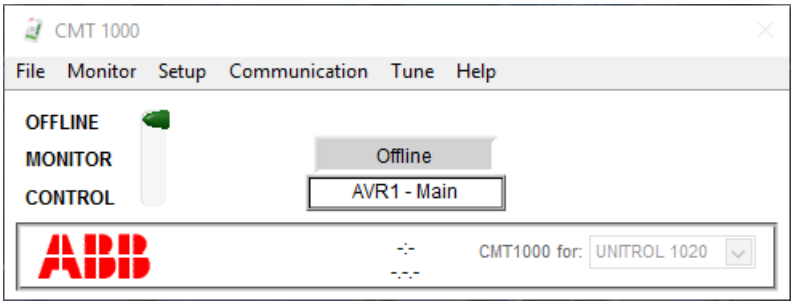


Make sure that you save the changed parameter values to the non-volatile memory (EEPROM) of the AVR. For instructions, refer to Write parameters to the non-volatile memory (EEPROM) of the AVR on page 75. If the changed parameter values are not saved, the data is lost when you start the AVR again.

Note! The EEPROM status indicator is shown in the main window only during monitor access or control access.

7.6 Menu structure

The main window of CMT 1000 has 6 menus, where you can get access to all of the software features. Each menu item is in a group in accordance to its functionality.



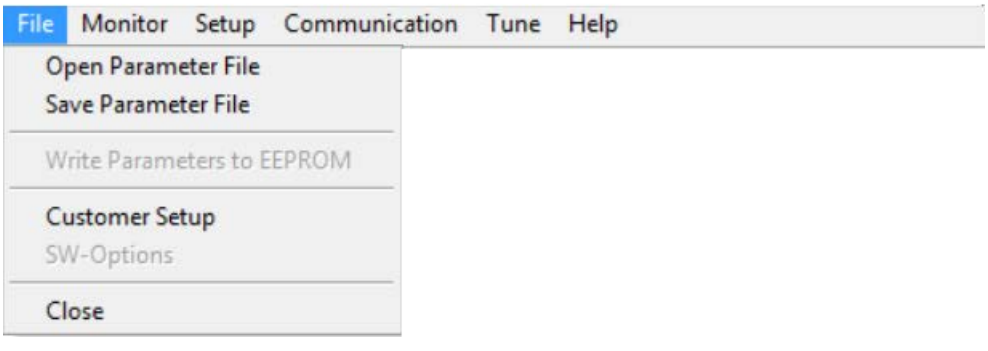
Overview of the menus:

- File menu: Open or save parameter files and enable software options
- Monitor menu: Online measurements
- Setup menu: Set parameters
- Communication menu: Set IDs / Ports / Modbus
- Tune menu: Tune regulators
- Help menu: Software information

Note! To close the windows, click the cross button in the top-right corner of the window. If there is no cross button, the information in the window tells you how to close the window.

Note! If some menu items are shown in gray, they are not available in the AVR or you need to change the access level to control access.

7.6.1 File menu



File menu items:

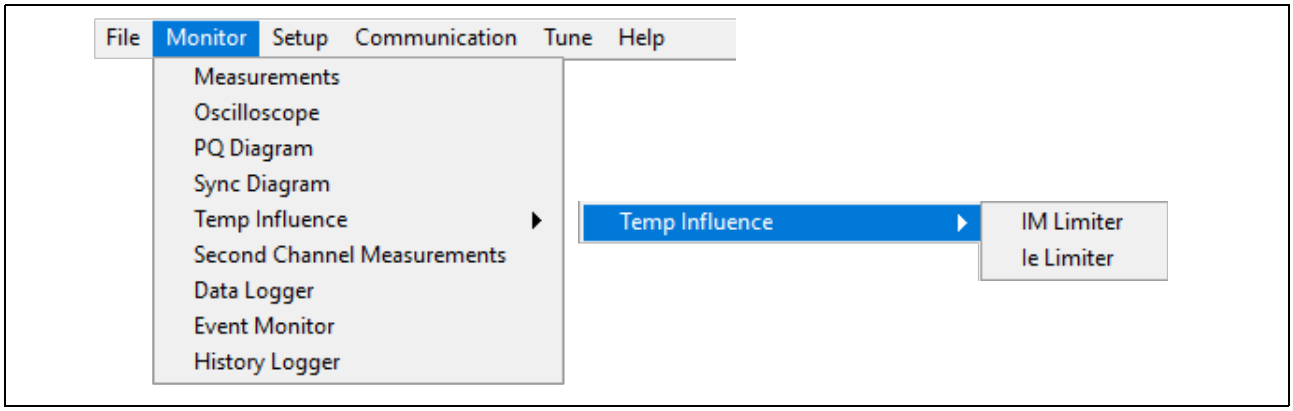
- Open Parameter File: Open a parameter file from the hard disk of the PC
- Save Parameter File: Save a parameter file to the hard disk of the PC
- Write Parameters to EEPROM: Save the parameters to the non-volatile memory (EEPROM) of the AVR
- Customer setup: Use a custom application
- SW-Options: Enable software options
- Close: Close the CMT 1000 application

Refer to Parameter files on page 73 for instructions on how to use parameter files.

Refer to Use a customer setup on page 72 for more information on custom applications.

Refer to Enable a software option on page 45 for more information on software options.

7.6.2 Monitor menu

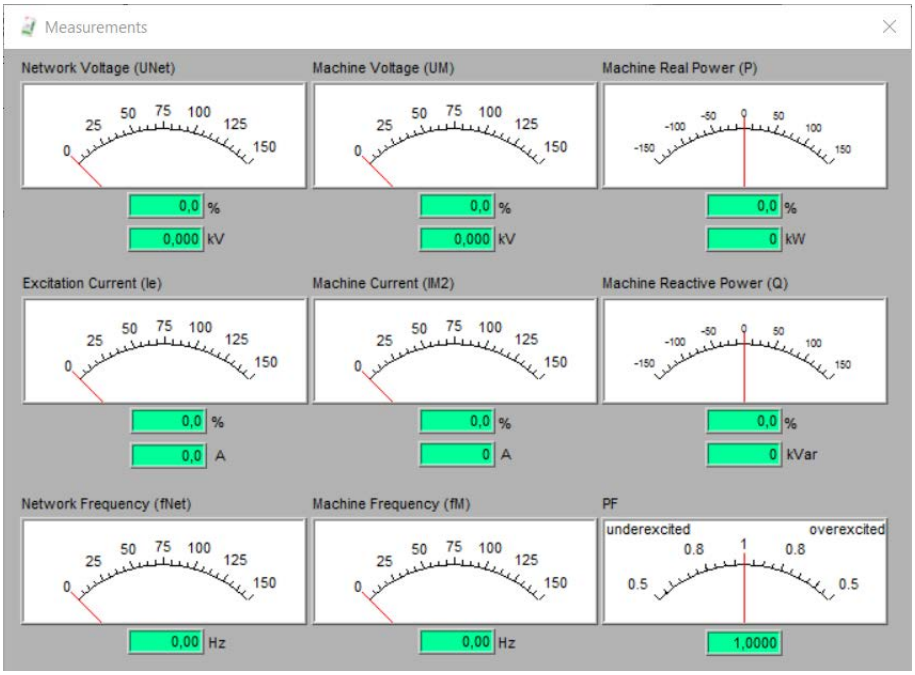


Monitor menu items:

- Measurements: Online measurements (Main channel)
- Oscilloscope: Online measurements
- PQ Diagram: Online measurements
- Sync Diagram: Online measurements for Synchronization
- Temp Influence: Temperature influence visualization for machine and excitation current
- Second Channel Measurements: Online measurements from the second channel (Redundant channel in a double channel system)
- Data Logger: Data log viewer
- Event Monitor: Event viewer
- History Logger: History log viewer

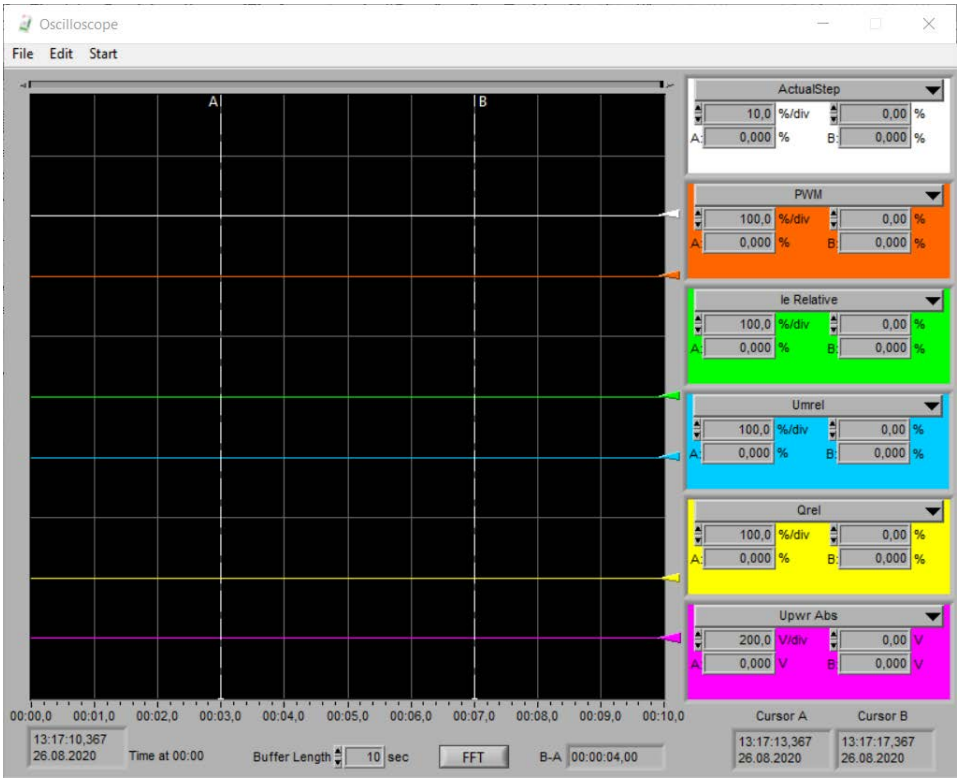
7.6.2.1 Measurements

The Measurements window shows the measurements of the AVR.



7.6.2.2 Oscilloscope

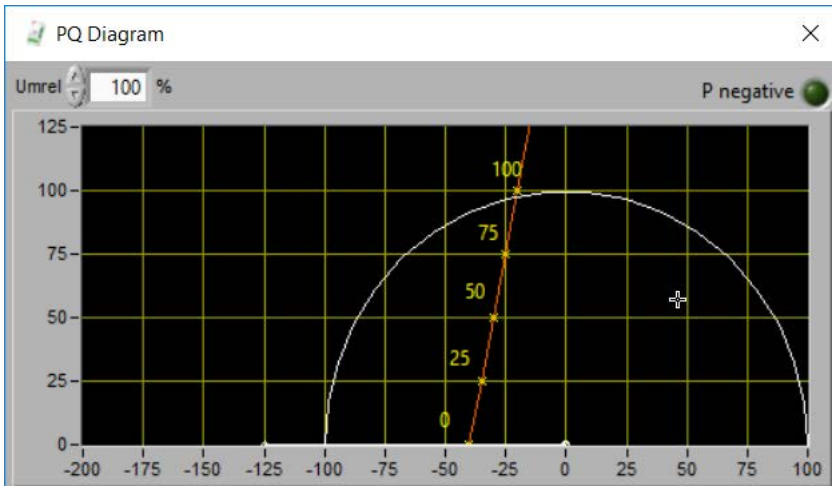
The Oscilloscope window shows a visualization of 6 signals at a time (out of 21 signals). For more information, refer to Oscilloscope on page 79.



7.6.2.3 PQ Diagram (Power chart)

The PQ Diagram window shows the measurements of reactive power Q (on the x-axis) and active power P (on the y-axis) in relation to the machine voltage.

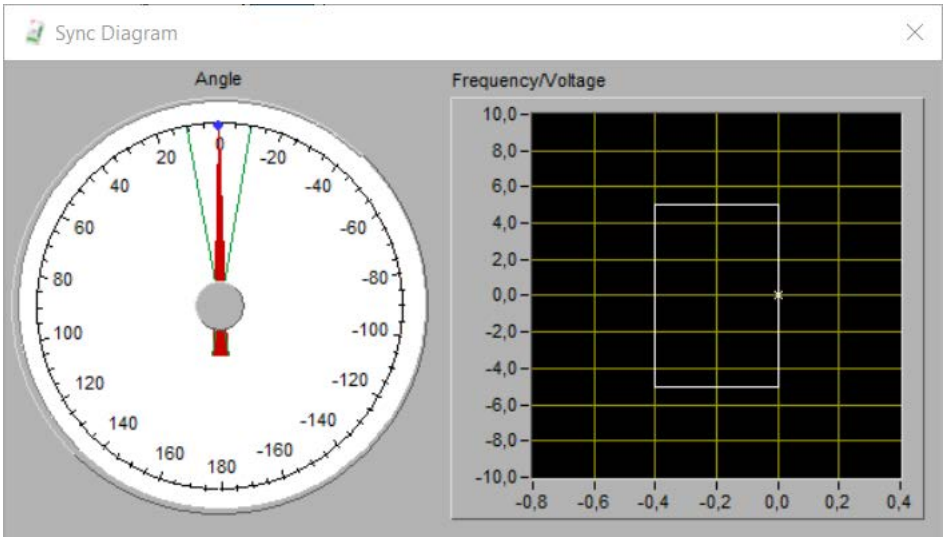
The white arrow (at the bottom of the figure) shows the current operating point when the synchronous machine is connected to the grid. When the synchronous machine is idle, the arrow is at 0, because there is no active or reactive power.



7.6.2.4 Synchronization Diagram, Synchroscope

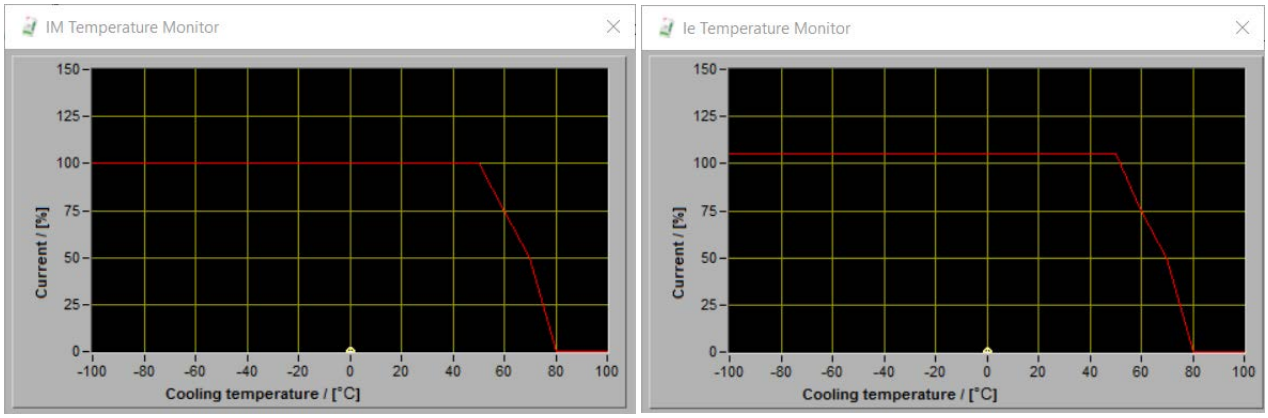
The Sync Diagram window shows the measurements of the differential voltage machine to network (U_M - U_{NET} [%]) and Slip (f_{NET} - f_M [Hz]). Synchronization software is required.

For more information, refer to the *UNITROL 1000 Com-Instructions and PID tuning* (3BHS399489 E01).



7.6.2.5 I_M and I_e Temperature Monitor

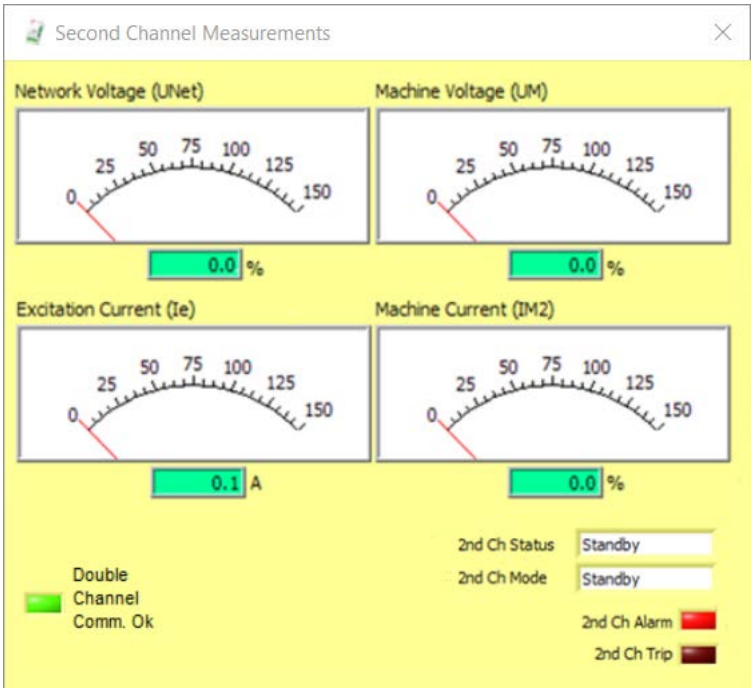
The I_M Temperature Monitor and I_e Temperature Monitor windows show the measurements of machine current (I_M) and excitation current (I_e) in relation to the cooling temperature.



7.6.2.6 Second Channel Measurements

The Second Channel Measurements window shows the measurements from the second channel (Redundant) in a Double Channel system. Double Channel (DCH) software required.

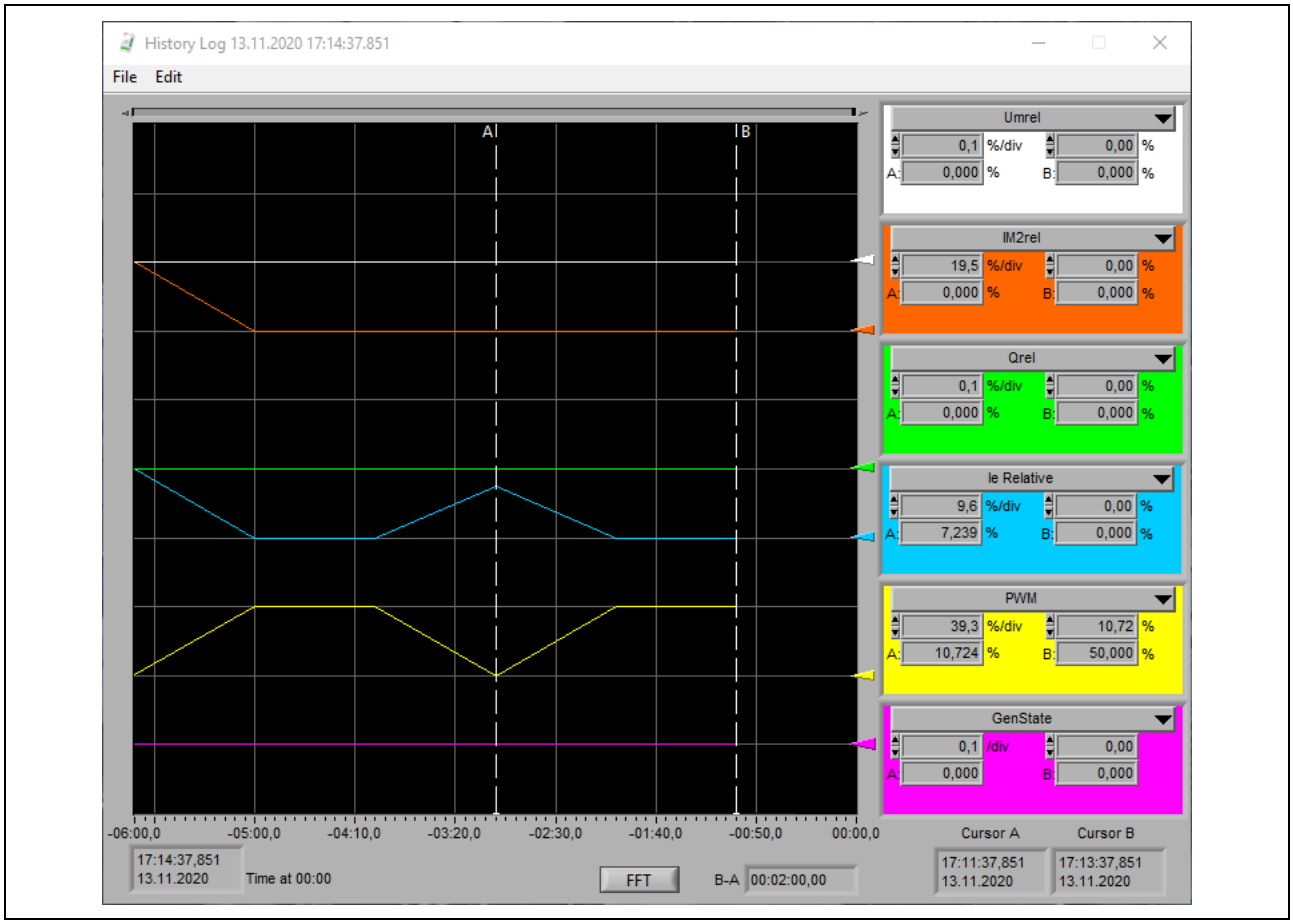
For more information, refer to Double Channel (DCH) software on page 52 and *Control SW manual* (3BHS399489 E02).



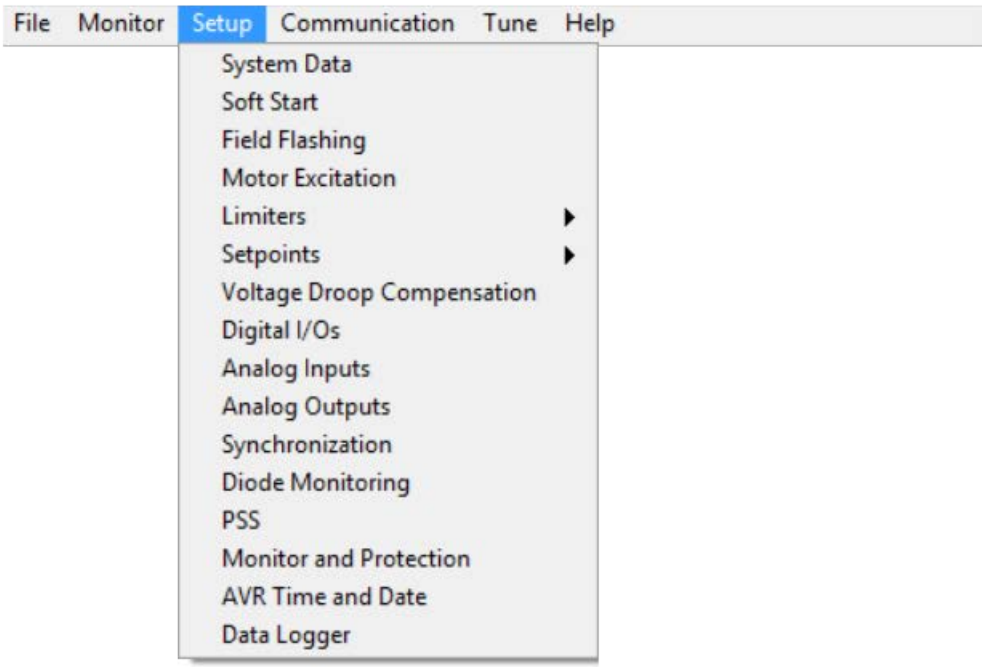
7.6.2.7 History Logger

The History Logger window shows visualization of history logs from the AVR.

For more information, refer to History Logger on page 86.



7.6.3 Setup menu



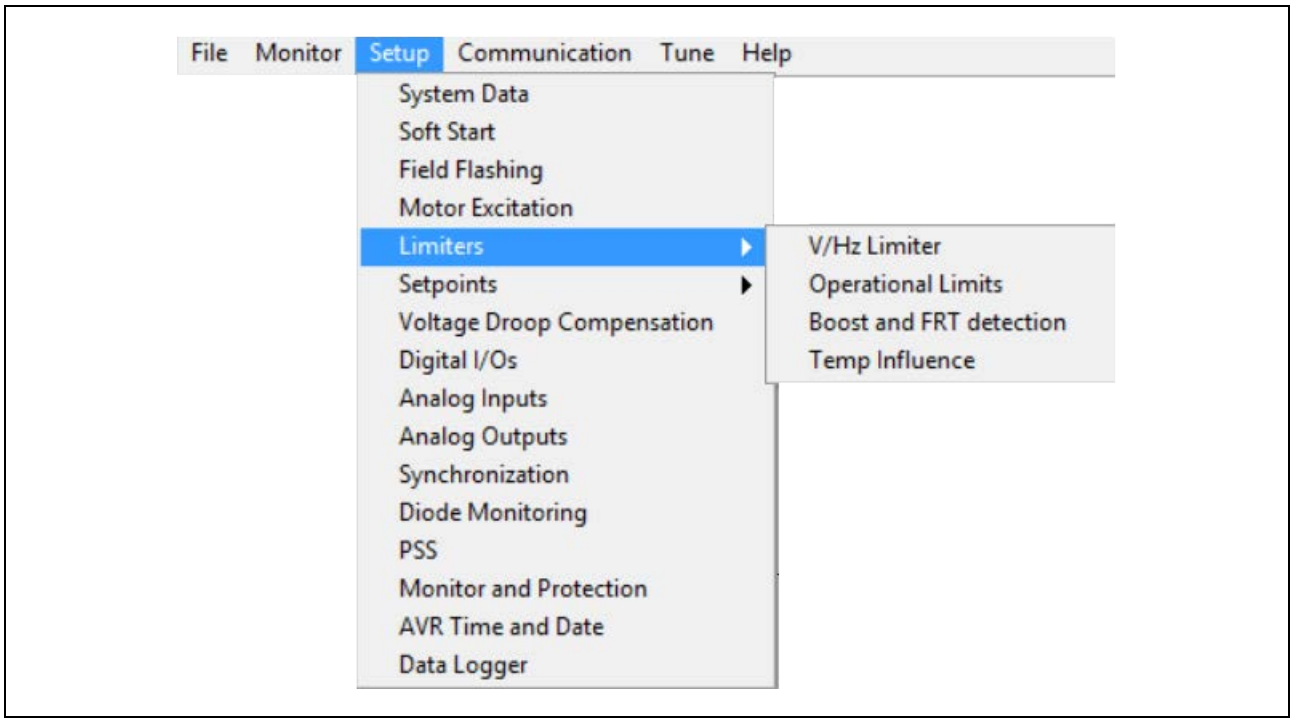
Setup menu items:

- System Data: Set parameters for system data
- Soft Start: Set parameters for Soft Start ramp
- Field Flashing: Settings for Field Flashing
- Motor Excitation: Settings for Motor Excitation
- Limiters: Settings for limiters
- Setpoints: Settings for setpoints
- Voltage Droop Compensation: Settings for VDC software
- Digital I/Os: Set digital inputs and outputs
- Analog inputs: Set analog inputs
- Analog outputs: Set analog outputs
- Synchronization: Set parameters for synchronization
- Diode Monitoring: Settings for Rotating Diode Monitoring
- PSS: Set parameters for Power System Stabilizer
- Monitor and Protection: Settings for monitor and supervision functions
- AVR Time and Date: Set the time and date of the AVR
- Data Logger: Settings for Data Logger

For more information on the device software, refer to Device software on page 38 and *Control SW manual* (3BHS399489 E02).

Note! When CMT 1000 is off-line you can see also software options that are not available in your AVR.

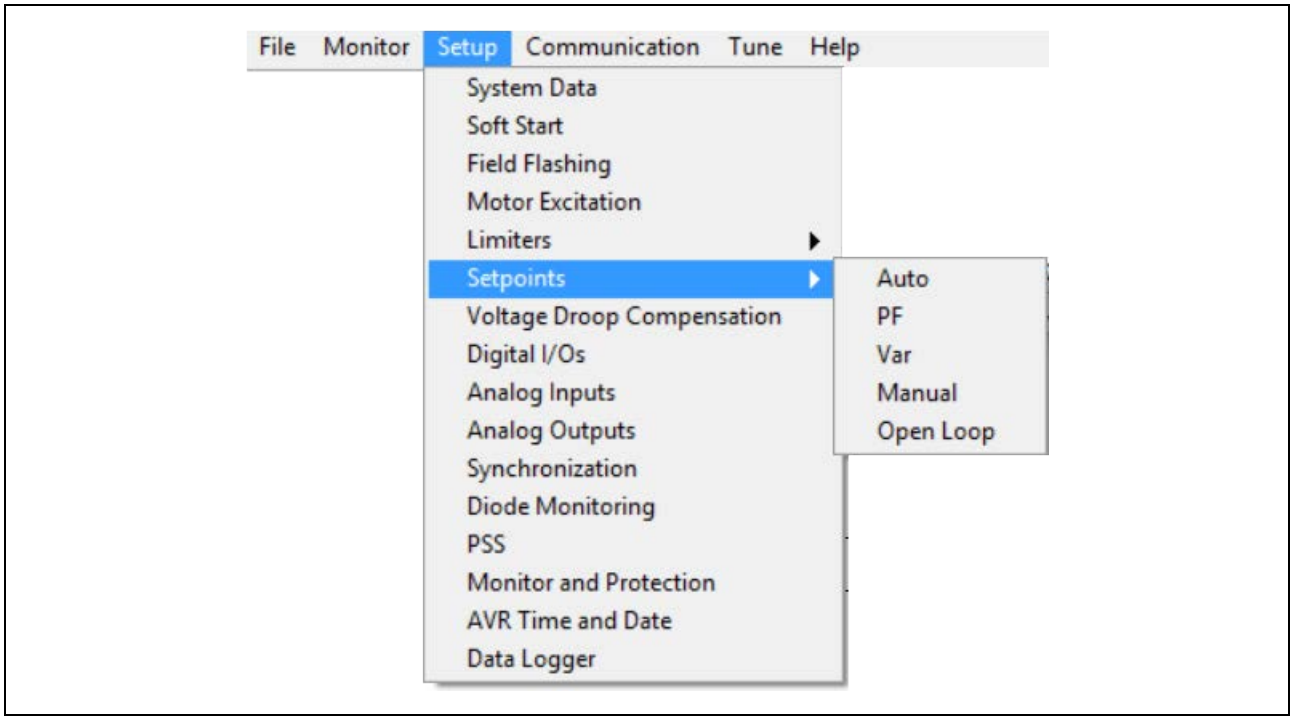
7.6.3.1 Setup > Limiters menu



Limiters menu items:

- V/Hz Limiter: Configuration of V/Hz limiter
- Operational Limits: Configuration of PQ, U_M, I_M and I_e limiters
- Boost and FRT detection: Line short-circuit support and fault ride through
- Temp Influence: I_M and I_e limiters temperature influence

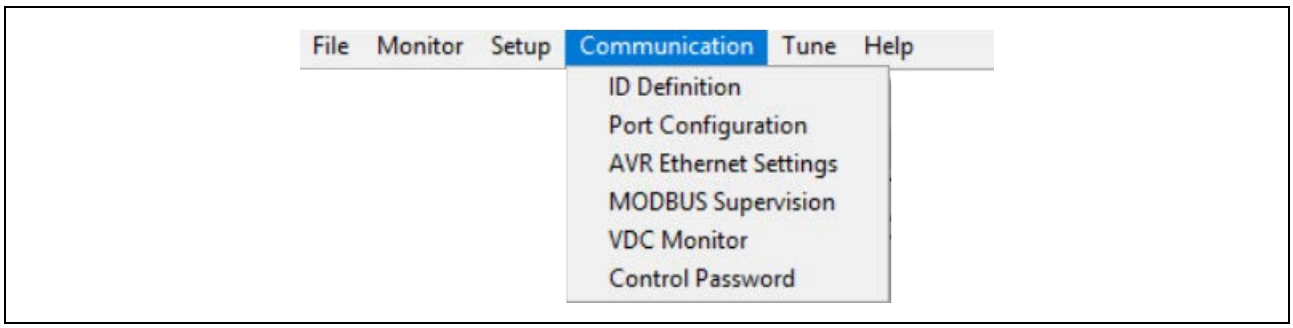
7.6.3.2 Setup > Setpoints menu



Setpoints menu items:

- Auto: Set the setpoints for Auto mode
- PF: Set the setpoints for PF mode
- Var: Set the setpoints for VAR mode
- Manual: Set the setpoints for Manual mode
- Open Loop: Set the setpoints for Open Loop mode

7.6.4 Communication menu



Communication menu items:

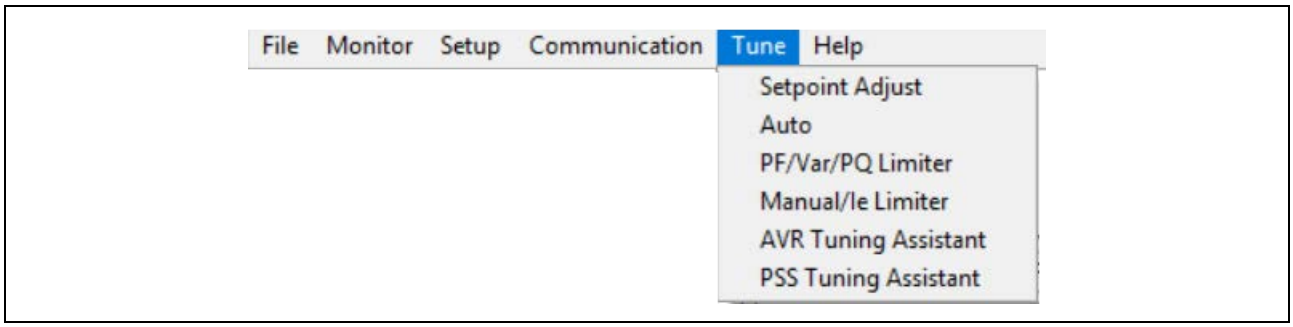
- ID Definition: Set the AVR-ID (for VDC) and the channel identification (for DCH)
- Port Configuration: Configuration of a serial COM port or TCP/IP address
- AVR Ethernet Settings: Settings for the Ethernet communication
- Modbus Supervision: Set Modbus for remote access
- VDC Monitor: Monitoring tool for VDC
- Control Password: Protection against change of parameters

For instructions on the starting procedure and configuration of the AVR, refer to Starting procedure on page 56 and Set the AVR-ID and channel identification on page 71.

For information on the Modbus protocols, refer to the *Modbus Reference Manual* (3BHS358281 E80).

For password protection, refer to Set a control password on page 72.

7.6.5 Tune menu



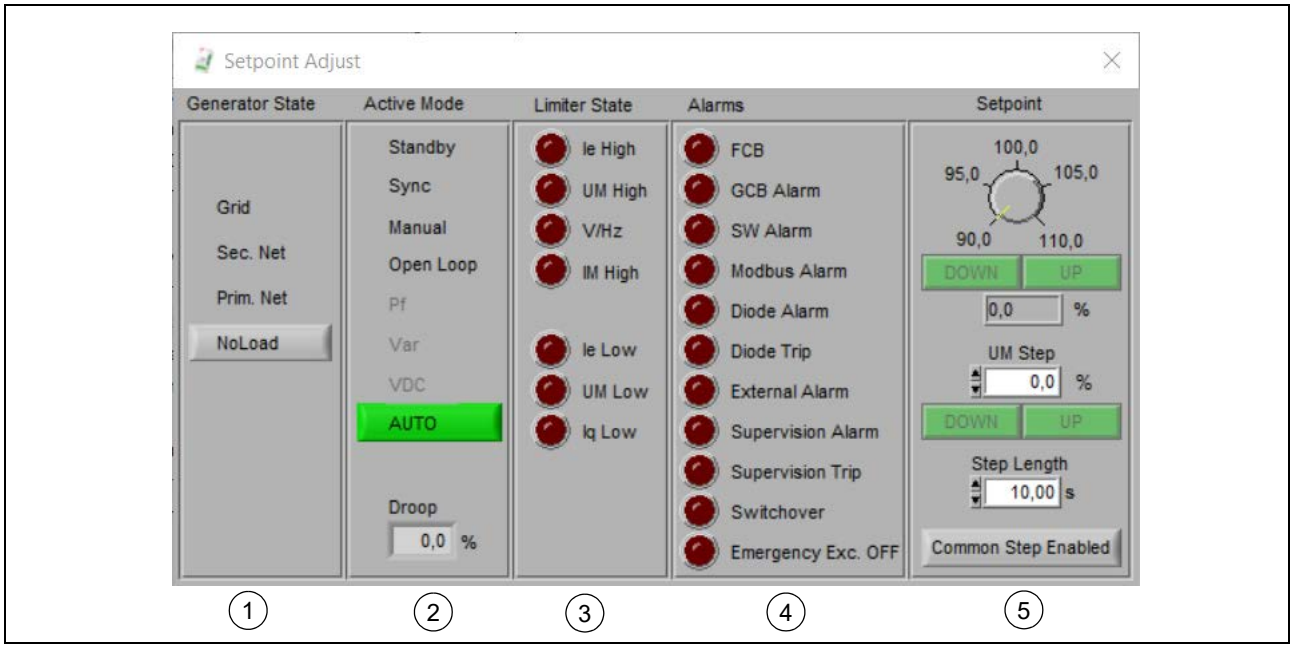
Tune menu includes:

- Setpoint Adjust: Generator states, control modes, alarm and limiter statuses, setpoints and steps
- Auto: Parameters for Auto mode (PID) and Kq Droop
- PF/Var/PQ Limiter: Parameters for PF mode, VAR mode and PQ limiter (PI)
- Manual/Ie Limiter: Parameters for Manual mode (PI) and I_e limiter
- AVR Tuning Assistant: Instrument for commissioning
- PSS Tuning Assistant: Power System Stabilizer

7.6.5.1 Setpoint Adjust

The Setpoint Adjust window includes a visualization of the control modes, generator states, limiters and alarm status. Here you can adjust setpoints and do step response tests.

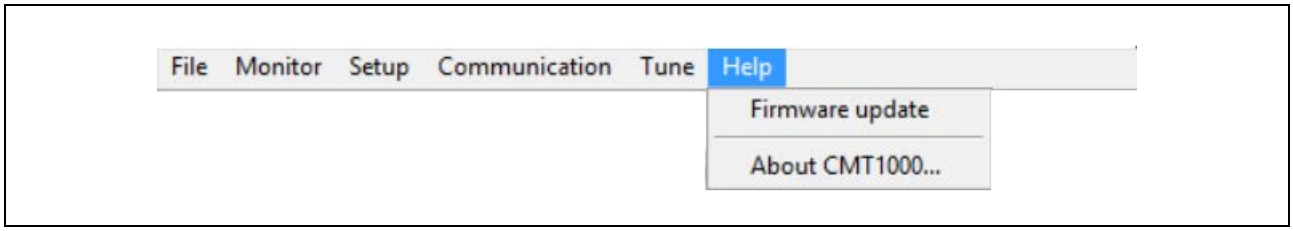
Note! It is recommended to keep the Setpoint Adjust window always open.



1. **Generator State** shows if the synchronous machine is connected to the grid, a secondary network, a primary network or if it has no load.
2. **Active Mode** shows the active control mode of the AVR in green.
   Some control modes can be gray (disabled) if:
   - A software option is not available
   - System conditions are not correct
   - A signal is not set correctly
3. **Limiter State** shows the active limiters in the system.
4. **Alarms** shows the active alarms in the system. An alarm status is not shown if the related software option is not available in the AVR.
5. **Setpoint** shows the setpoint of the control mode that is active.
   - You can adjust the setpoint with the DOWN and UP buttons. Note that you can adjust the setpoint also with analog or digital inputs (“Decrease” and “Increase” signals).
   - You can apply a step to increase or decrease the setpoint of the active control mode. Enter a step value at UM Step and click the DOWN or UP button. Adjust the step with Step Length.

7.6.6 Help menu

In the Help menu you can update the device software of the AVR and get information on the software revisions.



Help menu items:

- Firmware update: Update the device software
- About CMT 1000: Information on the software revisions of the DSP, MCU and CMT 1000

7.6.6.1 Update the device software

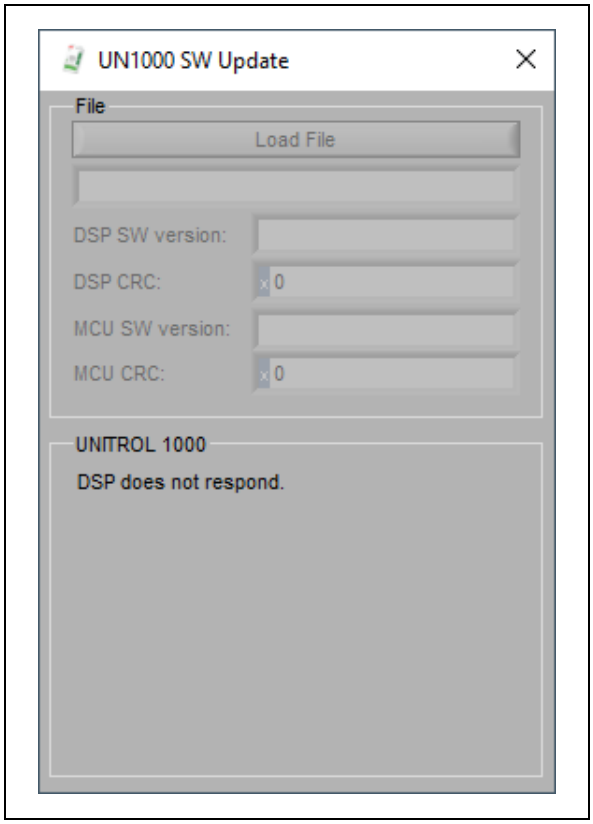
CAUTION

Prepare a backup file of the parameters before you update the device software. For instructions, refer to Upload a parameter file to your PC **on page** 75**.**

Note! You can update the device software with a USB or Ethernet connection between the AVR and CMT 1000. Ethernet connection is faster.

To update the device software:

1. Download the correct software revision from the myABB business portal. For instructions, refer to Documentation, software and tools on page 8.
2. Make sure that CMT 1000 has control access.
3. Open the Help menu.
4. Select Firmware update.
5. Click Load File and select the correct file on your PC.
6. A new window opens. Click Update.
7. A new window opens. Click Continue.
8. The update process is completed in approximately 3 minutes.
9. After the update is completed (at 100 %), disconnect the USB cable or Ethernet cable. Disconnect and connect the power supply to the AVR.
10. Connect CMT 1000 with a USB cable or Ethernet cable to the AVR again.



11. Make sure that the new revision of the device software and CMT 1000 are compatible.

If problems occur:

1. Click Continue to close the update windows.
2. Disconnect the USB cable or Ethernet cable. Reconnect the cable after 5 seconds.
3. Select Control access in the main window of CMT 1000.
4. Do the update procedure again.

7.6.6.2 About CMT 1000

In the About CMT 1000 window you can see:

- AVR S/N: Serial number of the AVR
- Control: Software revision of the measurement and control unit (DSP) of the AVR
- MCU: Software revision of the micro-controller unit (MCU) of the AVR
- SW Revision: Software revision of CMT 1000
- Configuration: ABB or Custom application

Click on the window to close it.

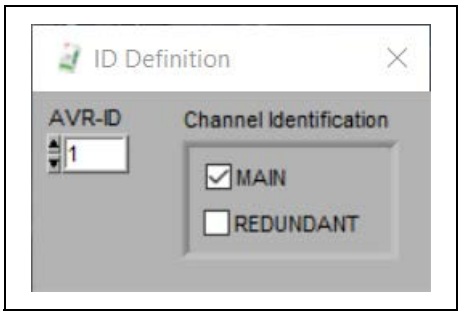
Note! The serial number of the AVR is shown in the About CMT 1000 window. Please give the serial number to the ABB representative when you make requests for software options.

7.7 Additional tools

You can use additional tools to read parameter files and IEEE Comtrade files:

Software tool	Description	URL
Notepad++	To compare parameter files and indicate differences.	http://notepad-plus-plus.org
TOP	To read IEEE Comtrade files and to do overlays.	http://www.pqsoft.com/top/

7.8 Set the AVR-ID and channel identification



To identify the AVR:

1. Open the Communication menu.
2. Select ID Definition.
3. Enter a number between 1 to 31 as an AVR-ID.
4. Select the channel identification: Main or Redundant.

Set an AVR-ID for each AVR. Each AVR must have a unique AVR-ID that identifies the AVR in a (serial) bus. However, in a double channel system the AVR-ID of the two AVRs must be identical.

Channel identification is Main by default. In a double channel system the channel identification must be Main for Channel 1 and Redundant for Channel 2. The main window of CMT 1000 shows the channel identification even if the Double Channel software is not available in the AVR.

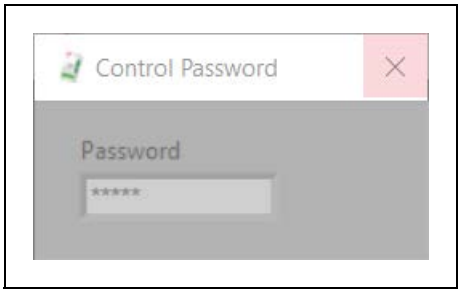
If you do not use the Double Channel software, you can change the channel identification without an effect on the AVR. However, a change of the channel identification has an effect on the Modbus ID that is used for remote access with CMT 1000. The Modbus slave ID that is used for remote access with CMT 1000 is a number between 1 and 63. The number depends on the AVR-ID and the channel identification (Main or Redundant). For more information on Modbus protocol, refer to the *Modbus Reference Manual* (3BHS358281 E80).

7.9 Set a control password

You can use a control password to protect against parameter changes by unauthorized persons. If you use a control password, you must enter it every time to get control access with CMT 1000. The control password activates control access for 10 minutes.

To set a control password:

1. Make sure that CMT 1000 has control access.
2. Open the Communication menu.
3. Select Control Password.
4. Enter a 4-digit code in the range of 0001 to 9999.



Settings for a control password:

- 0000 No password is active (default)
- 4783 Default password, independent of any setting

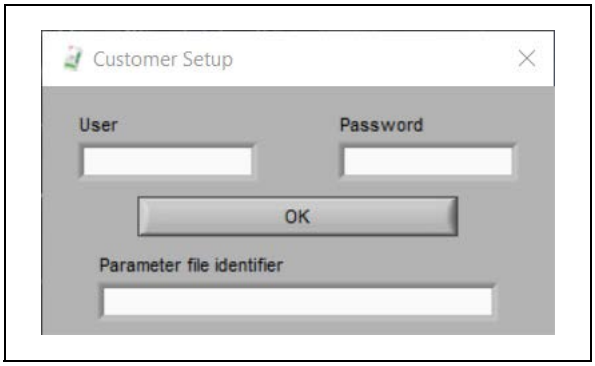
Note! The control password is used only to protect against parameter changes. Use the control password to prevent control access (write access) to the AVR. The control password does not deny access to the AVR by other connected Modbus masters.

7.10 Use a customer setup

It is possible to use the AVR with a user-defined application (OEM customers). Customer setups are protected with a password. Customer setup requires a user name and a password.

To enable a customer setup:

1. Open the File menu.
2. Enter your user name and password.
3. Select OK.



Note! Use the customer setup when CMT 1000 is offline to create and change parameter files. When CMT 1000 is connected to an AVR, you can see all of the parameters depending on the device setup.

7.11 Parameter files

A parameter file contains the parameter values of the AVR. You can examine a parameter file in CMT 1000 or in a text editor. Engineering personnel can prepare a parameter file that contains a set of parameter values for the commissioning of an AVR.

Make sure that you understand the effect of the access levels on parameter files. For more information, refer to Access level statuses on page 90.

CAUTION

- Be careful if you examine a parameter file in a text editor.
- Edit a parameter file only in CMT 1000.
- Do not use a parameter file that has incorrect changes. Incorrect parameter settings can cause damage to the AVR.

An example of a parameter file (an INI file):

```
[SYSTEM DATA]
Ie Nominal = 8.8A
Potential Transformer = Single_Phase
UM Nominal = 0.398kV
UM Primary = 0.398kV
UM Secondary = 243.4V
UNet Nominal = 0.39kV
UNet Primary = 0.38kV
UNet Secondary = 229.0V
IM2 Nominal = 2249A
IM2 Primary = 2250A
IM2Secondary = 1.000A
CT Phase = 0
Ie No Load = 39.0%
Kceiling = 7.00V/V
Xq = 1.14
f Nominal = 50.00Hz
Single Phase Machine = FALSE


[FIELD FLASHING]
Off Level = 0.0%


[SOFTSTART]
Starting Level = 20.0%
Hold Time = 2.0s
Ramp Time = 10.0s
Frequency Start Threshold = 10.0Hz
Upwr Start Threshold = 0V
Line Charging Starting Level = 20.0%
Line Charging Hold Time = 20.0s
Line Charging Ramp Time = 80.0s
```

You can:

- Examine a parameter file (on page 74)
- Edit a parameter file (on page 74)
- Download a parameter file to the AVR (on page 74)
- Write parameters to the non-volatile memory (EEPROM) of the AVR (on page 75)
- Upload a parameter file to your PC (on page 75)
- Prepare a configuration file for commissioning (on page 76)

If problems occur, refer to Problems with a parameter file on page 76.

7.11.1 Examine a parameter file

To examine a parameter file in CMT 1000:

1. Make sure that CMT 1000 is offline.
2. Open the File menu.
3. Select Open Parameter File. The parameter file opens only in CMT 1000. It does not have an effect on the AVR.
4. You can examine the parameter values in the instruments of CMT 1000.
5. If necessary, change the parameter values in CMT 1000.

To examine a parameter file in a text editor:

1. Open a text editor.
2. Select a parameter file on your PC.
3. You can examine the parameter values in the parameter file.
4. Make sure that you do not change any parameters.

7.11.2 Edit a parameter file

To edit a parameter file:

1. Make sure that CMT 1000 is offline.
2. Open the File menu.
3. Select Open Parameter File. The parameter file opens only in CMT 1000. It does not have an effect on the AVR.
4. Edit the parameters in the necessary instruments of CMT 1000.
5. Select Save Parameter File in the File menu.
6. Enter a name for the parameter file.
7. Select a location on your PC.
8. The parameter file is stored on your PC.

7.11.3 Download a parameter file to the AVR

To download a parameter file to the AVR:

1. Make sure that CMT 1000 has control access.
2. Open the File menu.
3. Select Open Parameter File.
   - The parameter file opens in the RAM of the AVR.
   - Note that this procedure overrides the old parameter file in the RAM.
4. Examine the parameter values in CMT 1000 to make sure that the data is correct.
5. If you want to save the parameter values permanently in the non-volatile memory (EEPROM) of the AVR, refer to Write parameters to the non-volatile memory (EEPROM) of the AVR on page 75.
6. If you do not want to save the new parameter values, restart the AVR. The AVR starts next time (power cycle on the control supply) with the previous parameter values.

7.11.4 Write parameters to the non-volatile memory (EEPROM) of the AVR

CAUTION

Save the parameters to the non-volatile memory (EEPROM) of the AVR each time you adjust the parameter values. If the parameters are not saved to the EEPROM, after a power cycle the AVR starts with the previous values.

To save the parameters on the non-volatile memory (EEPROM) of the AVR:

1. Make sure that CMT 1000 has control access. All parameters are read directly from the AVR.
2. Open the File menu.
3. Select Write Parameters to EEPROM.
4. Make sure that the EEPROM status indicator in the main window of CMT 1000 is ON (refer to EEPROM status indicator on page 59).
5. If the EEPROM status indicator is ON, the parameter values are saved in the AVR.
6. If the EEPROM status indicator is OFF, do the procedure again.

7.11.5 Upload a parameter file to your PC

Note! If it is necessary to replace an AVR with a spare unit, prepare a backup file. Save all of the used parameter values in a parameter file.

To upload a parameter file to your PC:

1. Make sure that CMT 1000 has the necessary access level:
   - Monitor or control access to read the parameters directly from the AVR.
   - Off-line to save a new parameter file with data from CMT 1000 only.
2. Open the File menu.
3. Select Save Parameter File.
4. Enter a name for the parameter file.
5. Select a location on your PC.
6. The parameter file is stored on your PC.

7.11.6 Prepare a configuration file

You can use a parameter file called “a configuration file” as a reference parameter file for the commissioning of one or more AVRs.

To create a configuration file:

1. Make sure that CMT 1000 is offline and not connected to an AVR.
2. Make sure that you do not have a parameter file open in CMT 1000.
3. Do the necessary changes to the parameter values.
4. Open the File menu.
5. Select Save Parameter File.
6. Enter a name for the parameter file.
7. Select a location on your PC.

The configuration file is stored on your PC. The configuration file includes the selected parameter values for one or more AVRs.

7.11.7 Problems with a parameter file

CAUTION
CMT 1000 gives a warning message if it is not possible to download a parameter file to the AVR. It is the responsibility of the user to make sure that all of the parameters are set correctly before operating the AVR.

Parameter files must be compatible and created with the same CMT 1000 revision that you use. A warning message occurs if:

- A parameter file is not compatible with your CMT 1000 release.
- A parameter value is out of the permitted range of selection.
- A software option is marked as activated in the parameter file, but it is not available in the AVR.
  - The warning message shows a list of the software options that are marked as activated in the parameter file, but that are not available in the AVR.
  - The software options are activated in the AVR only when you enable them in CMT 1000. Refer to Enable a software option on page 45 for more information.

7.12 Adjust digital I/Os

You can:

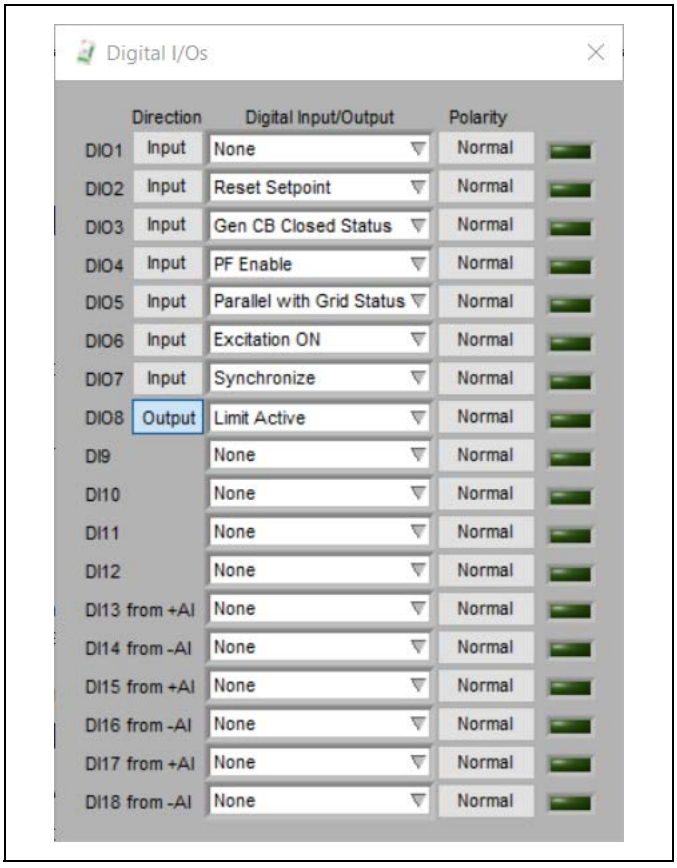
- Set digital inputs DIO1 to DIO8 as input and output at the same time.
- Use digital inputs DI13 to DI18 as virtual digital inputs. They are not set as digital inputs in the analog inputs section.
- Set analog inputs as digital inputs (DI13 to DI18). Refer to Set an analog input as a digital input on page 78.

Note! When you use analog inputs for digital input signals, make sure that both signals are not active at the same time.

Note! The digital input with the highest number overrides digital inputs with a lower number. You can set an input signal two times to enable a function, such as "Excitation ON" during commissioning. For more information, refer to the *UNITROL 1000 Comm-Instruction and PID Tuning* (3BHS399489 E01).

To adjust the digital I/Os:

1. Make sure that CMT 1000 has the necessary access level:
   - Control access to adjust the current parameters in the AVR
   - Off-line to prepare a new parameter file
2. Open the Setup menu of CMT 1000.
3. Select Digital I/Os.
4. Select a digital I/O between DIO1 and DI12. For instructions on digital inputs from DI13 to DI18, refer to Set an analog input as a digital input on page 78.
5. If necessary, select a direction: Input or Output. You can select a direction for the inputs DIO1 to DIO8.
6. Click the white box to open the menu of digital inputs and outputs.
7. Select a signal.
8. Select polarity: Normal or Inverted. Refer to Polarity and forcing digital signals on page 49.
9. The status indicator on the right shows:
   - ON: the signal is logical 1
   - OFF: the signal is logical 0
10. Save the parameter changes:
    - To the AVR (refer to Write parameters to the non-volatile memory (EEPROM) of the AVR on page 75)
    - To your PC (refer to Upload a parameter file to your PC on page 75)

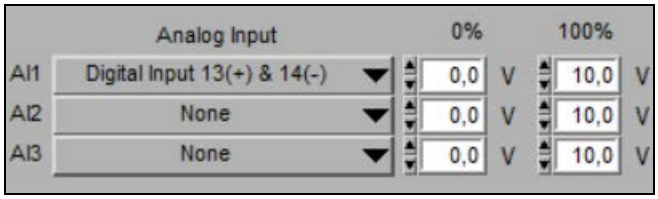


7.12.1 Set an analog input as a digital input

You can set analog inputs as digital inputs to enable the digital inputs DI13-DI18.

To set an analog input as a digital input:

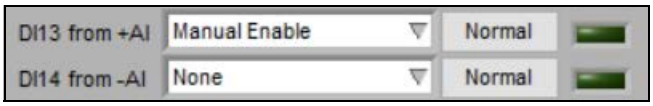
1. Make sure that CMT 1000 has the necessary access level:
   - Control access to adjust the current parameters in the AVR
   - Offline to prepare a new parameter file
2. Open the Setup menu of CMT 1000.
3. Select Analog Inputs.
4. Select an analog input: AI1, AI2 or AI3.
5. Click the gray box to open the menu of digital inputs.
6. Select a signal. For example, to enable the digital inputs DI13 and DI14, select Digital Input 13(+) & 14(-).



7. Adjust the input range:

   U_{in} 0 % = 2.0 V

   U_{in} 100 % = 5.0 V
8. Open the Setup menu of CMT 1000.
9. Select Digital I/Os.
10. Select the necessary signals for the digital inputs DI13-DI18. Click the white box to open the menu of digital inputs.



11. Select polarity: Normal or Inverted. Refer to Polarity and forcing digital signals on page 49.
12. The status indicator on the right shows:
    - ON: the signal is logical 1
    - OFF: the signal is logical 0
13. Save the parameter changes:
    - To the AVR (refer to Write parameters to the non-volatile memory (EEPROM) of the AVR on page 75)
    - To your PC (refer to Upload a parameter file to your PC on page 75)

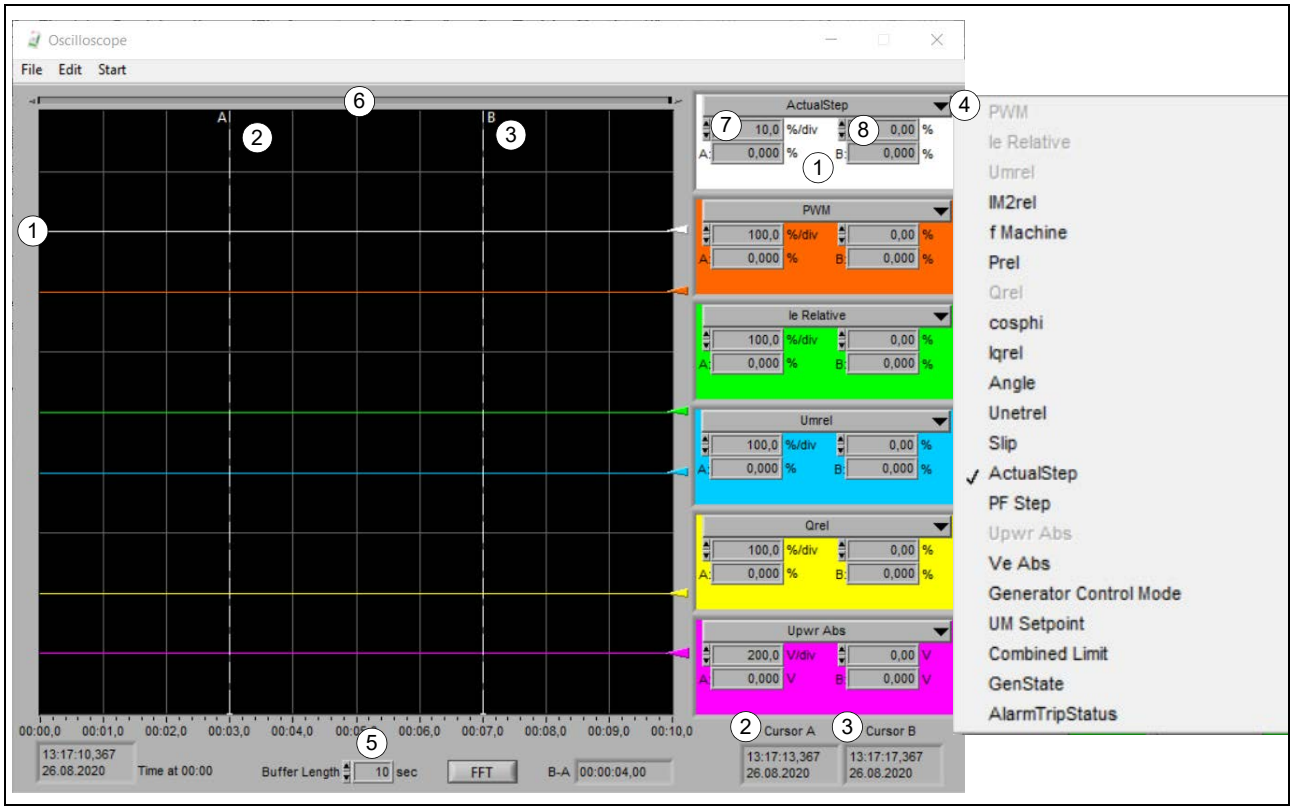
7.13 Oscilloscope

The Oscilloscope visualizes 6 signals at a time (out of 21 signals in the signal menu). You can examine real-time measurements and saved transient data.

You can:

- Set signals for visualization (on page 80)
- Adjust the buffer length (on page 80)
- Save a setup (on page 81) or use a saved setup (on page 81)
- Record operation of the AVR (on page 81)
- Save a waveform file (on page 82) and open a saved waveform file (on page 82)
- Examine a saved waveform file and use a sweep buffer (on page 82)

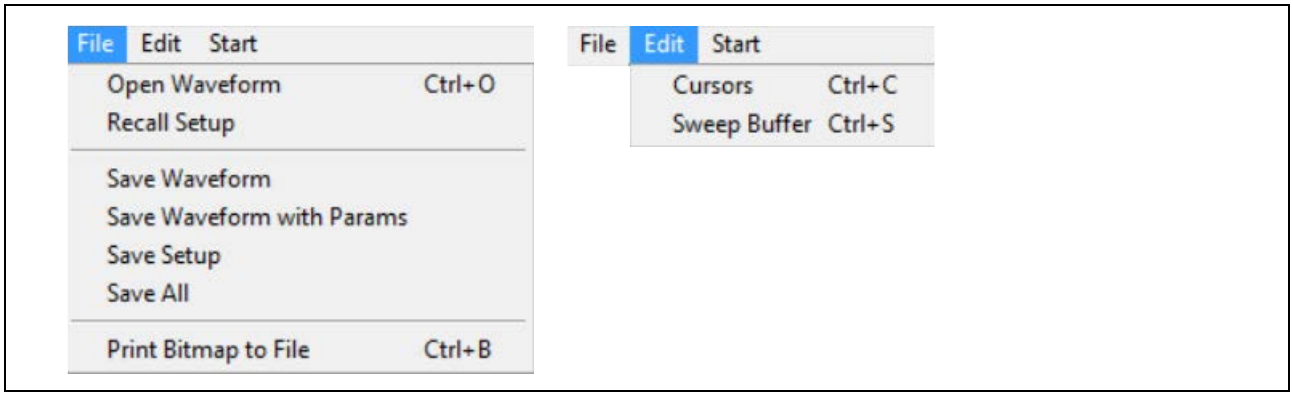
If problems occur, refer to Problems with the Oscilloscope on page 85.



No.	Description
1	Color-coded signals
2	Cursor A
3	Cursor B
4	Signal menu
5	Buffer length
6	Zoom bar
7	Scaling
8	Offset

Note! For a description of the analog signals shown in the Oscilloscope, refer to Analog status signals on page 84.

Oscilloscope menu items:



When you use the Oscilloscope, it is recommended to have these windows open:

- Measurements
- Setpoint Adjust
- Monitor and Protection
- Digital I/Os
- Applicable instruments, such as PQ Diagram and Tune windows

7.13.1 Set the signals

To set a signal in the Oscilloscope:

1. Open the Monitor menu in the main window of CMT 1000.
2. Select Oscilloscope.
3. On the right side of the Oscilloscope window, you can set a signal for each of the 6 color-coded sections.
4. Click the arrow down next to the signal to open the signal menu.
5. Select a signal from the signal menu.
6. You can save the setup to use the same settings later (refer to Save a setup on page 81).

7.13.2 Adjust the buffer length

You can adjust the buffer length of the Oscilloscope to examine and record data on a specific time frame.

To adjust the buffer length:

1. If necessary, make sure to save the data on the Oscilloscope before you change the buffer length (refer to Save a waveform file on page 82).

Note! After the transient data goes through the buffer length, you cannot save the data anymore.

2. In the bottom of the Oscilloscope window, select the box next to Buffer Length.
3. To change the value, select the arrow down or up. You can select a predefined value: 1, 2, 5, 10, 20, 50, 100, 200 or 500 seconds.
4. After you select a new value, the Oscilloscope window changes.
5. If necessary, use the zoom bar to see a bigger or smaller area of the signal. The zoom bar does not have an effect on the buffer length.

7.13.3 Save a setup

To save the settings of the Oscilloscope:

1. Make sure that CMT 1000 has monitor or control access.
2. Make sure you have the correct signals and buffer length.
3. Open the File menu of the Oscilloscope.
4. Select Save Setup.
5. Enter a name for the setup file (a file with a *.cfg suffix).
6. Select a location on your PC.
7. You can use the setup file to record operation later, or on another AVR.

7.13.4 Use a saved setup

To use a saved setup:

1. Open the File menu of the Oscilloscope.
2. Select Recall Setup.
3. Select the correct setup file (a file with a *.cfg suffix) on your PC.
4. The Oscilloscope uses the saved setup.

7.13.5 Record AVR operation

To record the operation of the AVR:

1. Make sure that CMT 1000 has monitor or control access.
2. Select 6 signals of the 21 options.
3. Make sure that the buffer length is correct.
4. Click Start to record.
5. Click Freeze Waveform to stop recording.
6. You can save the waveform file on your PC (refer to Save a waveform file on page 82).

Note! The menu items Start and Freeze Waveform change their names after you select it.

7.13.6 Save a waveform file

To save a waveform file:

1. In the Oscilloscope window, open the File menu.
2. Select Save Waveform.
3. Select a location on your PC.
4. Enter a file name.
5. The saved waveform file has a *.cwf suffix.

7.13.7 Open a saved waveform file

CAUTION

Use the correct version of CMT 1000 to open waveform files. Waveform files that are saved with older CMT 1000 releases (3.xxx or 5.xxx) are not compatible with the CMT 1000 release 6.xxx.

To open a saved waveform file from your PC:

1. In the Oscilloscope window, open the File menu.
2. Select Open Waveform.
3. Find the location on your PC.
4. Select the waveform file. The waveform file opens in the Oscilloscope.
5. If necessary, adjust the buffer length to see the full transient data (refer to Adjust the buffer length on page 80).
6. To examine the saved waveform file, refer to Examine a waveform file on page 82.

7.13.8 Examine a waveform file

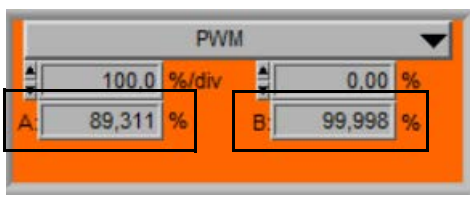
You can:

- Use the cursors A and B (refer to Use the cursors on page 82)
- Examine a saved waveform file (refer to Examine a saved waveform file on page 83)
- Use a sweep buffer (refer to Use a sweep buffer on page 83)

7.13.8.1 Use the cursors

To use the cursors:

1. Make sure that the cursors are enabled (Edit > Cursors).
2. You can move the cursors with your mouse (click + hold + drag) along the signal curve.
3. You can see the instantaneous value of the signals at the cursor point (A and B) on the right side of the Oscilloscope window.
4. If you want to select different signals for visualization, refer to Set the signals on page 80 for instructions.



7.13.8.2 Examine a saved waveform file

The recorded data in a saved waveform file includes all of the 21 signals that you can select. Open other instruments to see the data. Some data is shown in the right side section of the Oscilloscope.

To examine a saved waveform file:

1. Make sure that CMT 1000 is offline.
2. Make sure that the cursors are enabled (Edit > Cursors).
3. Select the signals that you want to examine (refer to Set the signals on page 80).
4. Open the necessary instruments in accordance with the signals you want to examine.
5. Set the cursor A on the signal curve at the time point where you want to examine the transient data.
6. Open the related instrument. The related instrument shows the measurements at the time point.
7. Move the cursor A along the signal curve to examine the measurements in the related instruments.
8. If necessary, adjust the dimensions of the Oscilloscope. Refer to Adjust the buffer length on page 80.

Note! When you move the cursors along a signal curve, the instruments show historical data only if CMT 1000 is off-line. During monitor and control access the instruments show real-time measurements from the AVR.

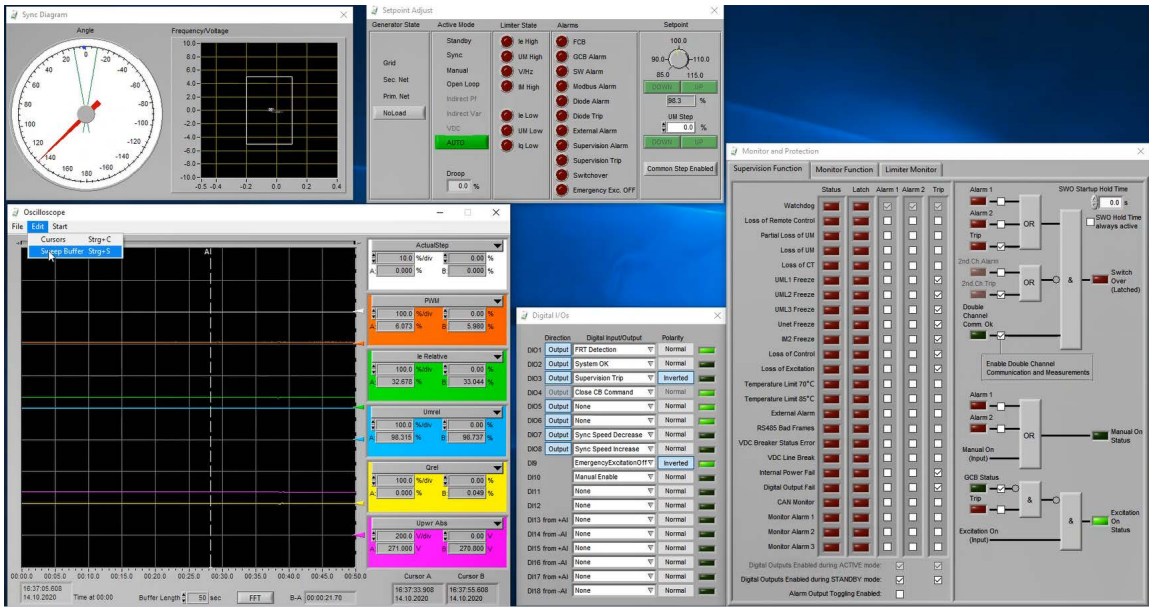
7.13.8.3 Use a sweep buffer

A sweep buffer shows recorded transient data at real-time speed on the Oscilloscope and in the related instruments.

To use a sweep buffer:

1. Make sure that CMT 1000 is off-line.
2. Make sure that the cursors are enabled (Edit > Cursors).
3. Select the signals that you want to examine (refer to Set the signals on page 80).
4. Open the necessary instruments in accordance with the signals you want to examine.
5. Set the cursor A on the signal curve at the time point where you want to examine the transient data.
6. Open the Edit menu and select Sweep Buffer.
7. Cursor A goes automatically along the signal curve to the end of the transient data at real-time speed.
8. Open the related instruments. The selected instruments show the measurements at real-time speed.
9. If necessary, adjust the dimensions of the Oscilloscope. Refer to Adjust the buffer length on page 80.

An example of a sweep buffer:



7.13.9 Analog status signals

There are 4 analog signals that show status changes on the Oscilloscope. The decoding of those signals is explained as follows:

Generator Control Mode		Combined Limit[1]		GenState		AlarmTripStatus	
Signal	**Name**	**Signal**	**Name**	**Signal**	**Name**	**Signal**	**Name**
0	Auto	**0**	None	**0**	Idle (NoLoad)	**0**	None
1	VAR	**1**	Minimum Excitation Current Limiter active (Min I_e)	**1**	Change NoLoad -> Primary Net	**+1**	SW Alarm active
2	PF	**2**	Minimum Machine Voltage Limiter active (Min U_M)	**2**	Primary Net	**+2**	FCB Alarm active
3	Manual	**3**	Minimum Iq Limiter active (Min I_Q)	**3**	Change Primary Net <-> Secondary Net	**+4**	External Alarm active
4	Open Loop	**4**	Maximum Excitation Current Limiter active (Max I_e	**4**	Secondary Net	**+8**	Modbus Communicati on Alarm active

Generator Control Mode		Combined Limit[1]		GenState		AlarmTripStatus	
Signal	**Name**	**Signal**	**Name**	**Signal**	**Name**	**Signal**	**Name**
5	VDC	**5**	Maximum Machine Voltage Limiter active (Max U_M)	**5**	Change Secondary Net -> NoLoad	**+16**	Diode Alarm active (requires RDM SW)
6	Sync	**6**	Reserved	**6**	Primary Net or Secondary Net -> Grid ON	**+32**	Diode Trip active (requires RDM SW)
7	Standby	**7**	Maximum Machine Current Limiter active (Max I_M)	**7**	Grid ON	**+64**	Supervision Alarm active (requires Double Channel SW)
		+8	V/Hz Limiter active	**8**	Grid ON -> Primary Net or Secondary Net	**+128**	Supervision Trip active (requires Double Channel SW)
		+16	Minimum Setpoint reached			**+256**	DCH SwitchOver active (requires Double Channel SW)
		+32	Maximum Setpoint reached				

1) Notes on Combined Limit.

Excitation ON active:

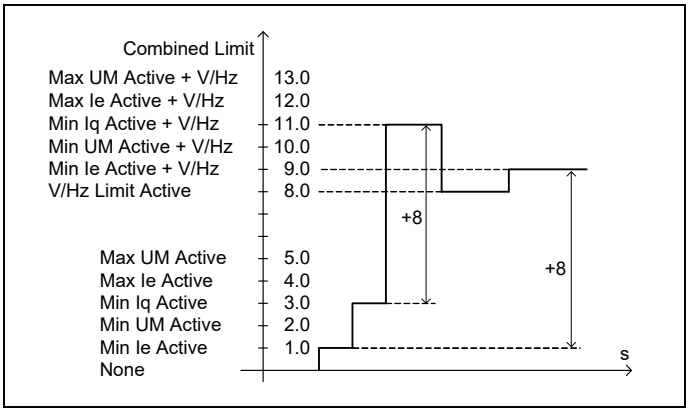
Combined Limit = See values above

Excitation ON not active:

Combined Limit = negative value

Emergency Excitation OFF = -16’384

An example of Combined Limit Status:



7.13.10 Problems with the Oscilloscope

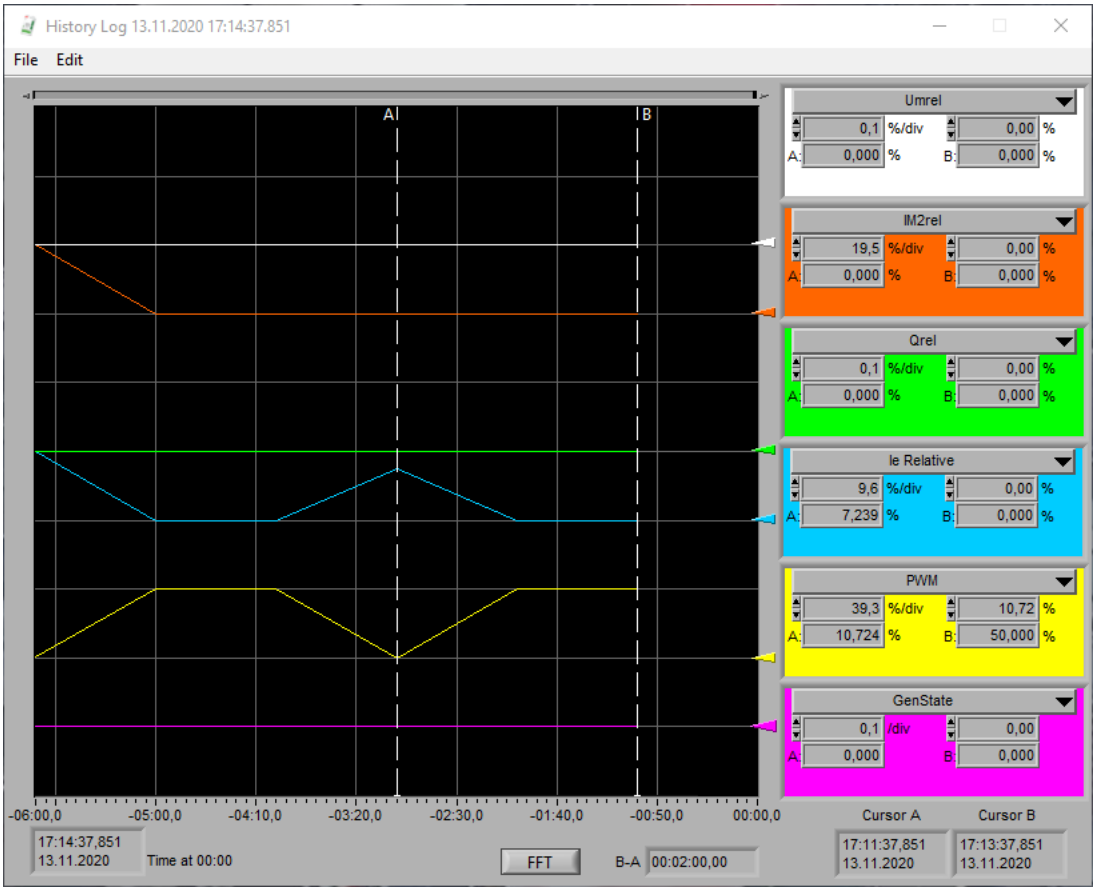
If problems occur:

1. Make sure that the cabling is done correctly.
2. Make sure that the communication between the AVR and CMT 1000 is satisfactory.

During measurement errors, the Oscilloscope freezes and shows the last correct (error-free) measurement for each signal, until you find a solution to the problem.

7.14 History Logger

History Logger records the last two hours of operation. Measurements from 12 defined signals are stored every minute in the non-volatile memory (EEPROM) of the AVR. History Logger requires the History Logger software.



You can use cursor A to show the data on the six measurement channels on the right. You can change the visualized signals. Cursor B shows the default values that are used with the Excitation OFF signal and each time that excitation starts.

You can monitor the signals that follow:

Signal	Description	Default value
Umrel	Machine voltage	0 %
IM2rel	Machine current	0 %
Qrel	Reactive power	0 %
PWM	AVR output (PWM)	50 %
GenState	Generator state	0
Generator control mode	Control mode	0
FMachine	Machine frequency	0 Hz
Combined Limit	Active limiters	0
Prel	Active power	0 %
Upwr	AVR input voltage (rectified)	0 V
Temperature DSP	Temperature of the DSP	0°C

7.14.1 Open a history log from your PC

To open a saved history log file from your PC:

1. Make sure that CMT 1000 is off-line.
2. On the right side of the main window of CMT 1000, select CMT 1000 for UNITROL 1020.
3. Open the Monitor menu of CMT 1000.
4. Select Data Logger.
5. In the Data Log Viewer window, select Open from Disk.
6. A new window opens.
7. In the CombineDataLogFile.vi window, click Change Path.
8. Select a data log file on your PC.
9. The data log file opens in the History Logger.

8. Commissioning

This chapter gives an overview of the commissioning procedure. Only certified personnel can do commissioning of the AVR. Make sure to read and obey the safety instructions on Safety on page 13.

For full instructions on how to do the commissioning of the AVR, refer to the *UNITROL 1000 Com-Instructions and PID tuning* (3BHS399489 E01).

8.1 Precautions

WARNING
 **Do not touch the live parts of the AVR. Manipulation of live parts can cause death or injury, or damage to the machine. The unit operates with dangerous voltages of up to 300 V AC or 300 V DC as power input (and up to 500 V AC for machine and network voltage measurement).**

WARNING
 **Be careful when you touch or connect the cables on the front plate of the AVR. There is a risk of electric shock. The secondary voltage of the excitation transformer and the voltage of the excitation field are fed into the excitation cabinet.**

Disconnect the system completely from power sources before commissioning. Secure against re-connection. Make sure that no measuring voltages or control voltages >50 V are present at the terminals.

At an interrupted field circuit the input capacitor is slowly discharged through internal circuits.

In order to prevent unintentional closing of open voltage circuits by third parties, the circuits in question should be identified at the point of interruption (for example with a warning sign).

Before you start the unit, make sure that the connection terminals are wired up in accordance with the plant schematic.

8.2 Commissioning procedure

This section provides an overview of the commissioning procedure. For detailed instructions on commissioning, refer to *UNITROL 1000 Com-Instructions and PID tuning* (3BHS399489 E01).

Commissioning procedure overview:

1. Make sure that all of the connections are correct and safe.
2. Download the configuration file to the AVR. Make sure that the parameters are correct.
3. Examine the digital and analog I/Os in standstill.
4. Do tests with the machine:

a) Standstill

- Measure the resistance of the exciter stator winding.

b) No-load condition

- Increase the speed of the machine to nominal.
- Start excitation in Manual mode and increase the manual setpoint until machine voltage is at 50 %.
- Use CMT 1000 to verify the AVR measurements and compare them with other equipment used, such as protection devices.
- Increase the setpoint until the machine voltage is at 100 % and tune the AVR with the AVR tuning assistant.
- Do step response tests to examine performance in Manual mode and Auto mode.

c) Machine connected to the grid

- Select Auto mode (voltage regulator).
- Increase the voltage setpoint to verify the polarity of the of IM measurement. Q must increase.

d) Do step response tests to examine performance in Auto mode and direct VAR regulator modes.

5. Finalizing commissioning

- Save the parameters on the AVR and verify the status with CMT 1000.
- Save backup files for project documentation.

WARNING

To prevent unstable regulation and damage to the machine, do tests for all used regulator modes and limiters.

WARNING

If you use synchronization, refer to the procedure in the *UNITROL 1000 Com-Instructions and PID tuning* (3BHS399489 E01). Take special care with synchronization to prevent physical injury or death, or damage to the equipment.

9. Operation

This chapter gives instructions on how to operate the AVR. Before you operate the AVR, read and understand the safety instructions in Safety on page 13. Only qualified personnel are permitted to operate the AVR. Operating personnel must be familiar with the excitation system and the related safety hazards.

Note! ABB recommends periodical training for operating personnel.

DANGER

Dangerous voltage. There is a risk of electric shock.

CAUTION

Do not change parameters after commissioning before you think about the consequences of parameter changes. If you run the excitation system with incorrect data, it can cause incorrect operation, decrease the control accuracy and cause damage to the equipment.

9.1 Operators and access levels

The measurement and control unit (DSP) of the AVR manages the access level statuses and priorities of the operators. Digital inputs have the highest priority to control the AVR. Thus, the AVR is by default in local control with digital inputs. Each operator has a specified priority that has an effect on access requests (refer to Priority of the operators on page 91 and Access requests on page 91).

In addition to digital inputs, you can control the AVR with two operators:

- CMT 1000 (refer to Commissioning and maintenance tool CMT 1000 on page 54)
- Remote access (refer to the *Modbus Reference Manual* (3BHS358281 E80))

9.1.1 Access level statuses

All operators can have monitor access to read data at the same time. Only one operator at a time can have control access to read and write parameters.

9.1.1.1 CMT 1000

The access level status of CMT 1000:

- Offline (no access)

  If the status is offline, the micro-controller unit (MCU) of the AVR considers the operator as disconnected to the AVR. If CMT 1000 senses a compatible AVR, only the AVR-ID, channel identification, and time and date are updated.

- Monitor access (read)

  With monitor access, you can read data from the AVR. It is not possible to change parameters.

- Control access (read and write)

  With control access, you can have full control of the AVR. You can read and write data.

9.1.1.2 Remote access

Send an access request through Modbus. For information on remote access, refer to the *Modbus Reference Manual* (3BHS358281 E80).

9.1.2 Priority of the operators

The priorities of the operators are:

- **Local control with digital inputs (default)**
  The AVR is by default in local control with digital inputs. After other operators disconnect, the AVR goes back to local control.
- **CMT 1000 (medium priority)**
  When CMT 1000 has control access, other CMT 1000 applications or plant control system over remote access cannot get control access. When you set CMT 1000 to off-line, the AVR goes back to local control with digital inputs.
- **Remote access (lowest priority)**
  You can get control access with a remote access connection only if the AVR is in local control with digital inputs and no other operators have control access.

9.1.3 Access requests

The access level status of each operator is stored in the measurement and control unit (DSP). The status information is used to give and deny access requests.

All operators can send a request to have control access. The measurement and control unit (DSP) gives the access to only one operator at a time, based on the priority of the operator. Typically all requests to change the access level to monitor access are approved, because all operators can read data from the AVR at the same time.

Access requests are not approved if:

- More than one CMT 1000 tries to connect to the same AVR
- More than 10 independent remote access connections try to connect to the same AVR

Note! If these limitations are surpassed, one or all of the connected operators can lose their access and go off-line. This practice is not recommended by ABB.

10. Troubleshooting

This chapter gives instructions on how to find faults in the excitation system. Note that this chapter does not fully include all possible faults. Before you start to do work on the excitation system, make sure that you read and understand the safety instructions in Safety on page 13.

10.1 Evaluate AVR operation

To evaluate the correct operation of the AVR:

1. Make sure that the green status LED flashes on the AVR. Refer to Status LEDs on page 20.
2. Connect CMT 1000 to the AVR. Open the Setpoint Adjust window (Tune menu > Setpoint Adjust) and make sure that the settings and operation point are correct. Refer to Setpoint Adjust on page 69.

10.2 A list of possible faults

The table below includes possible faults that can occur in the excitation system. The list includes also the procedure how to examine the fault.

Possible faults:

- The machine cannot be excited (on page 92)
- The machine voltage cannot ramp up (on page 93)
- The machine overvoltage after start-up (on page 94)
- The voltage is not stable in no-load operation (on page 95)
- The machine is not stable in island operation with other machines on the same busbar. A period of oscillation of reactive power and possibly active power (on page 95).
- The machine is not stable in parallel to the grid operation. A period of oscillation of reactive power and possibly active power (on page 96).

10.2.1 Machine cannot be excited

Fault	Cause/Indication	Procedure
Excitation is not on.	Excitation ON command is not received. Setpoint Adjust window shows a gray background on the active mode.	Examine the digital inputs or remote control setup.

Fault	Cause/Indication	Procedure
Excitation is not on.	Excitation is blocked. Setpoint Adjust window shows a red background on the active mode.	Make sure that: • Emergency Excitation OFF digital input is not active • Start frequency is reached as defined in Soft Start • U_{PWR} threshold is reached as defined in Soft Start
The field circuit breaker does not close.	Wiring or digital inputs are not correct.	Examine the wiring of the field circuit breaker. If you use the FCB control function, make sure that the “FCB closed Status” digital output is correct.

10.2.2 Machine voltage cannot ramp up

Fault	Cause/Indication	Procedure
The machine voltage cannot ramp up with shunt supply and field flashing support.	Field flashing does not supply the necessary voltage to ramp up the machine voltage.	Examine the circuit breaker that is related to field flashing. Make sure that the input voltage for field flashing is at 20 % or more of the machine voltage.
The machine voltage cannot ramp up with shunt supply only.	Start-up is based on the residual magnetism of the machine. The residual magnetism of the machine does not provide the necessary supply voltage to ramp up the machine voltage.	Increase the residual magnetism of the machine. Follow the machine instructions.
No power electronics supply U_{PWR}.	Wiring is not correct.	Examine if a protective circuit breaker is open. Measure the power electronics supply U_{PWR} with the Oscilloscope.
Machine voltage cannot ramp up after you have examined the above-mentioned points and setpoints.	V/Hz limiter is active. V/Hz limiter ramp up is set to 100 %. Machine voltage cannot ramp up because the setpoint is set to 0 %.	Set the V/Hz Limiter ramp up to 90 %.

Fault	Cause/Indication	Procedure
Machine voltage cannot ramp up after you have examined the above-mentioned points and setpoints.	Machine voltage cannot ramp up because of the initial setpoint settings.	Examine the initial setpoint settings. Make sure that the initial setpoint is more than 0 %.
Machine voltage ramps up for a short time before excitation goes stops.	A supervision trip is active and forces the excitation to stop.	Examine the active supervision functions. Clear the alarms and trips.

10.2.3 Machine overvoltage after start-up

Fault	Cause/Indication	Procedure
High overvoltage of the machine.	The voltage setpoint is not correct because of incorrect PT settings.	Examine the system data parameters and PT settings.
A short period of machine overvoltage after start-up.	Especially with a shunt supply, the ramp up of excitation can take more time than expected. The ramp time is too short or hold time is not used.	Examine the soft start settings. Make sure that you use hold time to get stable operation before the ramp up starts. Make sure that the ramp time is long enough.
A short period of machine overvoltage after start-up. Field flashing is used.	Field flashing is switched off too late. Or the applied field flashing voltage is too high and it causes a too high excitation current.	Examine the parameters for field flashing.
Bad voltage regulation.	Tuning is not done correctly.	Do a step response test and examine the result with the Oscilloscope to examine the tuning of the AVR. Use the PID tuning assistant to get a correct tuning.

10.2.4 The voltage is not stable in no-load operation

Fault	Cause/Indication	Procedure
Bad voltage regulation.	Tuning is not done correctly.	Do a step response test and examine the result with the Oscilloscope to examine the tuning of the AVR. Use the PID tuning assistant to get a correct tuning.

10.2.5 Machine is not stable in island operation

Fault	Cause/Indication	Procedure
The operation point is not stable.	Reactive load sharing does not operate correctly.	Examine the operation mode and droop settings You must have: • Auto mode with negative Kq settings • or VDC mode with negative Kq setting Make sure that each machine operates with the same voltage setpoint and Kq settings. Typically Kq is set at -4 %.
One or more machines have an active limiter.	Typically the PQ limiter activates to keep the machine voltage within the permitted operation point. Reactive load sharing does not operate if one or more machines are not in Auto mode or VDC mode. If one or more machines is operated in Manual mode, for example after local load application or rejection, the reactive load is not shared equally between the machines.	Make sure that each machine is operated in Auto mode or VDC mode. Make sure that the reactive load is shared equally between the machines on the same busbar.
Oscillations of the active power.	An external governor control or an incorrect cylinder firing of the machine can cause oscillations of the active power.	Use the Oscilloscope to examine the oscillations.

10.2.6 Machine is not stable in parallel to the grid operation

Fault	Cause/Indication	Procedure
The operation point is not stable. PSS is not active.	Network conditions have changed. PID settings are too aggressive.	Evaluate the external reactance. Use the PID tuning assistant to get a correct tuning.
The operation point is not stable. PSS is active.	PSS settings are too aggressive. Or PSS tuning is not correct.	Use the PSS tuning assistant to evaluate the correct PSS tuning.

10.3 Defective unit

DANGER

Do not open or remove the metal front cover that protects the AVR.

CAUTION

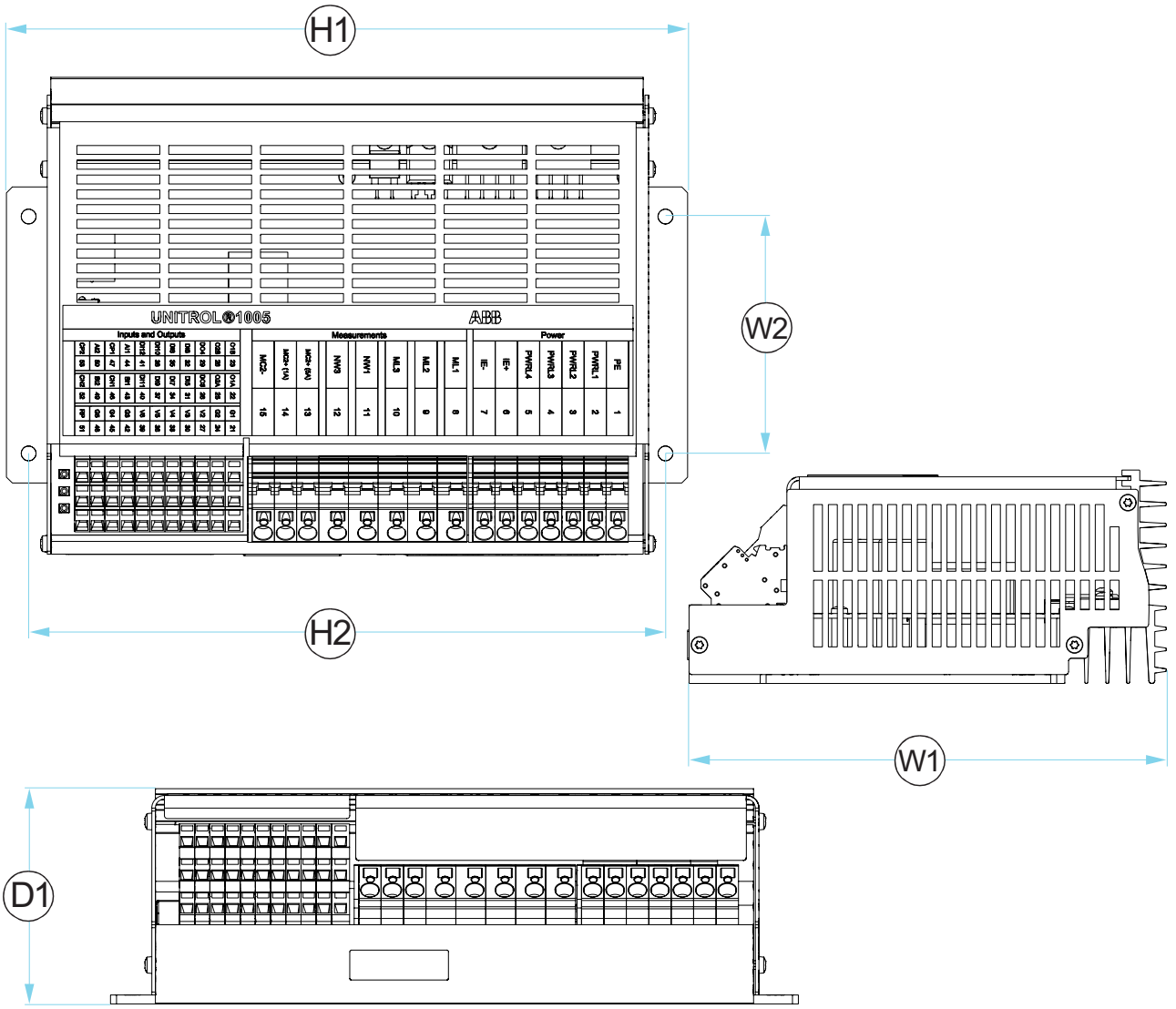
Before you replace an AVR with a spare unit, make sure that you save the parameters to your PC. Refer to Upload a parameter file to your PC **on page** 75**.**

If the AVR is defective, send it to the service center with a detailed description of the fault or failure. Contact ABB for information on your local service center. Refer to Support information on page 10.

11. Technical data

This chapter gives the technical data of the AVR.

11.1 Dimensions



Dimensions and weights											
D1		W1		W2		H1		H2		Weight	
mm	in	mm	in	mm	in	mm	in	mm	in	kg	lb
72	2.8	161	6.3	80	3.1	230	9.1	215	8.5	1.5	3.3

11.2 Electrical data

Electrical data of the power and measurement terminals	
Power supply input (AC/DC)	
AC nominal voltage (sinusoidal)	16 - 250 V AC
AC voltage (maximum sinusoidal)[1]	Maximum 300 V AC
Frequency	40 - 600 Hz
DC nominal voltage	25 - 300 V DC
Maximum DC voltage	420 V DC
Maximum peak voltage (non-sinusoidal)	420 V peak
Test voltage for 1 min	2.8 kV DC
Maximum power consumption (only internal electronic circuits)	7 W
Maximum crowbar firing current for 10 ms	100 A rms
Power supply input (startup)	
Single-phase voltage	6.0 V AC
DC voltage	16.0 V DC
Auxiliary supply for controller only	
DC nominal input voltage	18 - 30 V DC
Excitation output	
Continuous current at 55 °C	8 A
Continuous current at 70 °C	5 A
Maximum current for 10 s at 55 °C	16 A
IGBT and free wheeling diode	
Maximum forward voltage of an integrated free wheeling diode (25 °C, I_F = 8 A)	2.6 V
Maximum reverse voltage of a free wheeling diode	600 V

Electrical data of the power and measurement terminals	
Derating factor (m.a.s.l. >1000 m)	
For installation altitude higher than 1000 m above sea level, a derating factor (kH) applies to the nominal excitation current (Ie). In the formula, h is the installation height of the application in meters above sea level. It is not necessary to reduce nominal voltages, but external overvoltage protection must be adjusted.	$kH = 1 - 85.7\ E^{-6}\ (h - 1000\ m)$
Voltage regulation	
Accuracy at 25 °C	0.2 %
AVR response time (three-phase / single-phase measurement)	< 20 ms / < 50 ms
PWM limitation	0.5 - 99 %
Exciter current measurement	
Full range	0 - 25 A DC
Accuracy after a digital filter	Maximum +/- 1 %
Resolution of a sensor	20 mA
Machine voltage measurement	
Nominal voltage (maximum)	3 x 500 V AC
Full range voltage (phase to phase)	700 V AC
Input impedance	6.0 MOhm
Test voltage for 1 min	2.8 kV DC
Accuracy[2] (-40 to 70 °C / 25 °C)	+/- 1 % / 0.1 %
Network voltage measurement	
Nominal voltage (max.)	1 x 500 V AC
Full range voltage (phase to phase)	700 V AC
Input impedance	6.0 MOhm
Test voltage for 1 min	2.8 kV DC
Accuracy[2] (-40 to 70 °C / 25 °C)	+/- 1 % / 0.1 %
Machine current measurement	
Nominal current	1 / 5 A
Full range current	2.8 / 13.4 A AC

Electrical data of the power and measurement terminals	
Maximum current for 10 s (1 A)	4 A rms
Maximum current for 1 s (1 A)	8 A rms
Maximum current for 10 s (5 A)	22 A rms
Maximum current for 1 s (5 A)	38 A rms
Accuracy	Maximum +/- 1 %
Resolution	Maximum 0.1 %

1: A maximum of a 300 V AC input voltage is permitted. Note that a higher voltage causes severe damage to the unit.

2: Frequency bandwidth: 10 - 200 Hz. Define the accuracy up to 150 Hz with 3 % and up to 200 Hz with 10 %.

Overcurrent capability for excitation output									
Duration	3 s	10 s	20 s	30 s	1 min	2 min	5 min	cont.	units
Ambient temperature									
55 °C	24	16	14	12	11	10	9	8	A
60 °C	21	14	12	11	10	9	8	7	A
65 °C	18	12	11	10	9	8	7	6	A
70 °C	16	10	9	8	7	6	5.5	5	A

Note! Do not load the device for 100 times the defined duration, if an overcurrent occurs.

Electrical data of the analog and digital inputs and outputs	
Analog input +/- 10 V	
Full range peak voltage	+/- 10 V
Input impedance	1100 kOhm
Common mode range	+/- 15 V
Accuracy	< +/- 1 %
Resolution	10 mV
Analog input 20 mA	
Full range peak voltage	20 mA
Input impedance	100 Ohm
Common mode range	+/- 15 V

Electrical data of the analog and digital inputs and outputs	
Accuracy	< +/- 1 %
Resolution	0.1 mA
Digital inputs	
Number of inputs	8
Input impedance to GND	2.2 kOhm
GND reference	PE
Input voltage range	0 - 28 V
Digital input thresholds (high/low)	13 V / 5 V
Digital outputs, isolated	
Number of isolated outputs	2
Voltage range of 24 V output	21 - 25 V
Maximum output current 24 V output	50 mA
Digital outputs, non-isolated	
Number of outputs	2
Voltage range of 24 V output	21 - 25 V
Maximum output current 24 V output	500 mA
24 V output for contacts	
Maximum 24 V driver current (to GND)	50 mA

Note! The maximum cable length for digital and analog input and output cables is 30 m. Refer to Control cabling requirements **on page** 27**.**

Electrical data of the communication interfaces	
Ethernet interface	
Data rate	10/100 MBit/s
Maximum cable length	100 m
Auto-MDIX	
Auto-negotiation and parallel detection	
Isolation to PE	1 kV DC
USB service interface	
Data rate	12 MBit/s
Maximum cable length	3 m

Electrical data of the communication interfaces	
USB version	1.0, 2.0

11.3 Environmental data

Environmental data	
Permitted ambient temperature	
Maximum storage temperature	0 - 55 °C
Recommended storage temperature	25 °C
Operating temperature	-40 - 70 °C
Maximum heat sink temperature	90 °C
Mechanical stability	
Vibration, IEC60068-2-6	DNV class B
Shock and bump, IEC 60255-21-2	Class 2
Seismic, IEC 60255-21-3	Class 2
EMC immunity	
EN 61000-6-2 (Generic immunity standard)	
EMC emission	
IEC 61000-6-4 (Generic emission standard)	
Isolation coordination	
IEC60664-1	
cUL certification (CSA compliant) (pending)	
UL 508, user group	
File number	Pending
DNV certification (pending)	
Housing	
Protection class of housing	IP20
Pollution degree	3
Dimensions L x W	230 x 161 mm
Height	72 mm
Weight	1.5 kg

11.4 Markings

CE marking

DNV.COM/AF

SQS

11.5 UL certification (pending)

To use the AVR in a UL compliant way, obey these rules:

- Maximum ambient temperature is 70 °C.
  - Maximum output capability at 70 °C 5 A / 150 V
- Use only 60/75 °C wires.
- Use only in a Pollution Degree 2 environment.
- Identify the correct connections with marks for for the power supply, control and load.
- Identify the grounding conductor terminal plainly with “PE”.

11.6 Reliability

UNITROL 1005		
MTBF (MIL-HDBK-217F)	GB (40°)	32.4 years
Failure rate in time	GB (40°)	3562 FIT
Operational lifetime of capacitors		> 150,000 h
Average ambient temperature		40 °C
Input power		Three-phase
Exciter current		8 A

11.7 Storage and recycling

Follow the storage procedures to avoid damage or a degradation of quality due to corrosion, dirt or mechanical damage. Take precautions from the time the unit goes to storage until the time you take the unit out of storage and install it.

Make sure to recycle:

- Packing materials
- Unit components

11.7.1 Storage conditions

Put the unit to storage in the original product package. Make sure that the environmental conditions are in the permitted range during storage. ABB recommends to keep the ambient temperature and the relative air humidity constant. Refer to Environmental data on page 102 for more information.

11.7.2 Recycling instructions

CAUTION
Only qualified personnel can discard electrical equipment. The inappropriate disposal of electrical equipment can cause an environmental hazard.

The unit has materials that can be used as raw materials for recycling. Speak to your local waste disposal company for an ecological separation of materials and waste management.

Obey the local regulations to discard:

- Batteries
- Capacitors
- Electronic components
- Printed circuit boards

Note! Only a licensed waste disposal company can remove and recycle printed circuit boards. It is necessary to remove any environmentally hazardous components from the printed circuit boards.

It is possible to discard the unit by manual disassembly or mechanical shredding.

11.7.2.1 Manual disassembly

1. Disassemble the unit manually into materials.
2. Follow the local regulations to recycle the materials that follow:
   - Aluminum (cabinets, heat sinks)
   - Copper
   - Iron
   - Plastics
3. Remove any environmentally hazardous components such as capacitors from the printed circuit boards.
4. Follow the local regulations to recycle the materials that follow:
   - Batteries
   - Capacitors
   - Electronic components
   - Printed circuit boards

11.7.2.2 Mechanical shredding

1. Remove dangerous materials and components that can cause damage to the environment.
2. Put the unit in a shredding machine.
3. The unit is mechanically shredded into small pieces.
4. Recycle the materials.

11.8 Ordering information

Description	Order code	Order text
UNITROL 1005-0011 ECO	3BHE043576R0011	
UNITROL 1005-0012 LIGHT	3BHE043576R0012	

11.9 Settings record for the AVR

Settings record		
Name and address of customer		
Plant		
Order No.		
Plant schematic No.		
Device identification		
Type plate		
Delivery date		
Software revision		
	Device software	
	CMT 1000	
Remarks		
Place and date of commissioning		
	Name	Company

For more information, visit

abb.com/unitrol

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