ADVANCED ENERGY®

THYRO-AX™
THYRISTOR-LEISTUNGSSTELLER / THYRISTOR POWER CONTROLLER

CONTENTS

LIST OF ILLUSTRATIONS AND TABLES

ABBREVIATIONS

AN1 - phase angle of the 1st half wave
SST - soft-start time
SYT - synchronized clock
T0 - cycle period
TS - switch-on time
TAKT - full wave mode Thyrotakt
VAR - phase angle firing Thyrovar
QTM - quick takt mode
SWITCH - switch mode

KEY FEATURES

• Integrated semiconductor fuse
• Type range 230-600 V~, 16-1500 A, single phase, two phase uand three phase
• Load voltage from 24 V~
• Touch display capable of full graphics
• Electronic supply with 230V~/110V~ (85 V-265 V permissible)
• Ohmic load and transformer load as well as load with large R_{warm} /R_{cold} ($\leq$ 6) and configurable peak current limitation up to 3 x I_{nom} in operating mode VAR.
• Soft-start function for transformer load
• Channel separation, needed in case of counter voltage
• Load current monitoring
• Measurement of real phase value (current, voltage, power and resistance)
• Fuse monitoring
• 5 Multi-I/Os
• 1 signaling relay
• 3 analog outputs
• Flexible connection: supply and outflow from above or below as selected
• Control modes U, U^2, I, I^2; P
• Thyristor short circuit protection
• Operating modes TAKT, VAR, SWITCH and QTM (QTM only in the case of the single phase device, VAR only in the case of the single and three phase device)
• Mains load optimization: internal for operating modes QTM and TAKT, connection for external mains load optimization e.g. Thyro-Power Manager (QTM only in the case of single phase device)
• Control by analog or digital setpoint, via PC, touch display or via optional bus adapter
• Data logger
• Operating hours counter
• Energy counter
• Internal/external measuring transformer
• USB interface
• Safe isolation in accordance with DIN EN 50 178
• UL approval (for standard devices 16 - 350A)

Options:
• Coupling to different bus systems e.g. PROFIBUS DPV1, Modbus RTU, DeviceNet, CANopen, PROFINET, EtherNet/IP and Modbus TCP. Other bus systems on request.
• Connection for optional visualization and commissioning software Thyro-Tool AX via USB (optional also via RS-232 adapter).The Thyro-Tool Family can also be used to an certain extent.

1. SAFETY NOTES

The safety notes and the operating instructions are to be read carefully before installing and commissioning.

1.1 OBLIGATORY INSTRUCTION

These safety notes and operating instructions shall carefully be read by all persons deployed for work using and employing the Thyro-AX prior to assembly, installation and the initial start-up of the Thyro-AX. These operating instructions are part of the Thyro-AX.

The operator of the device is committed to provide these operating instructions without limitation to all persons, who transport the Thyro-AX, start it up, maintain it, or perform other work tasks to it.

In accordance with the Product Liability Act the manufacturer of this product is obligated to inform about and warn against

• other than the intended use of a product
• the residual hazards of a product as well as
• incorrect usages and their consequences

The following information is intended for this purpose. This information should warn the product user and protect him and his appliances.

1.2 APPROPRIATE USAGE

The Thyro-AX is a power controller which is capable of communication. It can be used anywhere where alternating voltages, alternating currents or power need to be regulated in thermic process engineering. The Thyro-AX has several different operation and control modes, good connection to process and automatization technology, high regulation accuracy and simple handling.

• The Thyro-AX is a component which may only be used to control and regulate electric energies in industrial alternating or three-phase networks.
• The Thyro-AX may at most be operated with the maximum permissible connection values in accordance with the details on the type plate.
• The Thyro-AX may only be operated in connection with an appropriate upstream mains disconnecting device (e.g. switch, take note of DIN EN 50110-1)
• The Thyro-AX is not functional on its own and must be project planned for its appropriate usage in order to minimize the residual

hazards of the product.
• The Thyro-AX may only be used for the purpose for which it was intended, as persons may otherwise be exposed to dangers (e.g. electric shock, burns) and systems also (e. g. overload).
• It is not permitted to make any unauthorized modifications to the device or to use any spare parts or replacement parts not approved by Advanced Energy, or to use the device for any other purpose.
• The warranty obligations of the manufacturer are only applicable if these operating instructions are observed and complied with.
• It must be ensured that in the case of an error no uncontrolled large currents, voltages of power can occur in the circuit.
• In the case of an error even with appropriate usage it is possible that the currents, voltages or power in the load circuit are no longer affected by the device (example: in the case of the destruction of of the power components (fully alloyed or high resistance) the following reactions may result: current interruption, half wave operation, continual flow of energy).

1.3 RESIDUAL HAZARDS OF THE PRODUCT

Even with intended use it is possible, in the case of an error, that the currents, voltages or power in the load circuit are no longer affected by the Thyro-AX.

If the power components are destroyed, for example, the following cases are possible: current interruption, continual flow of energy.

If such a case occurs, then the occurring load voltages and currents result from the physical sizes of the overall circuit. Throughout the project planning of the system it must be ensured, that no uncontrolled large currents, voltages or power can occur.

1.4 INCORRECT OPERATION AND THEIR CONSEQUENCES

In the case of incorrect operations, higher power, voltages or currents than intended can reach the thyristor power controller or the load. This can cause damage to the thyristor power controller or the load.
In particular, factory-set parameters may not be altered in such a way that the Thyro-AX is overloaded.

1.5 SCOPE OF SUPPLY

The supply consists of the following parts:
• Thyro-AX
• Accessory bag with screw/push terminals
• Operating instructions
• Safety note stickers

1.6 STORAGE

The devices may be stored originally OEM packaged in rooms, which
are dry and ventilated.
• permissible ambient temperature: -25 °C to +55 °C
• permissible relative air humidity: max. 85%
For longer storage durations, the devices should be contained in airtight
plastic skins with the addition of commercially available drying agents.

1.7 ASSEMBLY

• If stored in cold environments it must be ensured that the device is
  absolutely dry before commissioning. Therefore allow at least 2 hours
  acclimatization time before commissioning.
• Ensure sufficient ventilation and de-aeration of the cabinet if mounted
  in a cabinet.
• Observe minimum spacing.
• Ensure that the device cannot be heated up by heat sources below it.
  (see Technical data).
• Ground the device in accordance with the local regulations.
• Connect the device in accordance with the connection diagrams.

For further details see the chapter „Installation".

1.8 CONNECTION

Before connection, the indicated voltage on the type plate is to be
compared with the mains voltage to make sure they match. The electrical
connection is made at the points labelled on the Thyro-AX.

1.9 MAINTENANCE, SERVICE, FAULTS

The symbols used in the following are explained in the chapter on
safety requirements.
In order to avoid damage to personnel or property the user must note
the following points before all work:

CAUTION
In the case of smoke or smell development, as well as in the case of
fire, the power controller shall immediately be disconnected from the
power supply.
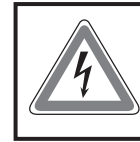
CAUTION
For maintenance and repair works the power controller must be dis-
connected from all external voltage sources and safeguarded against it
being switched on again. After switching off wait at least two minutes
for the snubber capacitors to discharge. The absence of voltage is to
be ascertained using appropriate measurement instruments. The device
is to be grounded and short-circuited. Adjacent components under
voltage are to be covered or separated off. These activities may only be
carried out by an electrically qualified person. The local electro-techni-
cal regulations are to be adhered to.

CAUTION
The thyristor controller contains voltages which are hazardous. Repairs
are strictly only to be carried out by qualified and trained maintenance
personnel.
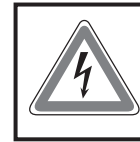
CAUTION
Hazard of electric shocks. Even after the separation from the mains,
capacitors can still contain dangerously high levels of energy.

CAUTION
Hazard of electric shocks. Even with a non-activated thyristor cont-
roller the load circuit is not separated from the mains by the thyristor
controller.

ATTENTION
Different power components are screwed in place with exact torques
according to their function. For safety reasons repairs to power com-
ponents are to be carried out by Advanced Energy Industries GmbH.
Repairs by personnel of the operator require a written confirmation of
the manufacturer.

1.10 REPLACEMENT OF THE INTEGRATED SEMI-CONDUCTOR FUSE

The device has got an integrated semiconductor fuse F1 for each power unit which is designed protection reasons for the thyristor. If it has to be replaced, the device shall immediately be disconnected from the power supply. Before resumption of operation it is responsible for seeing that all screws are fastened and no unfasten screw are in the cabinet.

1.11 SHUT DOWN, DIS-ASSEMBLY

If shutting down and dis-assembling the device for the reason of venue change or for disposal purposes the following safety rules must be complied with prior to the beginning of all work performed:

ATTENTION MAINS VOLTAGE!

Safety rules for work performed to electrical facilities:
1. Disconnect the device from the power supply (establish a voltage free status)
2. Secure against re-activation
3. Verify by measurement that there is no voltage present
4. Ground and short-circuit equipment
5. Cover or separate adjacent parts which are under voltage

For dis-assembly, perform the following steps:
1. Separate the device from the 230VAC, respectively 110VAC, power supply.
2. Separate all other connections.

Electrical connections are thus dis-assembled and now, the device can be removed by dis-assembly from the overhead rail.

2. SAFETY REQUIREMENTS

2.1 IMPORTANT INSTRUCTIONS AND EXPLANATIONS

For the protection of personnel and the maintenance of good working order, usage and repairs must be in line with the guidelines, and the safety requirements listed must be adhered to. The personnel who set up/disassemble the devices, start them up, operate them, maintain them, must know and adhere to these safety requirements. All works may only be carried out by specialist personnel trained for the purpose and equipped with the tools, appliances, means of testing and materials required and intended for that purpose.

In these operating instructions, there are important warnings before dangerous actions. These warnings are divided into the following classes of hazards:

DANGER
Hazards that can lead to serious injuries or fatal injuries.

WARNING
Hazards that can lead to serious injuries or considerable damage to property.

CAUTION
Hazards that can lead to injuries and damage to property.

CAUTION
Hazards that can lead to minor damage to property.

The warnings can also be supplemented with a special danger symbol
(e.g. „Electric current" or „Hot device") , e.g.

in case of risk of electric current or

in case of risk of burns.

In addition to the warnings, there is also a general note for useful
information.

NOTE
Content of note

2.2 GENERAL DANGER INFORMATION

DANGER

ELECTRIC CURRENT
Hazards that can lead to serious injuries or fatal injuries.

WARNING

ELECTRIC CURRENT
Risk of injury from current carrying parts
• Never operate the device without covering.

CAUTION

HOT DEVICE
Risk of burns from heat sinks and adjacent plastic parts (> 70 °C possible)
Do not touch the hot parts of the device.
Affix the warning sign "Risk of burns" in the immediate vicinity of the
device.

DANGER

HAZARDS DURING INSTALLING
Not adhering to the safety requirements in the operating instructions of
the power controllers being used can lead to danger of injury/danger
of damaging the device or system.
- Adhere to all safety requirements in the chapter "Safety" of the ope-
  rating instructions of the power controllers being used.

DANGER

UNSAFE SYSTEM DUE TO INCORRECT INSTALLATION
Incorrect installation can lead to unsafe operation of the system.
Therefore it is essential to maintain the following specifications:
- Only install the device in an upright position.
- Ensure sufficient ventilation and de-aeration of the cabinet if mounted
  in a cabinet.
- Observe minimum spacing (clearance: 150 mm above, 100 mm
  below). The devices can be installed next to one another without
  spacing between.
- Ensure that the device cannot heat up as a result of heat sources from
  below (the power loss is listed in the type overview table, see chapter
  Technical data).
- Ground the device in accordance with the local regulations (ground
  screw/bolt for protective conductor connection on the heat sink). The
  grounding also serves for EMC means (Y - capacitor 4.7 nF + 12 M).
- Cover energized parts
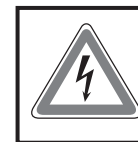
CAUTION

USE OF INCORRECT CONNECTION CABLES
Incorrect connection cables can lead to functional faults.
Use shielded control cables to connect the control signals.
For use in UL conditions: for power connections only use 60 °C or 75 °C
copper conductors (in accordance with the information in the Technical
data).

2.3 QUALIFIED PERSONNEL

Only qualified personnel who are familiar with the pertinent safety and installation regulations may perform the following with the Thyro-AX:
• transport
• installation
• connection
• commissioning
• maintenance
• testing
• operation

These operating instructions must be read carefully by all persons working with or on the device prior to installation and initial start-up.

2.4 REQUIREMENTS TO THE OPERATOR

The person responsible for the system must ensure that
• Safety notes and operating instructions are available and adhered to.
• Operating conditions and technical data are heeded.
• Protective devices are used.
• Maintenance personnel are informed immediately or the Thyro-AX is taken out of action immediately if abnormal voltages or noises, higher temperatures, waves or similar occur, in order to identify the cause.
• The accident prevention regulations valid in the respective country of use and the general safety regulations are observed.
• All safety devices (covers, warning signs etc.) are present, in perfect condition and are used correctly.
• The national and regional safety regulations are observed.
• The personnel have access to the operating instructions and safety regulations at all times.

2.5 INTENDED USE

CAUTION

The Thyro-AX may only be used for the purpose for which it was intended, as persons may otherwise be exposed to dangers (e.g. electric shock, burns) and systems also (e. g. overload).

It is not permitted to make any unauthorized modifications to the Thyro-AX or to use any spare parts or replacement parts not approved by Advanced Energy, or to use the Thyro-AX for any other purpose.

These operating instructions contain all the information required by skilled personnel using the Thyro-AX. Additional information and notes for non-qualified persons and for the use of the Thyro-AX outside of industrial assemblies are not contained in these operating instructions.

The warranty obligations of the manufacturer are only applicable if these operating instructions are observed and complied with.

2.6 LIABILITY

No liability is burdened for non-intended by the manufacturer use of the Thyro-AX. The operator or user, respectively, shall burden the responsibility for possibly necessary measures for the prevention of people and asset damage. In case of complaints, please contact us immediately and include the following information:
• type designation
• fabrication number /serial number
• complaint description
• duration in operations
• ambient temperature
• mode of operation

2.7 GUIDELINES

The devices of the type series Thyro-AX comply with the currently applicable EN 50178 and EN 60146-1-1. BGV A3 is considered by the compliance with EN 50274.

The CE sign attached to the device confirms compliance with the EC directives for 2006/95/EEC for low voltage and 2004/108/EEC for electro-magnetic compatibility, if the installation and commissioning instructions described within the operating instructions are followed.

Regulations and definitions for specialists are included in DIN EN 50110-1.

Safe separation in accordance with EN 50178.

3. NOTES ON THESE OPERATING INSTRUCTIONS

3.1 VALIDITY

These operating instructions correspond with the technical status of the Thyro-AX at the time of issue. The content is not the subject of the contract, but rather serves to provide information. We reserve the right to make amendments to the details in these operating instructions, in particular to technical data, operation, measurements and weights. Advanced Energy reserves the right to make content amendments and technical alterations to the details in these operating instructions unannounced. Advanced Energy cannot be held responsible for any inaccuracies or incorrect details in these operating instructions as there is no obligation to make ongoing updates to these operating instructions.

These operating instructions only apply to the Advanced Energy power controller Thyro-AX in the versions of the types indicated on the cover sheet. The safety notes contained are to be noted in particular.

3.2 TYPE DESIGNATIONS

The type designation of the thyristor power controller is derived from the configuration of the power unit and other features.

Thyro-AX 1A — Thyristor controller with single phase power unit, suited for single phase loads

Thyro-AX 2A — Thyristor controller with two phase power unit, suited for symmetrical loads in three phase operation in the three phase economy circuit (connection to L1 and L3) Thyro-AX calculates the values of load current, load voltage, power and resistance on phase L2 by measured values of phase L1 and L3.

Thyro-AX 3A — Thyristor controller with three phase power unit, suited for three phase loads

DESIGNATION (EXAMPLE)	CHARACTERISTICS	DIFFERENT VERSIONS OF THE POWER CONTROLLER
Thyro-AX 3A	Three phase power controller with three phase power unit	
...400-	with 400V type voltage	230 V, 400 V, 500 V, 600 V
...280	with 280A type current	16 ... 1500 A
H	with integrated semiconductor fuse	
F	with fan	
R	with signaling relay	
L	with load monitoring	*
P	with additional power control	
2	Identification 2, Thyro-AX series	

Example:
Thyro-AX 3A...RLP2
* device-specific

Thyro-AX ...H RLP2

Thyristor power controller with integrated semiconductor fuse, system bus interface, fully graphically capable touch display, additional 230 V~/ 110 V~ electronic supply input, signaling relay, load current monitoring and analog output, channel separation, with the operating modes TAKT, VAR, QTM and SWITCH, synchronization option for mains load optimization, the control modes U, U², I, I² and P. Suitable for the visualization and commissioning software Thyro-Tool AX.

3.3 HANDLING

These operating instructions for the Thyro-AX are structured in a manner so that according expert personnel may perform all work necessary for commissioning, maintenance, and repair.

If threats to personnel and material cannot be ruled out for certain work, such tasks are marked with a pictogram, from which the according content may be extracted from the before mentioned chapter „Safety requirements".

3.4 LOSS OF WARRANTY

Our supplies and services are subject to the general conditions of supply for products of the electrical industry, as well as our general sales conditions. Claims in connection with supplied goods must be submitted within eight days upon receipt, along with the packing slip. Claims made later cannot receive consideration.
Advanced Energy will rescind all possible obligations such as warranty agreements, service contracts, etc. entered into by Advanced Energy or its distributors without prior notice if maintenance and repair work is carried out using anything other than original Advanced Energy spare parts or spare parts purchased from Advanced Energy.

3.5 COPYRIGHT

No part of these operating instructions may be transmitted, reproduced and/or copied by any electronic or mechanical means without the express prior written permission of Advanced Energy Industries GmbH.
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3.6 FURTHER INFORMATION ON COPYRIGHT

Thyro-AX™ is an international registered trademark of Advanced Energy Industries GmbH.
All other company and product names are (registered) trademarks of the respective owners.

4. CONTACT

4.1 TECHNICAL QUERIES

If you have any technical queries regarding the subjects dealt with in these operating instructions, please get in touch with our team for power controllers:
Phone: +49 (0) 2902 763-520 or
Phone: +49 (0) 2902 763-290

4.2 COMMERCIAL QUERIES

If you have any commercial queries on power controllers, please get in touch with:
Phone: +49 (0) 2902 763-558
powercontroller@aei.com

4.3 SERVICE

Our team is at your service on the following hotline:
Advanced Energy Industries GmbH
Emil-Siepmann-Straße 32
D-59581 Warstein
Tel. +49 (0) 2902 763-0

4.4 INTERNET

Further information about our company or products please see
www.advanced-energy.com

5. COMMISSIONING

The Thyro-AX may only be started when there is absolutely no danger to persons or system.
• Protect the device against dust and damp
• Ensure that the ventilation openings are not blocked.
• Observe minimum spacing (clearance: 150 mm above, 100 mm below). The device can be installed next to each other without spacing between.
• Cover energized parts

5.1 CONNECTIONS

The device has to be connected to the power supply and to further external components or devices (PLC, Thyro-Power Manager or PC), which are contingent to the application, in accordance with the connection diagrams.

5.1.1 GROUNDING

The grounding of the device shall be performed in accordance with the local regulations (grounding screw/nut for connecting the protective conductor to the heat sink). Grounding also serves for EMC means (Y capacitor 4.7 nF + 12MΩ).

5.1.2 POWER SUPPLY AND LOAD

The connection of the power supply takes place in accordance with the illustrations.
1. Switch off power supply and ensure it cannot be switched back on again.
2. Ground the power controller.
3. Connect the load to the terminals (T1 + T3 in the case of the Thyro-AX 2A, T1 + T2 + T3 in the case of 3A devices, or only T1 in the case of the Thyro-AX 1A device)
4. Connect the terminals L1, L2 and L3 to the circuit breaker. In the case of Thyro-AX 2A and 3A devices the connection must be made to a clockwise rotating field in the power circuit.
5. Only in the case of Thyro-AX 1A and 2A devices: connect terminal X1.1 to N or the other / middle phase. When connecting to a phase

a 2A slow acting fuse is required, at N the connection can be made directly. The terminals (X1.1 and X1.2, 1.5mm2, grid 3.5) are bridged internally.
6. Make any other necessary connections.

The input voltage is used simultaneously for mains synchronization. Using flexible connection the terminals for the power can be used from above or from below. Contacts with the same designation are connected with one another internally so that the connections can be divided up to enable various combinations.

WARNING
HAZARDS DURING INSTALLATION
Danger of injury/damage to the device or system
- Take note of the labelling for the connections, as contacts with the same designation are connected internally and if confused there is a risk of a short-circuit occuring.

5.1.3 ELECTRONIC SUPPLY

The electronics of the control device is supplied by a separate connection with 230V~ / 110V~ (85V - 265V 47Hz - 63Hz). The connection is made at terminals X4.1 and X4.3 (1.5mm^2, grid 3.5). Terminals X4.1 and X4.2, along with X4.3 and X4.4 are internally bridged and offer an alternative connection option.
The connection cables are to be fused in accordance with the applicable regulations. An internal 2A fuse protects the device in the case of internal short-circuits. In the case of Thyro-AX 2A and 3A each power unit must be connected separately to the electronic supply, this is wired up correspondingly at delivery.

5.1.4 FAN

Devices with a rated current from 230A and more require a power supply of 230V~ for fan at terminal X7. Devices with a rated current of 30A and 100A come with a fan which is feed in by the device. In this case no extra connection is required. The connection is wired up correspondingly at delivery.

5.1.5 CONTROL SIGNALS

The control signals influence the functional mode of the device. Shielded control cables must be used for the connection of the control signals.

The following control signals are required for the operation of the device:
- Connect setpoint (setpoint 1 to X2.4 (signal) and X2.3 (ground) or connect setpoint 2 to X2.11 (signal) and X2.3 (ground). Alternatively via bus module or PC)
- Pulse inhibition (connect terminal X2.2 with ground X2.1)

If the pulse inhibition bridge is not connected then the device is blocked and will not function. Communication via the interfaces continues to be possible.

Please read carefully the information given in chapter 5.1.6. when using the USB interface.

5.1.6 USB INTERFACE

When using the USB interface, e.g. for the use of the Thyro-Tool AX, the special Advanced Energy USB cable has to be used between the PC and Thyro-AX to avoid malfunctions.

The shorter part of the wiring cable (plug - filter, approx. 30 cm) has to be connected to Thyro-AX while the longer part of the wiring cable (filter - plug) has to be connected to the USB plug of the PC.

5.1.7 CONNECTING TERMINALS (OVERVIEW)

TERMINAL		DESCRIPTION	GRID DIMENSION
X3	.1	root, common connection	5.08
	.2	N/O contact, open when there is a fault (closed circuit principle)	
	.3	N/C contact, closed when there is a fault	
X22	.1	bus setpoint activation (factory setting)/ setpoint switchover	3.5
	.2	TxD / connection to bus module	
	.3	RxD / connection to bus module / multi I/O 3 (In)	
	.4	control ground	
	.5	connection to slave power section	
	.6	connection to slave power section	
	.7	control ground	
	.8	analog output 3 0-10 V or 0(4)-20 mA	
	.9	multi I/O 1 (In/Out, default setting: In)	
	.10	external voltage transformer	
	.11	control ground	
	.12	external current transformer	
	.13	external current transformer	
X2	.1	control ground	3.5
	.2	pulse inhibition	
	.3	control ground	
	.4	analog - setpoint input 1, max. 10 V, max. 20 mA / multi I/O 4 (In)	
	.5	control ground	
	.6	sync. Out (internal mains load optimization) / multi I/O 2 (Out)	
	.7	sync. In (digital In, internal mains load optimization) / multi I/O 2 (In)	
	.8	+ 5V output, e.g. for a setpoint potentiometer (5 k$\Omega \leq R_{Poti} \leq$ 10 kΩ)	
	.9	analog output 1, 0-10 V or 0(4)-20 mA	
	.10	ground potential, as may be shielded control cable	
	.11	analog - setpoint input 2, max. 10 V, max. 20 mA / multi I/O 5 (In)	
	.12	analog output 2, 0-10 V or 0(4)-20 mA	
	.13	control ground	
X1	.1	auxiliary phase L2 / N	3.5
	.2	auxiliary phase L2 / N	
X4	.1	phase for additional electronics supply	3.5
	.2	phase for additional electronics supply	
	.3	N for additional electronics supply	
	.4	N for additional electronics supply	
X7	.2	phase for fan	3.5
	.3	ground for fan	

TAB. 1 CONNECTING TERMINALS (OVERVIEW)

5.1.7 CONNECTION DIAGRAMS
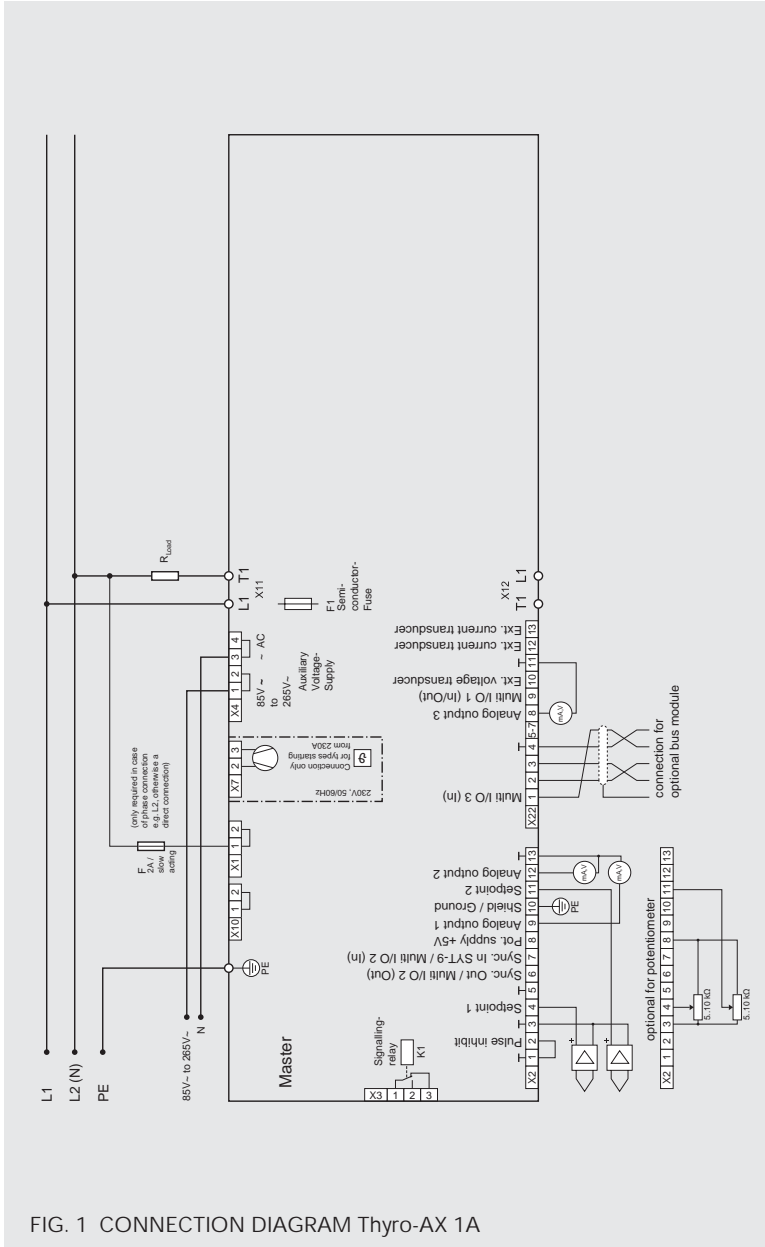
FIG. 1 CONNECTION DIAGRAM Thyro-AX 1A
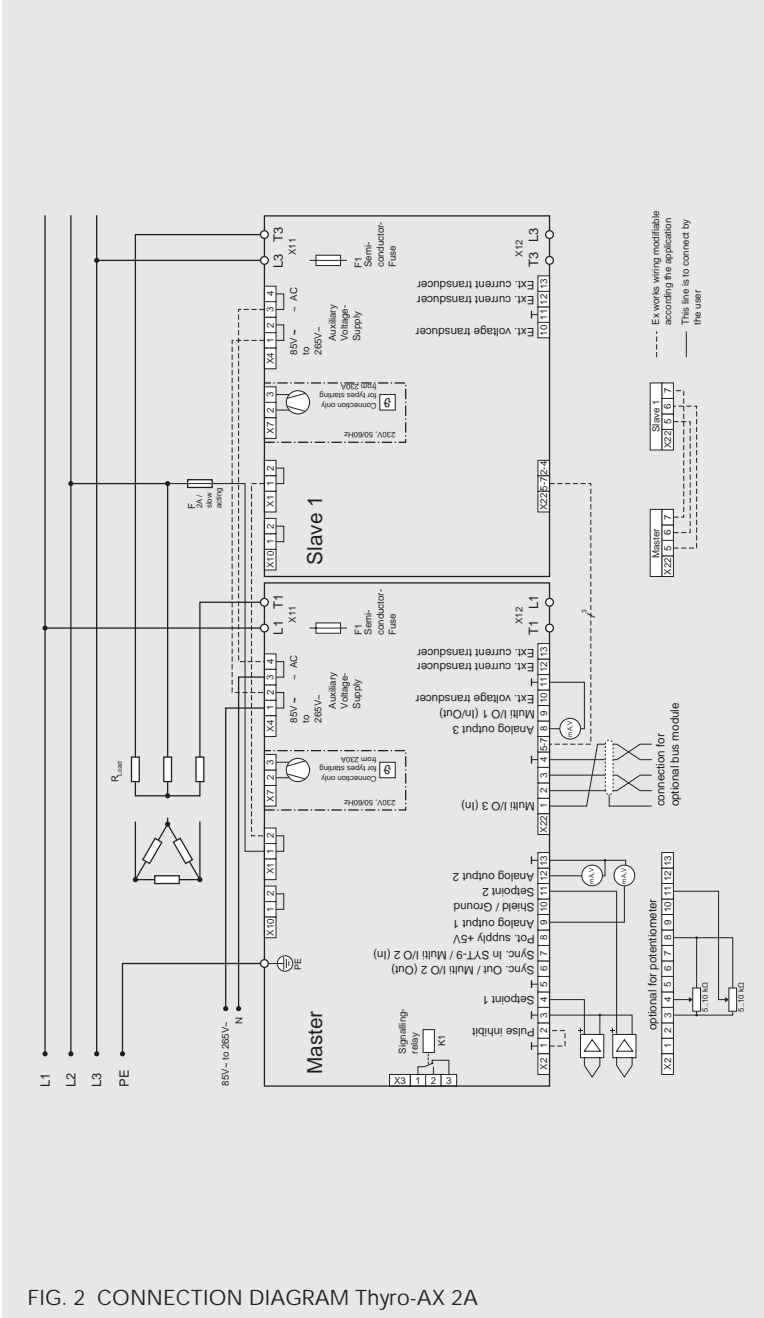
FIG. 2 CONNECTION DIAGRAM Thyro-AX 2A
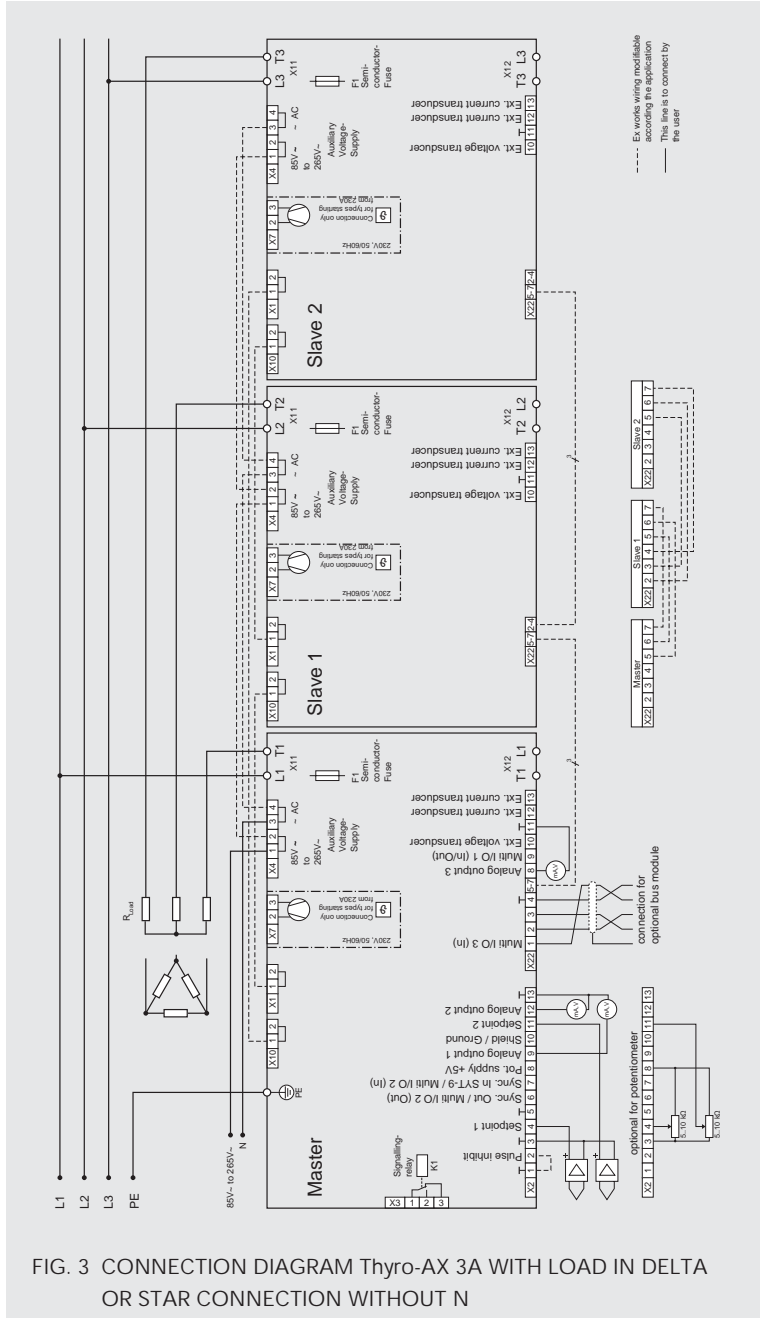
FIG. 3 CONNECTION DIAGRAM Thyro-AX 3A WITH LOAD IN DELTA
OR STAR CONNECTION WITHOUT N
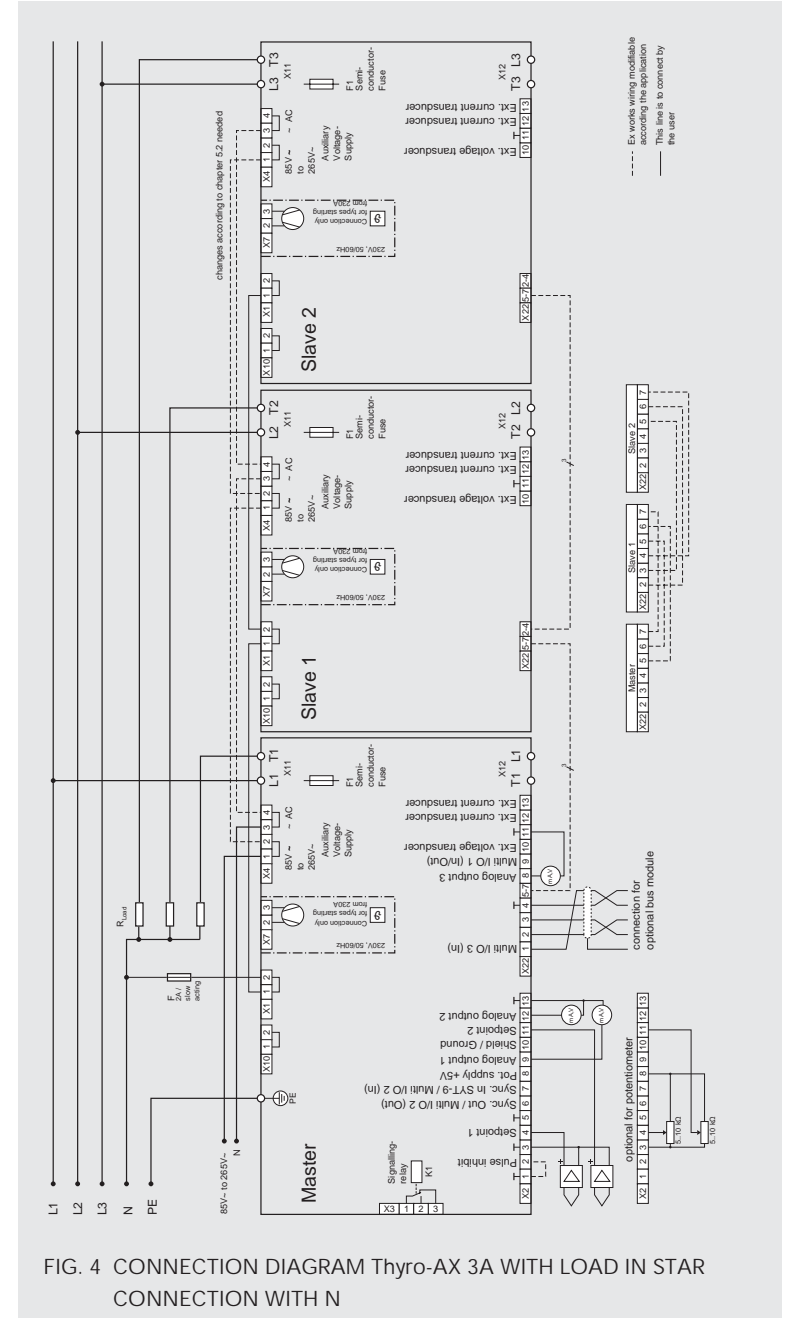
FIG. 4 CONNECTION DIAGRAM Thyro-AX 3A WITH LOAD IN STAR
CONNECTION WITH N
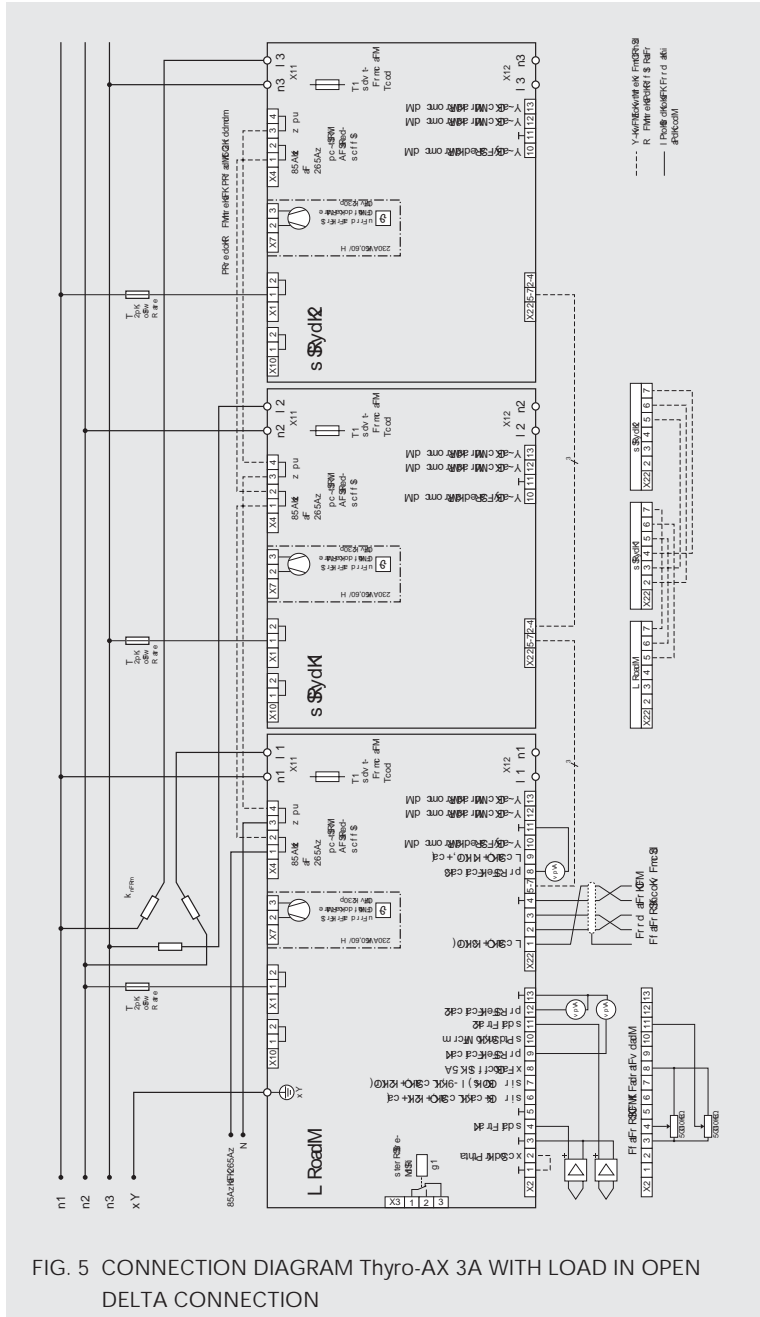
FIG. 5   CONNECTION DIAGRAM Thyro-AX 3A WITH LOAD IN OPEN
DELTA CONNECTION

5.2 LOAD CONFIGURATION

For load connection if applicable the wiring has to be adjusted for
terminals X1 and X10. This depends on the connection option and has
to be done in accordance to the respective connection diagram, see
chapter 5.1.7 Connection diagrams.
- Star or delta connection without N: Factory setting, no changes
  necessary
- Star connection with N: Changes of wiring of X1 and X10 necessary
- Open delta connection: Changes of wiring of X1 and X10 necessary

When changing the load connection is has to be adjusted via para-
meters. This setting can be done by touch display, Thyro-Tool AX soft-
ware or acyclic communication of a bus protocol.

Touch display

The general functionality of the touch display is explained in chapter 7.
Display and operational elements. If the connection option has not
previously been set up via EasyStart configuration or has not yet been
changed, the modification can be done in accordance to the following
structure:
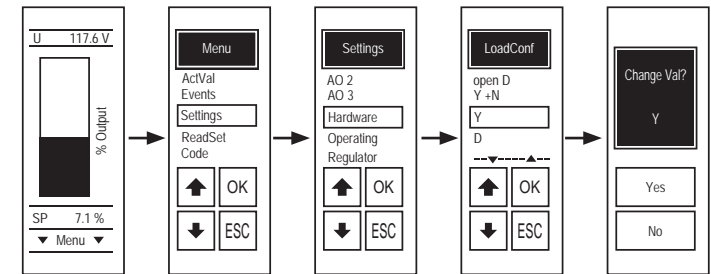
Thyro-Tool AX

Load configuration can be found under the same parameter name
(symbol: LoadConf). The modification has to be saved in the unit for
permanent usage.

Settings -> Hardware -> LoadConf -> Star connection with N (only
                                     Thyro-AX 3A version)
                                     Star or delta connection without
                                     N (factory setting)
                                     Open delta connection

5.3 IP20 PROTECTION

DANGER
Energized parts.

The device shall immediately be disconnected from the power supply before installation.

The Thyro-AX is designed according to IP20 protection code. To ensure protection during operation, the correct mounting is necessary of the added protection devices at each electric connection. In the following pictures the mounting of the protection devices is shown, this handling also applies to 2- or 3- phase units of Thyro-AX.

Devices of 45A/60 A/100A :

For non-used connections:
• The blind cover for non-used connections has to be inserted into the plug-in edge at the front top of the device
• The back part of the blind cover has to be pressed into the device cover until it snaps into place

For used connections (cable is connected):
• The protection cover has to be placed with its plug-in edge in the direction of the device and be placed at the cable with its semicircle gap
• Push the whole backplane over the sideways rails towards the cover
• Protection cover has to be hooked with its plug-in edge into the front hole
• Press the back part of the cover into the device cover until it snaps into place

blind cover

protection cover

backplate of protection cover
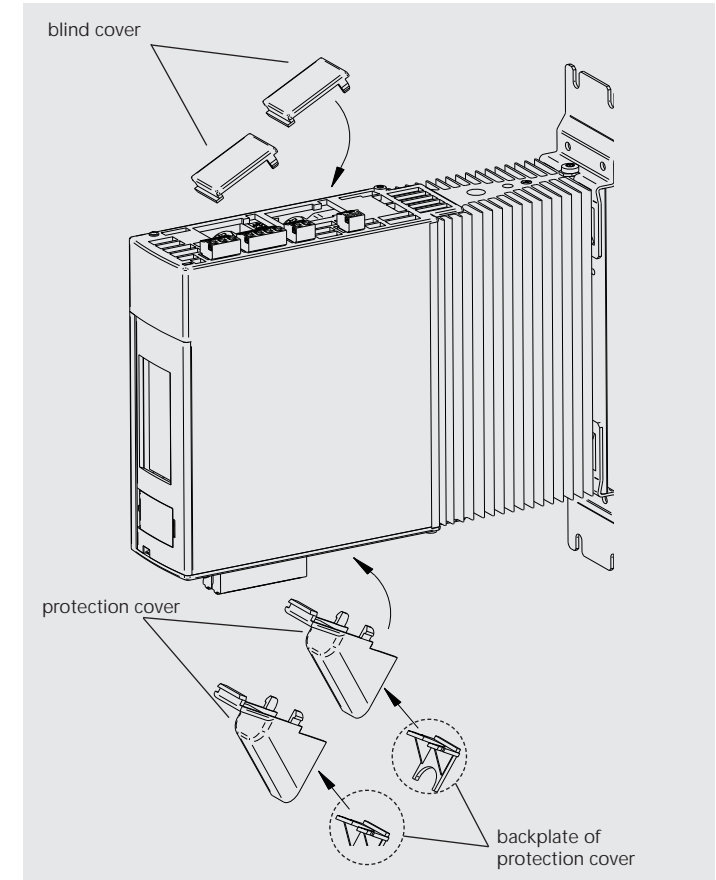
NOTE
In the case of both connection from top or from bottom are used at the same time, both backplanes of protection covers (see dotted line in the figure) have not to be mounted.

For devices of 100A please consider additionally that the rear backplate of protection cover (see dotted line in the figure) has always not to be mounted due to the close-by fuse cover. This is only the case when the device is connected from below.

Devices of 130A/170A/240A/280A/350A :

For non-used connections:
• The blind cover for non-used connections has to be inserted into the
  plug-in edge of the device

For used connections (cable is connected):
• The protection covers have to be mounted according to the direction
  arrows in the figure.
• If the customer used connections are wider than the standard gaps
  used for these protection covers, then the cover have to be adjusted
  by the customer in accordance to the given gaps.
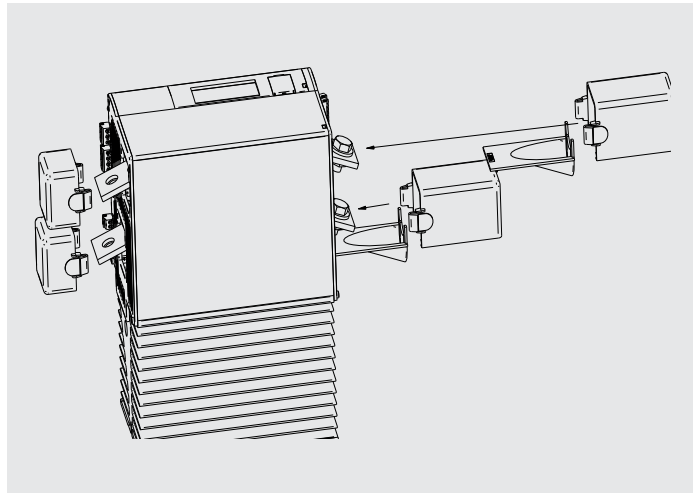
Devices 495A/650A:

For non-used connections:
• The blind cover for non-used connections has to be inserted into the
  plug-in edge of the device

For used connections (cable is connected):
• The protection covers have to be mounted according to the direction
  arrows in the figure.
• If the customer used connections are wider than the standard gaps
  used for these protection covers, then the cover have to be adjusted
  by the customer in accordance to the given gaps.

In Detail:
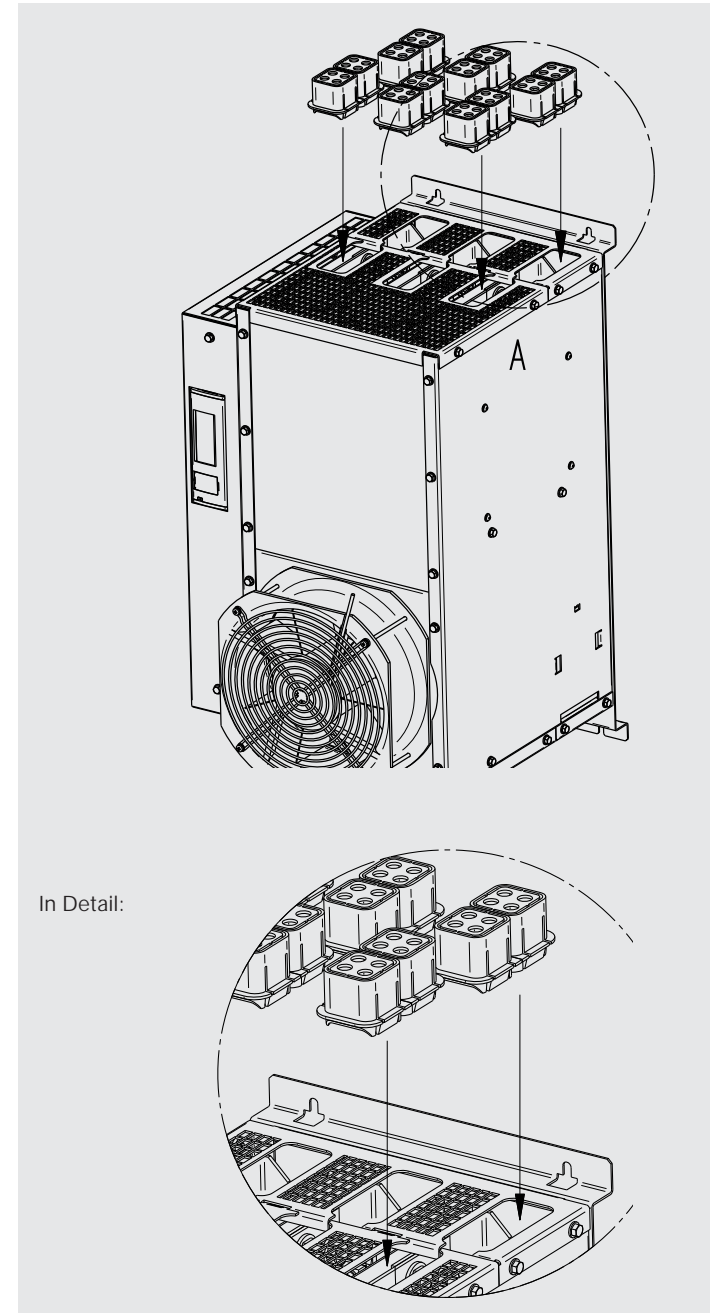
For devices 1000A/1400A/1500A:

Before connecting the device all coverages (above and / or below as well as in the front) have to be removed.

The connections coming from the customer side have to be connected to the copper bars of the device. Afterwards the according parts have to be removed with a side cutter so that the area around the copper bars to free for connection. Please be consider that an adequate IP20 protection can only exist when the area around the copper bars has only be removed as may be necessary.
Then the according coverages have to be fixed again on the device.

The following pictures illustrate a potential position of the coverages:
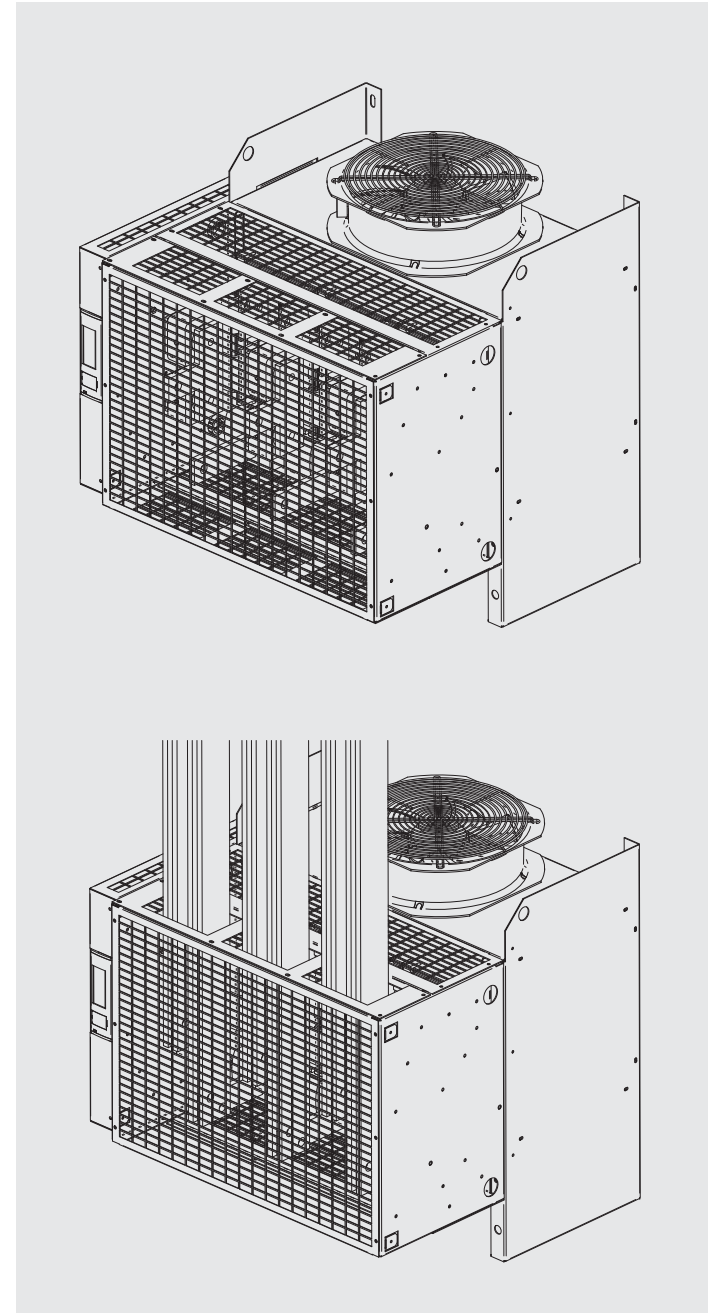
6. DESCRIPTION OF FUNCTIONALITY

So that the Thyro-AX can be fitted to the desired application optimally it is equipped with a variety of functions.

NOTE

OPTIMAL ADAPTATION OF THE Thyro-AX TO THE LOAD
With the selection of the operating and control mode the Thyro-AX can be optimally adapted to the load.

NOTE

INDICATED TIMES
The times indicated in the following (duration), e.g. T_0 or SST are given as the number of full waves. In this way the exact times for the frequency actually used can be indicated.

6.1 OPERATING MODES

For optimal adaptation to different applications and manufacturing procedures or varying electrical loads the appropriate operating mode is selected by the user.

6.1.1 FULL WAVE MODE TAKT

The mains voltage is switched periodically depending on the defined setpoint. In this operating mode almost no harmonics of the mains frequency occurs. Whole multiples of network periods are always switched, which avoids continuous current elements. The full wave mode is particularly suited to loads with heat inertia. Nevertheless, any occurring feedback to mains (e.g. flickering) can be reduced to a negligible amount with the aid of mains load optimization (see chapter Mains load optimization).

6.1.2 PHASE ANGLE FIRING VAR (ONLY THYRO-AX 1A AND 3A)

Depending on the defined setpoint the sinus wave of the mains voltage is shifted with a larger or smaller trigger delay angle α. This operating mode is characterized by its high control dynamics. In the case of phase angle firing, harmonics of the mains voltage occur. These can be minimized or considerably reduced by using various circuit types.

6.1.3. SST RAMP IN OPERATING MODE TAKT

After switching-on the power supply of the power controller (or after reset or re-start of control electronics) , the switching-on of load starts also in operating mode TAKT with Soft-Start ramp.
As soon as there is a set point at the power controller, this ramp (default setting 120ms or 6 network periods) will be passed through completely. Afterwards the device operates without ramp.
If Soft-Start time (SST) >= 600ms (30 network periods) is set, the power controller (after turning on the power supply at the power controller or after reset or re-start of the control electronics and followed by connecting a set point) stays as long in SST ramp as the turn on time is Ts > 600ms.
Afterwards the power controller operates without SST ramp, as before, even when Ts should be < 600ms. Background is the usage of a transformer which can be adjusted perfectly to TAKT operation by the settings and performance of SST ramp.

6.1.4 QUICK TAKT MODE QTM (ONLY THYRO-AX 1A)

Depending on the defined setpoint network half waves are switched. Quick takt mode is a quick operating mode which offers a higher dynamic than TAKT through its functioning in half wave switch principle. QTM is suitable for ohmic loads. Continuous current elements are avoided through the cycle duration. The quick cycle control is particularly suited to infra-red projectors as an alternative to phase angle firing. When using multiple controllers there is the option of keeping feedback to mains minimal through synchronization.

6.1.5 SWITCH MODE SWITCH

Depending on the defined setpoint whole network periods are always switched. Then a signal can be used as control input for switch mode operation. This means that on-off control can be realized. The feedback to mains is very slight in this functionality. The switch mode is suitable for ohmic load and transformer load.

6.2 SETPOINT PROCESSING

The Thyro-AX power controller has four setpoint inputs. All setpoint inputs are electrically isolated from the mains. For the analog setpoints 1 and 2 individual control characteristics can be configured via the parameters control begin and control end.

All setpoints are added up taking into consideration any preceding modifying symbols. The prerequisite for the influence of a setpoint on the overall setpoint is that it is approved through the setpoint enable register.
- setpoint 1 analog signal: (X2.4, X2.3 ground) 0-20 mA as default settings
- setpoint 2 analog signal: (X2.11, X2.3 ground) 0-5 V as default settings
- setpoint 3 digital signal: setpoint from higher-level system such as a PC with USB or via the optional bus interface.
- setpoint 4 digital signal: setpoint from digital potentiometer of the control panel

The setpoint inputs 1 and 2 are two electrically identical analog inputs for current or voltage signals with a downstream A/D transformer (resolution 0.025% of end value). The following signal ranges can be configured using the touch display, Thyro-Tool AX and bus:

0(4) - 20 mA (R_i = circa 250 Ω) maximum 24 mA

0 - 5 V (R_i = circa 8,8 kΩ) maximum 12 V

0 - 10 V (R_i = circa 5 kΩ) maximum 12 V

The setpoint signal can be adjusted by the user to the procedure controller or automation system.

To do this the start and end points of the control characteristics are altered. All COTS signals can be used.

If the power controller finds itself in a limitation (U_{max}, I_{max}, P_{max}) this is shown on the display (see chapter Events).
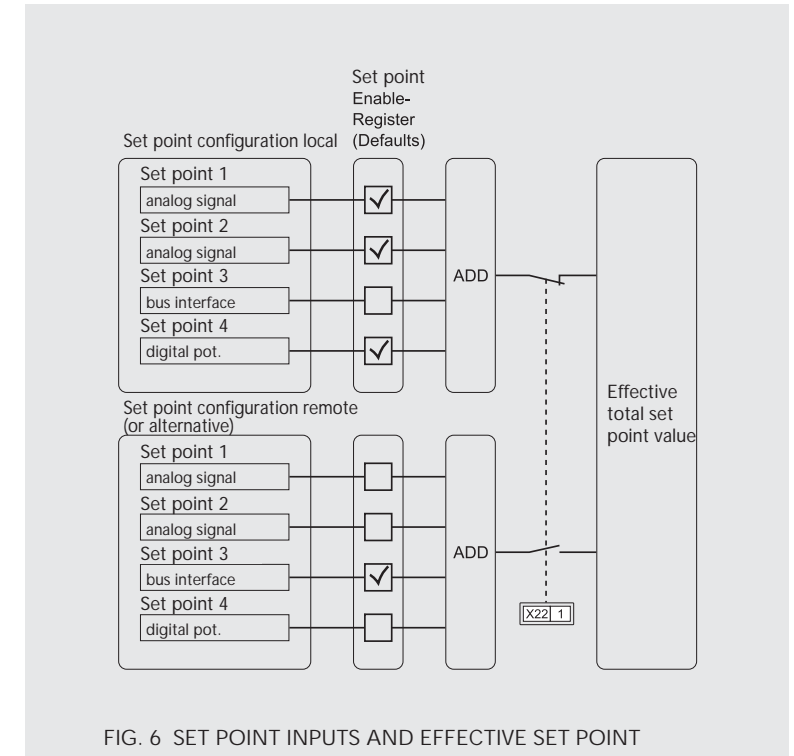
FIG. 6 SET POINT INPUTS AND EFFECTIVE SET POINT

CONFIGURE OVERALL SETPOINTS

Two configurations for the overall setpoint are possible which each allow optional combinations of setpoints. In this way an alternative configuration can be selected quickly by connecting X22.1 to ground. This allows a manual/automatic switching to be realized

The values of the default settings are:
- setpoint configuration 1 (no ground to terminal X22.1)
  o analog signal 1
  o analog signal 2
  o digital signal from digital potentiometer
- setpoint configuration 2 (alternative - ground to terminal X22.1)
  o digital signal from USB or bus interface

INPUTS FOR SWITCH MODE SWITCH

For the switch mode SWITCH it is possible to switch via a 24 V signal (5-24 V) as a digital signal to terminal X2.7 (Sync. In Digital In) or via the setpoint on the basis of a threshold. A digital switching signal or an overall setpoint from 50% causes a switching on, below this a switching off.

6.3 CONTROL MODES

Thyro-AX provides various types of control. The control has an influence on the size of the output of the power controller. Before commissioning the power controller and selection of a control mode the mode of functionality and effect on the application should be known.

CONTROL MODES ...H RLP2

Control mode	Control variable
U, U^2	Output voltage
I, I^2	Output current
P	Effective power

Mains voltage variations and load alterations are compensated directly and, as a result, quickly by bypassing the inert temperature regulation circuit (secondary control).

CONTROL CHARACTERISTICS AND CONTROL VARIABLE

The control variable influencing the load is proportional to the effective setpoint in the case of control modes U, I, P. In control modes U^2, I^2, the control variable influencing the load is a square of the effective setpoint.
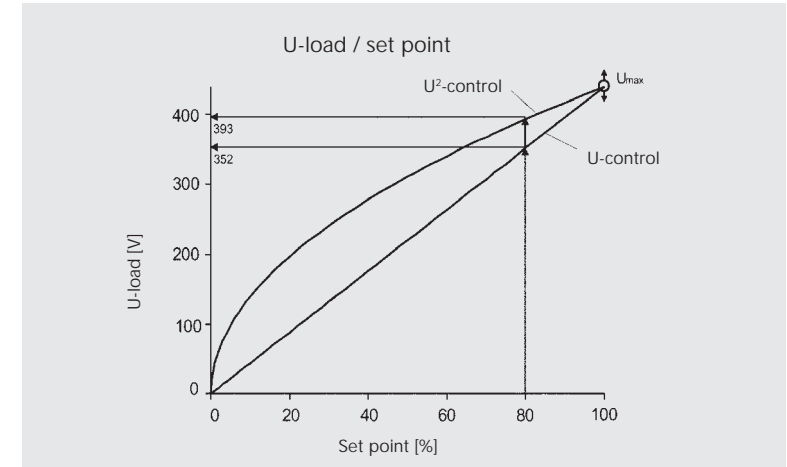
Load voltage U, U_{eff}
Load voltage U^2, U_{eff}^2
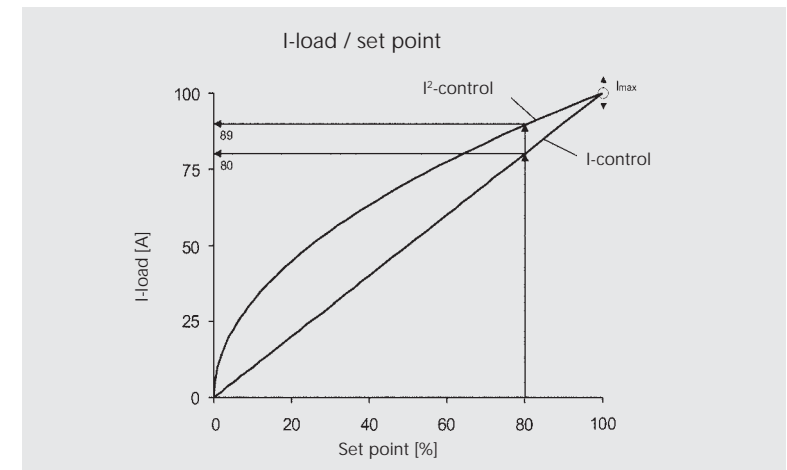
Load current I, I_{eff}
Load current I^2, I_{eff}^2

P-Load / set point
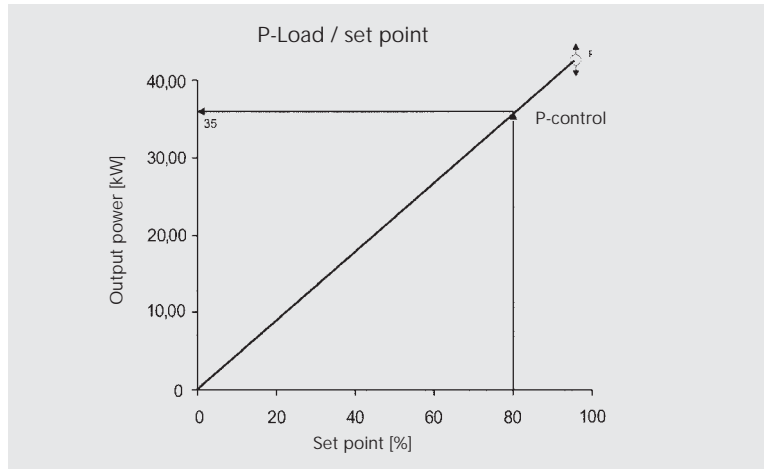
P output power

If the load resistance changes e.g. through the influence of tempera-
ture, ageing or load interruption, the variables influencing the load
change.

CONTROL MODE	LOAD RESISTANCE GETS SMALLER			LOAD RESISTANCE GETS LARGER		
	P	U_{Load}	I_{Load}	P	U_{Load}	I_{Load}
U	larger	=	larger	smaller	=	smaller
U^2	larger	=	larger	smaller	=	smaller
I	smaller	smaller	=	larger	larger	=
I^2	smaller	smaller	=	larger	larger	=
P	=	smaller	larger	=	larger	smaller

TAB. 2 EFFECTS IN THE CASE OF LOAD RESISTANCE CHANGE

6.4 LIMITATIONS

In addition to the configured control mode the following variables can
be limited:
• voltage limitation (U)
• current limitation (I)
• power limitation (P)

SECONDARY MODE OF CONTROL	END VALUE OF THE CONTROLLER	LIMITATIONS	
U	$U_{eff\ max}$	$I_{eff\ max}$	P_{max}
U^2	$U_{eff\ max}$	$I_{eff\ max}$	P_{max}
I	$I_{eff\ max}$	$U_{eff\ max}$	P_{max}
I^2	$I_{eff\ max}$	$U_{eff\ max}$	P_{max}
P	P_{max}	$I_{eff\ max}$	$U_{eff\ max}$

TAB. 3 EFFECTIVE LIMITATIONS

Besides this the Thyro-AX 1A/3A ...H RLP2 is equipped with a peak
current limitation ($\hat{i} = 3 \times I_{Nom}$) in phase angle.

6.5 PULSE INHIBITION

The pulse inhibition (terminals X2.1 – X2.2) is activated by opening
the pulse inhibition bridge, which means that current no longer flows.
When the pulse inhibition is activated the touch display turns red and
in the data logger "Pulse on" is listed. After switching on or after pulse
inhibition the first Takt pulse (in TAKT operation) runs through with
the soft start function. This is important for transformer load if it was
switched off in an undefined way (remanence). In the case of the
Thyro-AX 2A or Thyro-AX 3A the pulse inhibition is only wired to the
master (L1, left).

6.6 CURRENT AND VOLTAGE TRANSFORMER

The power controller has a current and voltage transformer on the load
side per power unit which is internally wired. In addition each controller
also has an external current and voltage transformer terminal which
can be used via internal link plugs as an alternative to the internally
built-in parts. This can increase the measurement accuracy in the case
of very small voltages. For details on how to convert over please use
the contact information indicated in chapter 4.

External current and/or voltage transformer are to be connected in-
phase, see connection diagram:

Mains/Load

U_{ext}

X22.10

X22.11

N

Mains

I_{ext}

K   k X22.12

X22.13

L   l
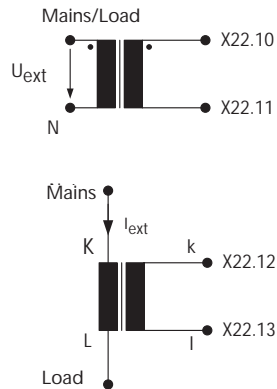
Load

The output value of the voltage transformer is 10V~ (at rated voltage) and the output value of the current transformer is 1V~ (at rated current). The corresponding load resistor has to be connected externally as well.

6.7 DISPLAY VIA ANALOG OUTPUT

The following variables are given at the analog output (e.g. when connecting an external measurement instrument):

• load current (highest phase current from L1, L2, L3)
• load voltage (highest conductor voltage)
• effective power (overall power) (only in the case of ...H RLP2)
• additional variables (can be selected via PC/Bus, e.g. mains voltage, setpoint etc.)

The variable to be given at the analog output can be configured by the user (see chapter control mode/analog output).

DEFAULT SETTINGS

ANALOG OUTPUT	OUTPUT VARIABLE
Analog output 1	load voltage
Analog output 2	load current
Analog output 3	power on the load

6.8 FAULT, STATUS AND MONITORING MESSAGES

The Thyro-AX has internal fault, status and user-defined monitoring messages. Their effects can be configured with the Thyro-Tool AX software. The reactions on the occurrence of a message(=event) can be determined by the user. As a reaction, the inhibition of the load current (pulse inhibition), as well as the display at the fault signaling relay K1 and the color of the display lights (red) can be configured as well as the data logger and the multi-I/O outputs (s. chapter 6.8.1). Besides this the mode of operation (open or closed circuit principle) can be configured at the fault signaling relay K1. Fundamental fault messages which make the operation of the device impossible in general switch the pulse inhibition or the fault signaling relay K1.

6.8.1 OVERVIEW

The following table indicates the various messages (events) and their specific classification of default settings (X).

DESCRIPTION OF FAULT	THYRO-TOOL AX MESSAGE	MESSAGE ON DISPLAY	DISPLAY LIGHTING ROT	RELAY**	PULSE INHIBIT	DATA LOGGER
NETWORK IST NOT OK (SYNC ERROR)	SYNC ERROR	SYNC ERROR	X	X	X*	X
HARDWARE ERROR	HARDWARE FAULT	HW FAULT	X	X	X*	X
MINIMUM FREQUENCY	FREQUENCY TO LOW	FMIN	X	X	X*	X
MAXIMUM FREQUENCY	FREQUENCY TO HIGH	FMAX	X	X	X*	X
VALID FREQUENCY TOLERANCE	FREQUENCY TOLERANCE EXCEEDED	FTOLERANCE	X	X	X*	X
NO ROTATING FIELD/ LEFT ROTATING FIELD (FOR AX)	NO ROTATING FIELD	NO ROTFIELD	X	X	X*	X
PHASE L1 IS MISSING	PHASE L1 MISSING	NO PHASE1	X	X	X*	X
PHASE L2 IS MISSING	PHASE L2 MISSING	NO PHASE2	X	X	X*	X
PHASE L3 IS MISSING	PHASE L3 MISSING	NO PHASE3	X	X	X*	X
SETPOINT FAILURE (SETPOINT < 4 mA)	SETPOINT < 4 mA (OPEN LOOP)	SETPOINT	X	X	X	X
NO SUPPLY VOLTAGE	NO SUPPLY VOLTAGE	NO POWER	X	X	X*	X
CONNECTION OF POWER UNITS	POWER UNIT DISCONNECTED	NOCONNPART	X	X	X*	X
FAILURE OF TEMPERATURE SENSOR	TEMPERATURE PROBE DEFECT	TEMPSENS	X	X	X	X
FUSE FAILURE	OPEN FUSE	FUSE	X	X	X*	X
THYRISTOR SHORT CIRCUIT	THYRISTOR SHORT CIRCUIT	THYRISTOR	X	X	X*	X
EEPROM ERROR	MEMORY ERROR	EEPROM	X	X	X*	
I2C ERROR	I2C ERROR	I2C	X		X	
ETHERNET ERROR	ETHERNET ERROR	ETH				
USB ERROR	USB ERROR	USB				
FIRMWARE ERROR	FIRMWARE ERROR	FIRMWARE	X	X	X*	X
POWER UNIT IS TOO SMALL FOR TYPE	POWER UNIT INCOMPATIBLE	INCOMPPART	X		X	X
U-MEASURING RANGE IS EXCEEDED	U MEASURING RANGE EXCEEDED	U RANGE	X			X
U-MEASURING RANGE IS EXCEEDED	I MEASURING RANGE EXCEEDED	I RANGE	X			X
NEGATIVE POWER	NEGATIVE POWER	NEG POWER	X			X
LCD ERROR	LCD ERROR	LCD	X			
PARAMETER ERROR	PARAMETER ERROR	PARAMETER	X		X*	X

* = cannot be deactivated ** = default setting of fault signaling relay K1: closed circuit principle

TAB. 4 ERROR

DESCRIPTION OF STATUS	THYRO-TOOL AX MESSAGE	MESSAGE ON DISPLAY	DISPLAY LIGHTING RED	RELAY**	PULSE INHIBIT	DATA LOGGER
PULSES ARE SWITCHED ON	IMPULSE ON	PULSE ON			-	
PULSE OFF AT TERMINAL X2.1-X2.2	PULSE SWITCH OFF TERMINAL	PULOFFT	X		-	
PULSE OF AT HARDWARE (ERROR)	PULSE SWITCH OFF HARDWARE ERROR	PULOFFHW	X		-	X
PULSE OF AT SOFTWARE (CONFIGURABLE)	PULSE SWITCH OFF EVENT	PULOFFEV	X		-	X
PULSE OF EXTERNAL	PULSE SWITCH OFF EXTERN	PULOFFEX	X		-	
LEFT ROTATING FIELD (MESSAGE ONLY)	LEFT ROTATING FIELD	LEFTROTF	X	X		X
U LIMIT	U LIMIT	U LIMIT				X
I LIMIT	I LIMIT	I LIMIT				X
P LIMIT	P LIMIT	P LIMIT				X
IPEAK LIMIT	I PEAK LIMIT	IPEAKLIMIT				X
ALPHA IS RESTRICTED	ALPHA RESTRICTED	ALPHA				
TS IS RESTRICTED	SWITCH ON TIME RESTRICTED	TS				
MAXIMUM CONTROLLER OUTPUT IS REACHED	MAXIMUM OUTPUT REACHED	MAXCONTROL				
SETPOINT OF BUSMODULE IS ACTIVE	BUSMODULE SETPOINT ACTIVE	BUS SETP				
BUSMODULE IS CONNECTED	BUSMODULE CONNECTED	BUS CONN				
CLOCK IST NOT SET	CLOCK NOT SET	NO CLOCK				
POWER UNITS ARE HIGHER THAN TYPE	POWER UNIT DIFFERENT	DIFF PPART				X
POWER CONTROLLER IS OK	POWER CONTROLLER OK	THYRO OK			-	

* = cannot be deactivated
** = default setting of fault signaling relay K1: closed circuit principle

TAB. 5 STATUS

DESCRIPTION OF MONITORING	THYRO-TOOL AX MESSAGE	MESSAGE ON DISPLAY	DISPLAY LIGHTING RED	RELAY**	PULSE INHIBIT	DATA LOGGER
U_{MAINS} MIN	U MAIN < MINIMUM	UN MIN				X
U_{MAINS} MAX	U MAIN > MAXIMUM	UN MAX				X
U_{LOAD} MIN	U < MINIMUM	UL MIN				X
U_{LOAD} MAX	U > MAXIMUM	UL MAX				X
I_{LOAD} MIN	I < MINIMUM	IL MIN				X
I_{LOAD} MAX	I > MAXIMUM	IL MAX				X
P_{LOAD} MIN	P < MINIMUM	PL MIN				X
P_{LOAD} MAX	P > MAXIMUM	PL MAX				X
R_{LOAD} MIN	R < MINIMUM	RL MIN				X
R_{LOAD} MAX	R > MAXIMUM	RL MAX	X	X		X
I_{PEAK} MAX	I PEAK > MAXIMUM	I_PEAK MAX				X
MAX. TEMP. OF HEAT SINK	TEMPERATURE UNIT > MAXIMUM	T_HEAT MAX	X	X	X	X

* = cannot be deactivated
** = default setting of fault signaling relay K1: closed circuit principle

TAB. 6 MONITORING

The events, which are captured by the Thyro-AX, are shown on the touch display in abbreviated form in a list. They correspond with the full forms in their meaning and can be discerned using the table above.

6.8.2 FAULT SIGNALING RELAY K1

NOTE

DEFAULT SETTING
The function explained here is described in its default setting.
This setting can be altered with the control panel, with a bus module, or with the Thyro-Tool AX.
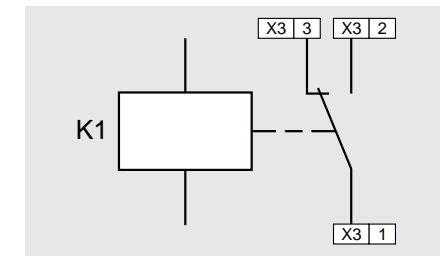
FIG. 7 CONTACT ASSIGNMENT FAULT SIGNALING RELAY K1

The fault signaling relay K1 is fitted with a changeover. Messages which lead to the switching of the fault signaling relay can be configured with the control panel, with a bus module, or with the Thyro-Tool AX. With the default setting the fault signaling relay K1 works in accordance with the closed circuit principle.

In the case of the following errors the fault signaling relay de-energizes and the power controller switches off:
• SYNC error
• internal error
• undervoltage in mains
• master/slave error
• error rotating field/phase

In the case of the following errors the fault signaling relay drops out, the power controller continues to run and a notification is sent (touch display):
• excess temperature
• undercurrent in the load circuit

6.9 MONITORING

Power controller and load circuit are monitored for errors. Messages are sent via the touch display, via a bus, or through the fault signaling relay K1 (see chapter Fault signaling relay K1).

The feature of monitoring (e.g. voltage or temperature) can be deactivated by Thyro-Tool AX software. In this case the adjusted limits will be disregarded and no message will be shown.

6.9.1 MONITORING THE MAINS VOLTAGE

NOTE

LIMITS OF THE VOLTAGE MONITORING

There are the following limits to the voltage monitoring:
- undervoltage monitoring: < 24 V
- overvoltage monitoring: +10% of the type voltage

This results in absolute limits for the monitoring of the mains voltage.

TYPE	UNDERVOLTAGE LIMIT	OVERVOLTAGE LIMIT
230 V	24 V	253 V
400 V	24 V	440 V
500 V	24 V	550 V
600 V	24 V	660 V

TAB. 7 LIMITS OF MAINS VOLTAGE MONITORING

In the default setting the pulse inhibition is switched internally if voltage drops below the undervoltage limit and the fault signaling relay K1 de-energizes (both can be configured).

6.9.2 DEVICE TEMPERATURE MONITORING

NOTE

DEFAULT SETTING

The function explained here is described in its default setting. This setting can be altered with the control panel, with a bus module, or with the Thyro-Tool AX.

The Thyro-AX is fitted with temperature monitoring. If the power controller dependent temperature is exceeded an event message is sent (see chapter Fault and status messages). The pulse inhibition is triggered as configured by default setting, but can be deactivated. Please note when it is deactivated, in case of fault there is the risk of overheat or damage of the device.

7. DISPLAY AND OPERATIONAL ELEMENTS

The parameters of the power controller can be altered via the integrated touch display.
In addition it shows the current values of the Thyro-AX.

CAUTION

Do not use any pointed or sharp-edged objects to operate. They can damage the surface of the screen.

The touch display is a pressure sensitive screen which can be operated with the finger. It contains fields which react to light pressure in order to register buttons being pressed. Depending on the menu displayed the areas which can be pressed vary in accordance with the contents displayed. There is a large actual value button and requirement specific buttons displayed in the lower section of the screen.
After a period of 30 seconds without a button being pressed the screen display reverts to the actual value view.
If there are more entries available than can be displayed on the screen a separating line appears when approaching the first or last entry. This marks the transition from the start to the end of the list and can be skipped over with the arrow buttons.

7.1 OPERATION OF TOUCH DISPLAY

All supported screens can be operated with a few buttons. The function of the button depends on the entry displayed. The current selection of the parameters in the list to be altered is indicated by a frame outline and can be altered with the OK button. Depending on the parameter variable a screen follows correspondingly in which alternative values for the parameter are offered. In the following the symbols and their various possible depictions are displayed.

▼ Menu ▼ , ▼ Menu ▼ : Call up menu.

⬆ , ⬇ : - Set the marking of an entry (frame outline) higher or lower in the list.
- Increase/decrease a numerical value or add/delete a decimal place.

⬅ , ➡ : Place a character position to left/right.

↵ , OK , Yes , YES : Confirm current selection and back to last screen.

ESC , ESC , No , NO : Reject current selection and back to last screen.

➕ , ➖ : Increase/decrease digital setpoint 2

The actual value button is described in chapter 7.2.

EXAMPLE OF ENTERING A NUMBER

The example shows the entry of numerical values via the screen buttons using the setting of I_{max}, which can occur in the course of EasyStart.
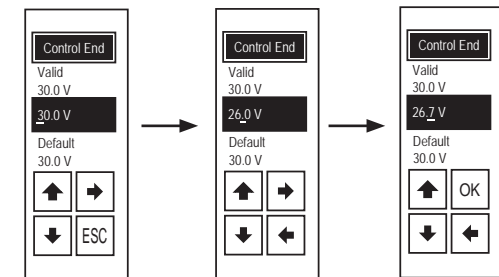
Use the cursor keys for higher and lower to increase or decrease the value number. Use the cursor keys for left and right to change the position of the number to be modificated. Furthermore entries can be confirmed (by pressing the right cursor key to the end of the row) or entries can be canceled (by pressing the left cursor key to the end of the row).

7.2 ACTUAL VALUE VIEW AND ACTUAL VALUE BUTTON

When pressing the actual value button several times the current values
of the Thyro-AX are displayed over several screens. By pressing several
times the screens are alternately displayed and start from the begin-
ning again if pressed again. Depending on the number of phases of
the power controller the actual value view is displayed for all phases.
The screen which appears at the end gives the type information of the
Thyro-AX. The last line on the screen gives the EasyStart identification
The actual value view can also be reached via *Menu -> ActVal.*
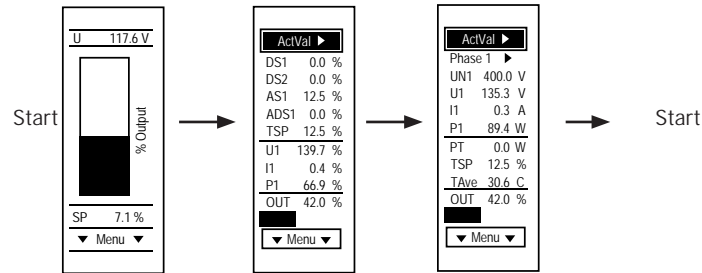
Using the actual value button you can leave the current menu at any
time in order to get back to the actual value view. In doing so the
current menu is aborted without being saved permanently in EEPROM,
however, the current alteration remains active and can be saved ma-
nually. The actual value button extends over the top half of the screen.
This means that regardless of what is displayed in the upper half of the
screen, the upper area, when pressed, functions as the actual value
button, even when the text is displayed. This enables a quick change
of the display for the values following an alteration of parameters.
During EasyStart changing to the actual value view via the button is not
possible.

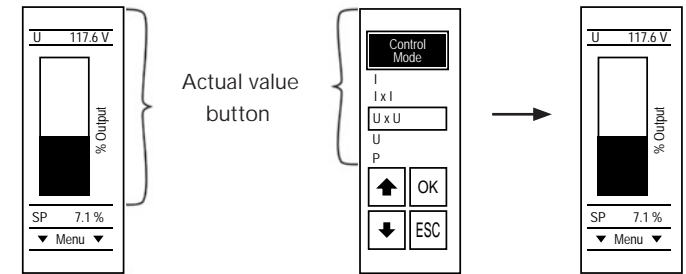FIG. 8   EXAMPLES OF AREAS TO BE PRESSED FOR ACTUAL VALUE
BUTTON

7.3 MESSAGE OVERVIEW AND ACKNOWLEDGMENT

If there is a message (event) at which the display turns red,
the lower button (▼ Events ▼ or ▼ Error ▼) can be used
in the message overview to show all active events.

If there is a message to acknowledge among the active
messages (s. table 8), it can be acknowledged by pressing
the OK button.

DESCRIPTION OF FAULT	THYRO-TOOL AX MESSAGE	MESSAGE ON DISPLAY	ACKNOWLEDGE VIA LCD DISPLAY
THYRISTOR SHORT CIRCUIT	THYRISTOR SHORT CIRCUIT	THYRISTOR	X
U-MEASURING RANGE IS EXCEEDED	U MEASURING RANGE EXCEEDED	U RANGE	X
I-MEASURING RANGE IS EXCEEDED	I MEASURING RANGE EXCEEDED	I RANGE	X
NEGATIVE POWER	NEGATIVE POWER	NEG POWER	X

* = cannot be deactivated
** = default setting of fault signaling relay K1: closed circuit principle

DESCRIPTION OF STATUS	THYRO-TOOL AX MESSAGE	MESSAGE ON DISPLAY	ACKNOWLEDGE VIA LCD DISPLAY
U LIMIT	U LIMIT	U LIMIT	X
I LIMIT	I LIMIT	I LIMIT	X
P LIMIT	P LIMIT	P LIMIT	X
IPEAK LIMIT	I PEAK LIMIT	IPEAKLIMIT	X
ALPHA IS RESTRICTED	ALPHA RESTRICTED	ALPHA	X
TS IS RESTRICTED	SWITCH ON TIME RESTRICTED	TS	X
MAXIMUM CONTROLLER OUTPUT IS REACHED	MAXIMUM OUTPUT REACHED	MAXCONTROL	X

* = cannot be deactivated
** = default setting of fault signaling relay K1: closed circuit principle

DESCRIPTION OF MONITORING	THYRO-TOOL AX MESSAGE	MESSAGE ON DISPLAY	ACKNOWLEDGE VIA LCD DISPLAY
U_{MAINS} MIN	U MAIN < MINIMUM	UN MIN	X
U_{MAINS} MAX	U MAIN > MAXIMUM	UN MAX	X
U_{LOAD} MIN	U < MINIMUM	UL MIN	X
U_{LOAD} MAX	U > MAXIMUM	UL MAX	X
I_{LOAD} MIN	I < MINIMUM	IL MIN	X
I_{LOAD} MAX	I > MAXIMUM	IL MAX	X
P_{LOAD} MIN	P < MINIMUM	PL MIN	X
P_{LOAD} MAX	P > MAXIMUM	PL MAX	X
R_{LOAD} MIN	R < MINIMUM	RL MIN	X
R_{LOAD} MAX	R > MAXIMUM	RL MAX	X
I_{PEAK} MAX	I PEAK > MAXIMUM	I_PEAK MAX	X

* = cannot be deactivated
** = default setting of fault signaling relay K1: closed circuit principle

TAB. 8 ACKNOWLEDGMENT

7.4 EASYSTART

In the case of the initial start of the device the managed parameterization EasyStart is called up with the help of which the fundamental parameterization is configured. The following screens are depicted in the displayed sequences. The ESC button calls up the previous page and as such allows alterations to be made to settings already inputted. During the configuration with EasyStart the pulse inhibition is active and prevents power being emitted at the load side.


Start screen:
The parameterization of the fundamental values starts with the button Yes. With No EasyStart is aborted, in order, for example, to transfer an already saved parameter file to the device using the Thyro-Tool AX.
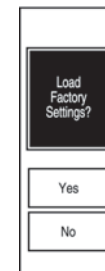
Load factory settings:
The button Yes sets the Thyro-AX back to its default settings. When pressing the button No, the Thyro-AX continues EasyStart feature on basis of its current settings. If EasyStart has been started once, it will request first the default settings before EasyStart start screen appears.
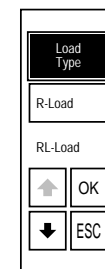
Load type:
Here, adjustment to a purely ohmic load or an inductive load, as occurs in transformers, is possible. As such in case of a purely ohmic load the power controller can clock more quickly with the R-Load setting and provides a larger dynamic on the output side. Configuring a transformer load with RL-Load causes an angle of the first half wave (Alpha 1st) each time it switches through and an optimization of the necessary time intervals for the controlled magnetization of the transformer coils.
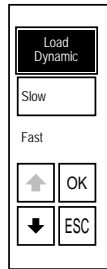
Load type, dynamic of the load:

```
┌──────────┐
│  Load    │
│ Dynamic  │
├──────────┤
│ Slow     │
│ Fast     │
├──────────┤
│ ⬆ │ OK  │
│ ⬇ │ ESC │
└──────────┘
```

This screen appears only if the configuration R-Load has been selected beforehand.

When configuring a load with heat inertia load with Slow (T_0 = 1 s) the distance between the ignition cycles increases so that the switch on and switch off duration lasts longer. In the case of loads which are thermally easy to influence by external effects, the switching time can be shortened by configuring Fast (T_0 = 0.1 s) to achieve a more even warm up.

Load type, connection:

```
┌──────────┐
│  Load    │
│ Config   │
├──────────┤
│ open D   │
│ Y +N     │
│ Y        │
│ D        │
│ --▼---▲- │
│ ⬆ │ OK  │
│ ⬇ │ ESC │
└──────────┘
```
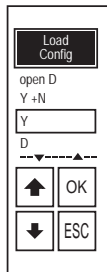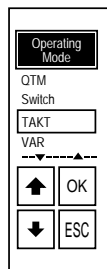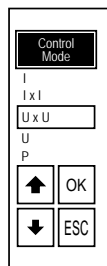
Depending on the connection option the adequate entry has to be chosen from the list. This is important for the accurate processing and displaying of data. Potential necessary changes of the connection can be taken from chapter 5.2. Load configuration.
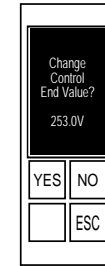
Operating mode:

```
┌──────────┐
│Operating │
│  Mode    │
├──────────┤
│ QTM      │
│ Switch   │
│ TAKT     │
│ VAR      │
│ --▼---▲- │
│ ⬆ │ OK  │
│ ⬇ │ ESC │
└──────────┘
```

The operating mode can be set as QTM, Switch, TAKT or VAR. At this the settings for the load type are taken into consideration. Notes on operating modes can be taken from the chapter Operating modes.
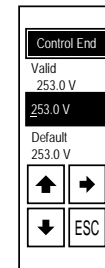
Control mode:

```
┌──────────┐
│ Control  │
│  Mode    │
├──────────┤
│ I        │
│ I x I    │
│ U x U    │
│ U        │
│ P        │
│ ⬆ │ OK  │
│ ⬇ │ ESC │
└──────────┘
```

The type of control can be set, the selection includes I, I², U, U², P and Off. Notes on control mode can be taken from the chapter Control modes.

Control end value:

```
┌──────────┐
│ Change   │
│ Control  │
│End Value?│
│          │
│  253.0V  │
│          │
├──────────┤
│YES │ NO  │
│    │ ESC │
└──────────┘
```

This screen only appears if the control mode has been selected beforehand, not if Off is selected.
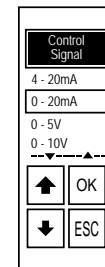
The control end value is the maximum value for control and limitation. In the case of full control through the setpoint this value defines the maximum which can be reached at the output. The unit is dependent on the control mode. In the case of voltage based control it is U_{max} in V, with current based control it is I_{max} in A, and with power based control it is P_{max} in W. In most cases the preconfigured value is sufficient and can be confirmed with the NO button.

Control end value, value input:

```
┌──────────┐
│Control End│
├──────────┤
│ Valid    │
│  253.0 V │
│ 253.0 V  │
│ Default  │
│  253.0 V │
│ ⬆ │ ➡   │
│ ⬇ │ ESC │
└──────────┘
```

This screen only appears when the YES button has been selected beforehand.

Similar to the unit from the previous screen an input field appears for the desired value of the control end value. After inputting all positions of the value the OK button appears to confirm.

Control signal:

```
┌──────────┐
│ Control  │
│ Signal   │
├──────────┤
│ 4 - 20mA │
│ 0 - 20mA │
│ 0 - 5V   │
│ 0 - 10V  │
│ --▼---▲- │
│ ⬆ │ OK  │
│ ⬇ │ ESC │
└──────────┘
```

The correct input variable must be selected corresponding to the signal for the setpoint definition. The selected value is related to the 1st analog setpoint. The 2nd analog setpoint remains set to 0-5V in order to enable an offset through the addition of the setpoints using an external potentiometer. The 3 analog outputs also receive the variable of the setpoint selected here. The configuration for the 2nd analog setpoint can be changed afterwards in EasyStart. The electrical limits of the levels must be heeded.
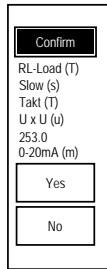
Confirmation of the settings:

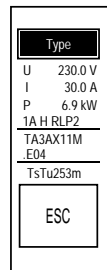When Yes is pressed all settings are saved in the internal EEPROM and the pulse inhibition is ended again. Pressing the No button returns to the last screen.

The characters in brackets each form an initial for the setting and are used for the EasyStart identification.

7.5 EASYSTART IDENTIFICATION

The EasyStart identification makes the comparison of the configurations of multiple devices easier. Depending on the settings selected a series of characters is generated which corresponds to the selected settings. If additional settings have been made outside of those covered by EasyStart, then a + (plus symbol) is added at the end of the identification code. This is an indication of additional alterations which have not been created by EasyStart.

The EasyStart identification can be reached from the main screen through pressing the actual value button multiple times. The last line gives the identification code.

7.6 RESTRICTION CODES FOR PARAMETERIZATION AND DIGITAL SETPOINT 2

The access via the touch display can be disabled and enabled for the following contents:

- parameter alteration: setting menu is displayed or hidden (factory setting: on)
- digital setpoint 2: DS2 is alterable via buttons following the screens of the actual value view (factory setting: off).

If the actual value view is not already called up this can be reached via *Menu ➔ ActVal*. The screen for the DS2 follows the other actual value screens and appears last. An alteration of the setpoint is possible with the button + and -. The factory setting is for this value to be added to the other setpoints and as such can be used as an offset.
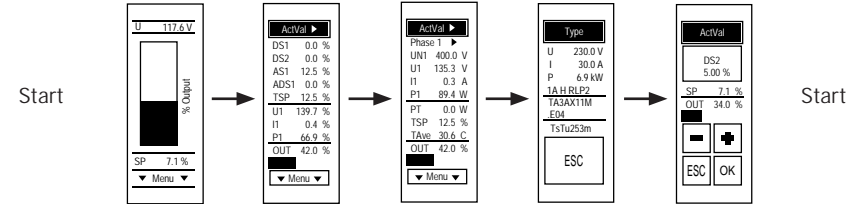
The functions can be hidden or displayed by entering the restriction code under *Menu ➔ Code*.

- DS2 restriction code: enable 234, disable 432 (restricted by default settings).
- Parameter restriction code: enable 345, disable 543 (restricted by default settings).

7.7 SAVE AND LOAD PARAMETERS WITH USB STICK

Parameters can be transferred from one device to another of the same type by using a USB stick.

If a USB stick is inserted, a request will appear to set the pulse inhibition or not. Thereby the output power will be 0. This is a requirement for loading and saving of parameters from or on the USB stick.

After loading, an option will appear to read parameters from the USB stick (when parameters are available for the specific device type on the USB stick and the device has not been locked by password protection (s. chapter 7.6)) or to save the current parameters of Thyro-AX (on the USB stick while existing parameters of the same device type will be overwritten).

After reading, it is requested if the parameters should be saved permanently on the device (EEPROM).

The USB overview can be seen when the USB stick is connected via its according menu item.

On the market there are various USB sticks, which mainly can be operate without any difficulties with Thyro-AX. Special sticks won't be recognized which provide additional drives or need special drivers.

7.8 MENU STRUCTURE

MENU	SUBMENU		DEFAULT VALUE	REMARKS
ActVal				Main menu of the current value overview. Also appears automatically after a period of 30 sec. of not changing
Event				List of all current active messages (events). OK has the function of acknowledging the relevant message.
Settings	Operating		1A: TAKT, 2A: TAKT, 3A: VAR	Operating mode, operating of thyristors
	Regulator		U x U	Current, voltage or power based control.
	Limit		Type values of the device	Maximum value for current, voltage and power.
	Takt (for operating mode TAKT)	CyclTime	50 per	Cycle period
		Alpha1st	1A: 60° el, 2A: 90° el, 3A: 90° el	Phase angle of the 1st half wave
		SST	6 per	Soft-start time
	Switch (for operating mode SWITCH)	Alpha1st	1A: 60° el, 2A: 90° el, 3A: 90° el	Phase angle of the 1st half wave
		SST	6 per	Soft-start time
	Monitoring		R_Max = (type voltage * 2)/type current	R_Max for load monitoring
	AS 1		0-20mA	Signal for analog setpoint 1
	AS 2		0-20mA	Signal for analog setpoint 2
	AO 1	Range	0-20mA	Dimensions for analog output 1
		Source	Average	Source for measurment (crucial if Value or ValuePh will be displayed).
		Value	OFF	Output of general values (source must be set to general).
		ValuePh	AO 1: U, AO 2: I, AO 3: OFF	Output of phase related values (source must be set to L1, L2, L3, Min, Max or average).
		ScaleMax		Full scale value
	AO 2	(like AO 1)		
	AO 3	(like AO 1)		
ReadSet				Overview of all device parameters.
Code				Authorization code for parameter changes and digital setpoint entry at display.
Save				Save the current parameters in EEPROM. This is shown automatically after a modification, when the menu is acknowledged.
Load	Load EEPROM			Load customer parameters from EEPROM.
	Load Factory Set.			Load default settings.
TeachIn				Start the load measuring for automatic load failure detection.
EasyStart				Start the quick configuration of the device by basic parameters.
Eth.Set.	DHCP/Static		DHCP	Method of assigning IP address.
	IP Adr		192.168.0.100	Read the assigned IP address or write the static one.
	Submask		255.255.255.0	Subnet mask of network.
	Gateway		192.168.0.254	Gateway of network.
	1. DNS		194.25.2.129	IP of domain name server 1.
	2. DNS		130.146.25.194	IP of domain name server 2.
USB Menu				Read and write the parameters via USB flash drive.

TAB. 9 MENU STRUCTURE THYRO-AX

7.9 THYRO-TOOL AX

The software Thyro-Tool AX (hereafter referred to as Tool) is suitable for parameterization and visualization of connected devices of series Thyro-AX. Parameter and line charts can be saved. During installation a server (Windows service: ThyroWindowsService) and client will be installed, which will be started parallel in the simplest case. There is an option to access device, which are connected to a computer, by using remote maintenance on another computer.
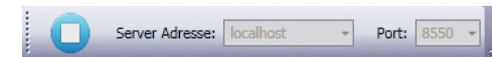

FIG. 9 CONNECTION TO LOCAL INSTALLED SERVER

The left side of the window offers an own explorer for open files and directly connected devices. On the right side, tabs are shown for each subsection which has been selected by double clicking on it. There are 3 different options to switch between the open windows:
- Double click on explorer (like opening for the first time)
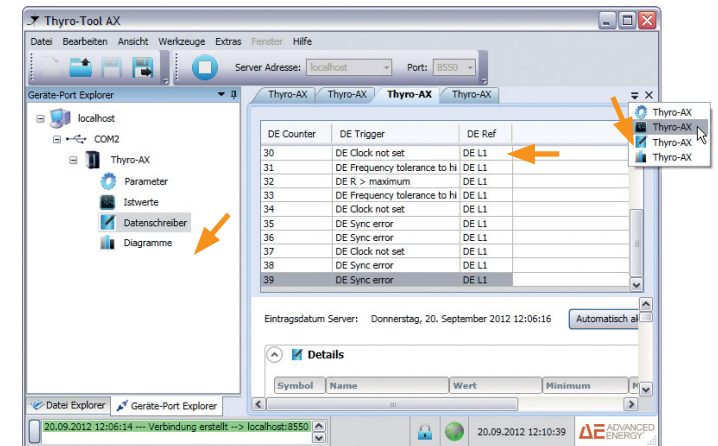- Select tab
- Drop-down menu (Overview with icons)

FIG. 10 SEVERAL OPEN TABS

The field with status messages can be transferred as an external window back and forth for an improved overview. Therefore stretch out the

button on the left side of the status field.
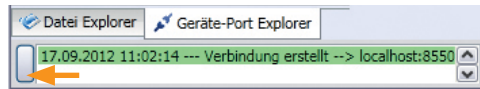
FIG. 11 MINIMIZE STATUS MESSAGES
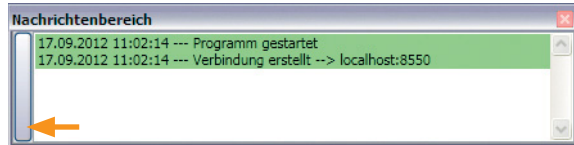
FIG. 12 MAXIMIZED STATUS MESSAGES

The order of tabs within the window is flexible. The following order is possible:
- Next to each other
- Above the other
- Single window with bar (separate for e.g. second screen)

To arrange the tabs, keep the mouse button pressed while moving. Therewith a context menu opens in the middle of the program screen. If the mouse pointer with the attached tab is released above one of these windows, the tab positions itself new as seen in the advised pre-view. Anytime a new positioning is possible.

FIG. 13 SEPARATE TAB

FIG. 14 PREVIEW OF ARRANGED TABS

The modified overview can be saved permanently as *Overview -> Layout -> save*.

7.9.1 MANAGE DEVICE AND FILES

Connected devices are shown directly with their virtual COM port under device port explorer when connected via USB. Thyro-AX devices within the network list their IP address. Devices can be connected before and after the software start.
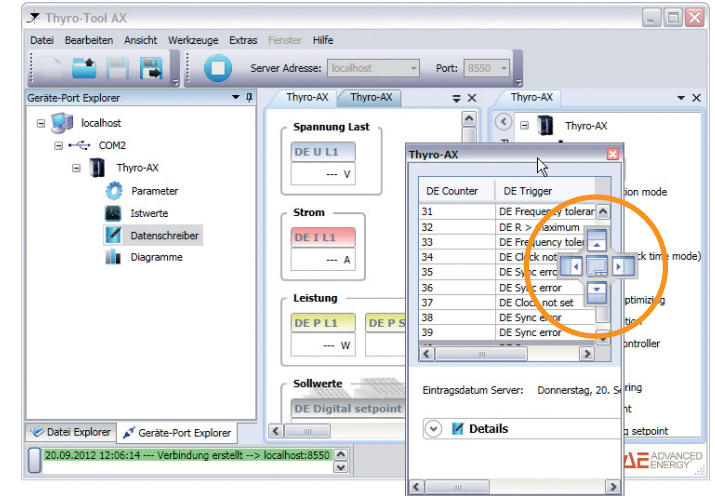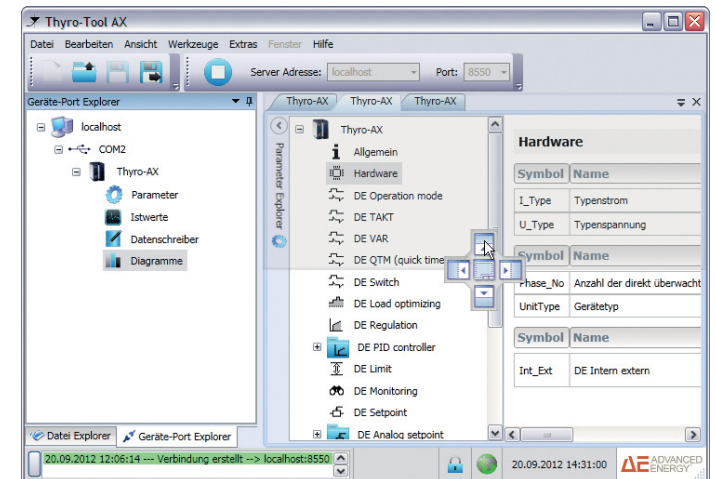
Files with ending .thyro can be selected by using the file explorer or the symbol ![icon] from the icon bar. All open files are displayed in the lower window of the explorer, where the available tabs are for opening. In the middle window are all .thyro files from the selected folder of the upper window.
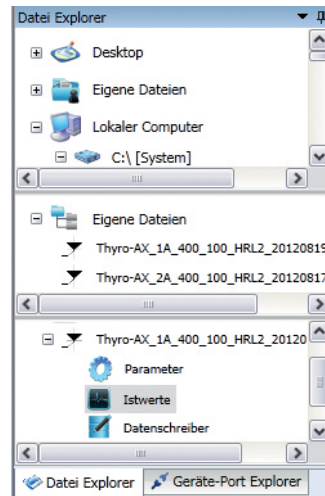

FIG. 15 OPEN THYRO FILES IN FILE EXPLORER

For both cases are the following tabs possible:
- Parameter (to change and adjust the performance)
- Actual values (to display the current available data and messages (events))
- Data logger (to record messages with time stamp)
- Diagrams (to record data in relation to the time as characteristic lines)

The thyro files include not only parameters but also actual values measured at the same time and entries of the data logger. Recorded diagrams are also enclosed and available for review, which will be loaded from the file.

7.9.2 PARAMETER

By one double click on parameter entry, the suitable window will open on the right side of the tool.
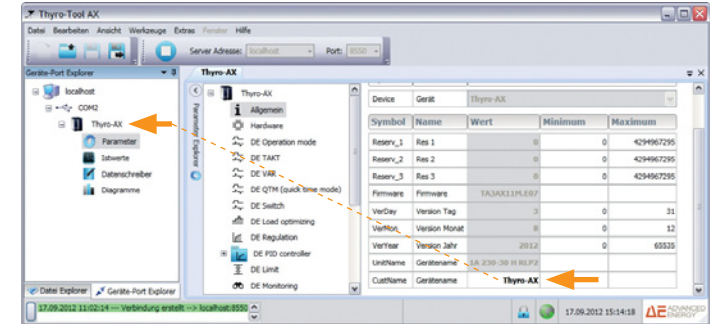
FIG. 16 CHANGE NAME OF DEVICE (RE-START IS NECESSARY)

The features are sorted by groups and are changeable via one click on each heading on the right side. Each feature has a help text known as ToolTip, which appears on mouse over the entry. It describes the features effect and where appropriate default values. Besides the value, the valid minimal and maximal value is registered as unchangeable for entries so that the permissible range of each value is known. If a value is changed and another field is selected, the value will be marked in red. Marked values are directly active (when the device is connected), but will be discarded at re-start. The button *save* ![icon] saves changes permanently to the device storage, so that they are preserved after restart.

Parameters can be saved to drive as .thyro files by using the button *save as* ![icon] .

To transfer a local file to the device, the device must be connected and the relevant .thyro file must be opened (file will appear in the lower window of the file explorer). A drop-down menu opens with a list of all open files and connections under *tools -> transfer parameter set*.
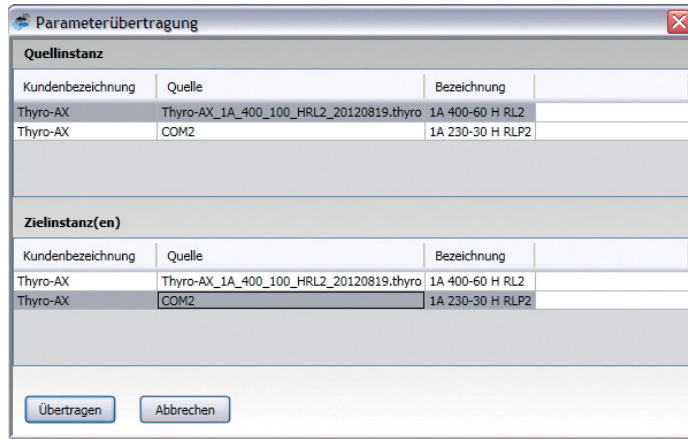
FIG. 17 TRANSFER OF PARAMETER FILE

The source file is under source instance and under target instance is the described device. By using the button *transfer*, the file transfer will start. Subsequently the values have to be saved.

Here is a list of different entry options for parameters:
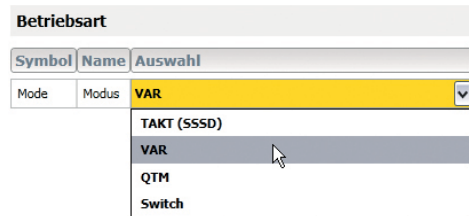
FIG. 18 DROP-DOWN MENU

Example for entries are summarized in a list and one can be selected from that list.

FIG. 19 FIELD

In those fields, values are displayed to the second decimal place. For internal purposes further decimal places can be entered which will be used for calculation. With mouse-over the precise value of each field can be seen without any limitations. This is of particular importance to control parameters.

FIG. 20 CHECKBOX

This is a list of possible entries. Multiple selection is possible and active entries are marked in light green. Active entries are grouped in the overview and non-selected are hidden. These lists are used for selection of messages (events), which should lead to certain actions, or for selection of set points, which are added in two switchable, customized configurations and therefore are captured simultaneously in sets.

8. MAINS LOAD OPTIMIZATION

HAZARDS WHEN CARRYING OUT ADJUSTMENT WORKS

Danger of injury / danger of damage of the device or system
> Adhere to all safety requirements of the chapter Safety.

Mains load optimization provides considerable advantages, e.g. the reduction of mains load peaks and feedback to mains. Mains load optimization is possible under the following conditions:
• applications with multiple power controllers
• operating mode TAKT or QTM
The mains load is optimized by cascading the switching on of the individual devices. There are two different processes for doing so.

8.1 INTERNAL MAINS LOAD OPTIMIZATION

(Operating modes QTM (Thyro-AX 1A) and TAKT)
In the operating modes QTM and TAKT a synchronization of 2-12 controllers is possible. The operating mode QTM works in a quick half wave mode with a pattern of switched and inhibited half waves at an interval of a fixed time < 1 sec, also known as T_0. In order to create a balance within the network if possible from the start (not only following T_0), the individual controllers synchronize themselves by offsetting by one network period. In the case of the first of the connected controllers the Sync. In Digital In X2.7 is bridged to +5V X2.8.
The subsequent controllers receive their pulse to X2.7 from Sync. Out terminal X2.6 of the previous controller. In the case of the last controller X2.6 remains free. (connection in series). The illustration 7 has to be considered when changing the internal mains load optimization.

8.2 SYNCHRONIZATION WITH dASM MODULE OR dASM BUS MODULE

If the power controllers operates according to full wave mode (TAKT) then this can lead to an increased burden on the mains caused by an unfavorable distribution of the switching on and switching off times. This then has negative effects as a consequence such as higher power loss, flicker effects etc. If load elements are used whose resistance increases over the course of time (ageing) then under certain circumstances a transformer with increased power output may even need to be used.

All of these negative effects can be avoided or reduced to a minimum by using the dASM feature of the dASM module or dASM bus module.

Key features:
• Minimized mains load peaks and related mains feedback rates.
• Setpoint and load alterations are not automatically taken into account for mains load optimization.
• Can also be used with already existing power controllers from Advanced Energy.

For details of connection and operation please refer to the according dASM module or dASM bus module operating manuals.

8.3 SYNCHRONIZATION WITH THE THYRO-POWER MANAGER

A similar effect, as with dASM, can be reached by Thyro-Power Manager. This device has a total of 10 digital outputs at terminals X3 and X4. These are set up as potential-free optical coupler outputs. In the case of mains load optimization they are used as synchronization outputs (SYT) for the connected power controllers or groups of power controllers. All cables are to be laid shielded, the shield is grounded at the power controller. (Details can be found in the operating instructions of the Thyro-Power Manager available separately).
In addition the illustration 8 has to be considered when changing the wiring diagram of Thyro-Power Manager.

8.4 SOFTWARE SYNCHRONIZATION WITH SOLID DELAY

Software synchronization is a method of mains load optimization which can be configured via an optional bus module or via the Thyro-Tool AX. The software synchronization is configured by inputting a parameter and causes a delay of the initial ignition following the Thyro-AX being switched on.
• Requirement is the equality of cycle period T_0 to the same value for all power controllers (recommended: T_0 = 50 periods (at 50Hz = 1 sec.).
When configuring with the Thyro-Tool AX:
• Set delay in menu load optimization -> SYNC offset time. Select a different value for each power controller.
All devices used must then be switched on at the load supply simultaneously, ideally with the aid of a corresponding switch/contactor.
A delay time up to the first switching on is set. The numerical value is given in periods. As a result the time until the first switching on is diffe-

rent for each power controller.

This procedure enables a slow switching on of the load, e.g. with a slow cycle time of 1 sec. The values at an interval of 100 lead to a switching on phase delayed by a cycle period T_0 (group formation). This formation, for example, allows the activation of an emergency power generator to be realized.
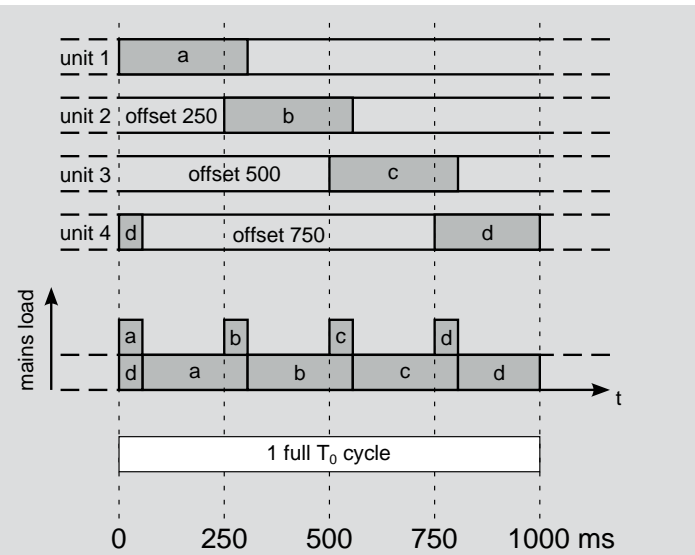

FIG. 21 EXAMPLE OF 4 CONTROLLERS E.G. WITH 100A, LOAD REGU-
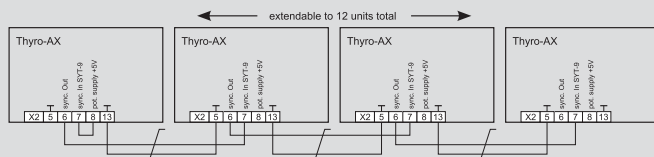LATION CIRCA 30% PARAMETER VALUE OF 4 UNITS: 50, 62, 75, 87
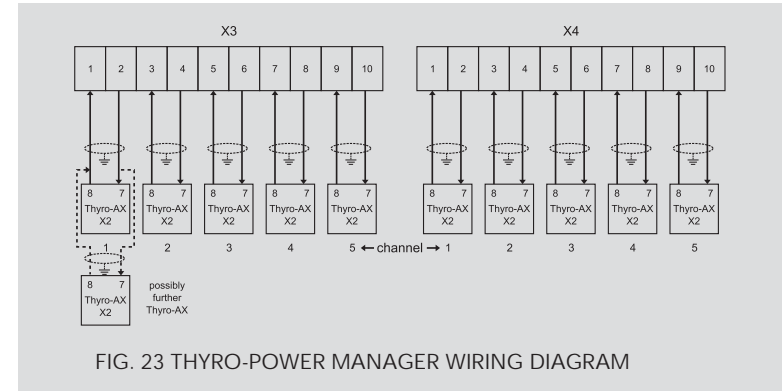

FIG. 22 INTERNAL MAINS LOAD OPTIMIZATION

FIG. 23 THYRO-POWER MANAGER WIRING DIAGRAM

9. LOAD MONITORING

Load monitoring is the identification of a breakdown of one or more resistors connected in parallel series at the time of an error. Therefore the values of load resistance characteristic have to be in the device. Those values are set or automatically determined regarding one of the following approaches:

1. Automatic measurement of nonlinear load characteristic with TeachIn feature

Via TeachIn feature (menu item TeachIn in main menu) the nonlinear load characteristic will be measured automatically.

NOTE:
During TeachIn feature, the unit will be processed for approx. 20s with power on to the connected load within the set limits for current, voltage and power (I_Max, U_Max and P_Max) at default setting.

Thereby the upper and lower tolerance limit of load characteristic (Rmin and Rmax) are determined and saved each for 10 zones.
The parameter RAutoTol (default setting: 10%) determines the tolerance requirement during TeachIn feature, the parameter is changeable with Thyro-Tool AX.
Through TeachIn feature the load monitoring is active.

2. Manual entry or change of nonlinear load characteristic with Thyro-Tool AX

With Thyro-Tool AX, the 10 values can be set and changed manually in menu LOAD CHARACTERISTIC for the upper and lower tolerance limits of load characteristic (R_{max} and R_{min}).
Furthermore the load monitoring can be activated or deactivated separately for the upper and lower tolerance limit (R_{max}, R_{min}) in menu MONITORING of Thyro-Tool AX.

3. Manual entry of linear load resistor value via display

By using menu items SETTINGS -> MONITORING on the display, the linear load resistor value R_Max can be entered manually.

R_Max shows at active load monitoring the arithmetic mean of 10 values of the resistor characteristics.
At deactivate load monitoring, the value for R_Max is 0.
If R_Max is set (by pressing OK) to a value > 0 on the display, the applicable existing nonlinear load resistor characteristic will be exchanged by the defined linear resistor of R_Max and load monitoring will be active.
If R_Max is set to 0 on the display, the load monitoring will be deactivated.

Alternatively the TeachIn-function can be used for an automatically adjustment of the parameter R_Max. TeachIn determines the value for R_Max by measuring the current and voltage plus a variable addition (parameter RAutoTol, default value: 10%, parameter RAutoTol can be changed with Thyro-Tool AX). While TeachIn determines the value for R_Max, the limits are still in use (I_Max, U_Max and P_Max).

NOTE
- Thyro-Tool AX can reactivate the load monitoring together with the (nonlinear) load characteristic of the device.
- The adjusted monitoring value Rmax should be in the middle between the resistance value without error and the resistance value at an error. However, it should not fall below 15%.
- In the tables below attention should be paid to minimal load nominal current (I-load-nominal / I-type controller) and minimal load nominal voltage (U-load-nominal / U-type controller). If the values are by far better as the ones in the tables, a better monitoring could be achieved by more parallel load resistances.

Thyro-AX 1A, Thyro-AX 2A and Thyro-AX 3A (load with separate star point without neutral conductor)

NUMBER OF PARALLEL LOAD RESISTANCES	$I_{LOAD\ NOMINAL}$ / $I_{TYPE\ CONTROLLER}$ *	$U_{LOAD\ NOMINAL}$ / $U_{TYPE\ CONTROLLER}$ *	RESISTANCE CHANGE IN FAULT**	RECOMMENDED SETTINGS FOR R_MAX
1	20%	40%	unlimited	R_{Load} +50%
2	20%	40%	+100%	R_{Load} +50%
3	40%	40%	+50%	R_{Load} +25%
4	40%	40%	+33%	R_{Load} +18%
5	40%	40%	+25%	R_{Load} +15%

Thyro-AX 2A and Thyro-AX 3A (load with common star point without neutral conductor)

NUMBER OF PARALLEL LOAD RESIS-TANCES	$I_{LOAD\ NOMINAL}$ / $I_{TYPE\ CONTROLLER}$ *	$U_{LOAD\ NOMINAL}$ / $U_{TYPE\ CONTROLLER}$ *	RESISTANCE CHANGE IN FAULT**	RECOM-MENDED SETTINGS FOR R_MAX
1	20%	40%	unlimited	R_{Load} +50%
2	20%	40%	+67%	R_{Load} +33%
3	40%	40%	+33%	R_{Load} +18%
4	40%	40%	+22%	R_{Load} +15%

Thyro-AX 2A and Thyro-AX 3A (load in delta connection)

NUMBER OF PARALLEL LOAD RESIS-TANCES	$I_{LOAD\ NOMINAL}$ / $I_{TYPE\ CONTROLLER}$ *	$U_{LOAD\ NOMINAL}$ / $U_{TYPE\ CONTROLLER}$ *	RESISTANCE CHANGE IN FAULT**	RECOM-MENDED SETTINGS FOR R_MAX
1	20%	40%	+73%	R_{Load} +36%
2	20%	40%	+31%	R_{Load} +16%
3	60%	40%	+20%	R_{Load} +15%

Thyro-AX 3A (load with common star point with neutral conductor / open delta connection)

NUMBER OF PARALLEL LOAD RESIS-TANCES	$I_{LOAD\ NOMINAL}$ / $I_{TYPE\ CONTROLLER}$ *	$U_{LOAD\ NOMINAL}$ / $U_{TYPE\ CONTROLLER}$ *	RESISTANCE CHANGE IN FAULT**	RECOM-MENDED SETTINGS FOR R_MAX
1	20%	40%	unlimited	R_{Load} +50%
2	20%	40%	+100%	R_{Load} +50%
3	40%	40%	+50%	R_{Load} +25%
4	40%	40%	+33%	R_{Load} +18%
5	40%	40%	+25%	R_{Load} +15%

* min value for 100% setpoint
** partial load fault

TAB. 10 LOAD RESISTANCE

NOTE

- In operating mode VAR, the monitoring is blocked for large control angles (for load with neutral conductor alpha > 140°, for load without neutral conductor alpha > 117°).
- In the operating mode TAKT the monitoring is blocked for low setting times (Ts) (by 2-phase devices Ts< 2 periods).

10. MULTI I/O

The multi I/O feature allows flexible classification of digital inputs and outputs for internal device features or status updates.
This allows the adjustment of Thyro-AX for very specific customer and application related requirements.
In table 9 are listed the features which can be assigned to the multi I/O inputs and outputs.

FUNCTION OUTPUT	REMARKT
OFF	No function.
Events	Output of messages (events). Messages can be set.
SYT-OUT	Mains load optimization, Output signal for following unit.
SYT-Time	Mains load optimization, Signal at the end of waiting period.
SYNC_OUT	Determined square wave signal of SYNC voltage to which the unit synchronizes 50Hz / 60 Hz.
REL_OUT	Position of relay.
THY_POS	Logic signal for pos. thyristor.
THY_NEG	Logic signal for neg. thyristor.
TS_TIME	Logic signal for turn-on time Ts at TAKT.
T0_TIME	Logic signal for cycle period T_0.
OUTPUT	Signal for level of modulation by flashing frequency.
BUS	Signal when the bus module is active.

FUNCTION INPUT	REMARK
off	No function.
SYT-IN	Mains load optimization, Input signal of previous unit.
SWITCH	Input of operating mode SWITCH.
BUS_SW	Input for selection of setpoint (Local / Remote).
OPERATE	Input for switching operating mode between VAR and TAKT. Prior VAR must be active as operating mode.
Dig_SW2_UP	Increase digital setpoint 2 with external button.
Dig_SW2_DOWN	Decrease setpoint 2 with external button.

TAB. 11 MULTI I/O

In table 12 of chapter Technical Data are listed the technical specifications of the five different multi I/O inputs and outputs. Please note that they are distinguished from each other, e.g. in signal level, in inverting, in capacity, etc.
Thyro-Tool AX is necessary for changing the default setting of multi I/O assignment.

11. DIMENSION DRAWINGS

Thyro-AX 1A...16A

Thyro-AX 1A...30A

front view without USB cover

view A without protection caps

Thyro-AX 1A...45A, ...60A

front view without USB cover

Thyro-AX 1A...100A

Front view without USB cover

view A without protection caps

side view

Thyro-AX 1A...130A, ...170A

Front view without USB cover

view A without protection caps

side view

Thyro-AX 1A...230A, ...240A, ...280A, ...350A

Thyro-AX 1A...1000A

Thyro-AX 1A...1400A, ...1500A

front view without USB cover
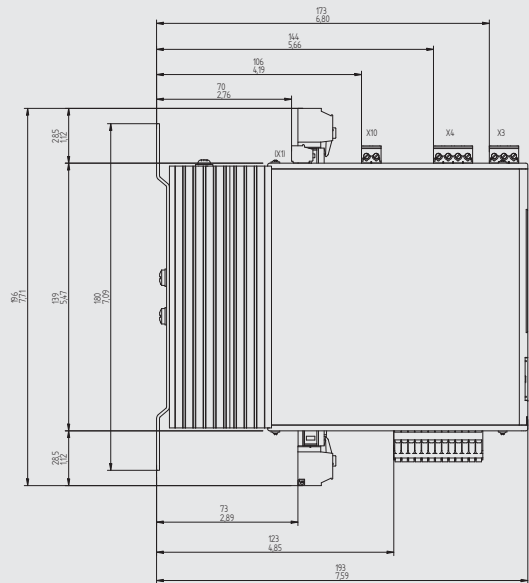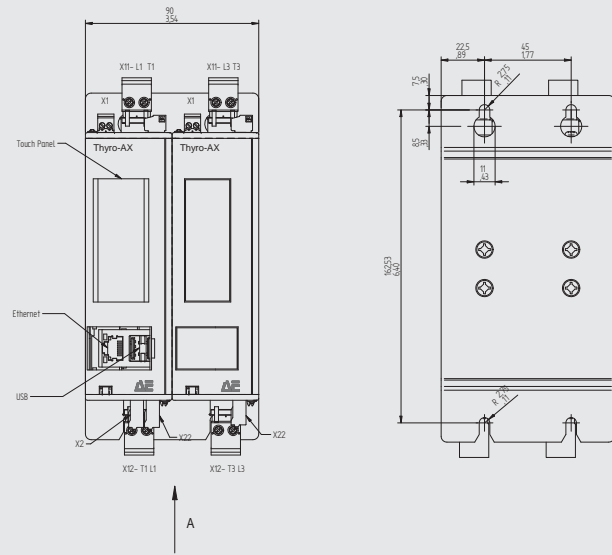
Thyro-AX 2A...16A

front view without USB cover

side view

Thyro-AX 2A...30A

front view without USB cover

Thyro-AX

Thyro-AX

Touch Panel

USB

Ethernet

X2   X22

X22

A

view A without protection caps

Thyro-AX 2A...45A, ...60A

front view without USB cover

Thyro-AX

Thyro-AX

Touch Panel

USB

Ethernet

X2   X22

X22

A

view A without protection caps

Thyro-AX 2A...100A

Thyro-AX 2A...130A, ...170A

Thyro-AX 2A...230A, ...240A, ...280A, ...350A

Draufsicht Thyro-AX ...-1000 HFR.2

Thyro-AX 2A...1000A

Draufsicht Thyro-AX ...-1000 HFR.2

Thyro-AX 2A...1400A, ...1500A

front view without USB cover

Thyro-AX

Touch Panel

USB

Ethernet

Thyro-AX 3A...16A

front view without USB cover

Thyro-AX

Touch Panel

Ethernet

USB

side view

Thyro-AX 3A...30A

front view without USB cover

view A without protection caps

Thyro-AX 3A...45A, ...60A

front view without USB cover

view A without protection caps

Thyro-AX 3A...100A

Thyro-AX 3A...130A, ...170A

Thyro-AX 3A...230A, ...240A, ...280A, ...350A

Frontansicht

Draufsicht

Seitenansicht

Thyro-AX 3A...1000A

Frontansicht

Draufsicht

Thyro-AX 3A...1400A, ...1500A

12. TECHNICAL DATA

12.1 TECHNICAL DATA

TYPE VOLTAGE ...H RLP2
24V to 230V + 10%
24V to 400V + 10%
24V to 500V + 10%
24V to 600V + 10%

IP20 PROTECTION

DANGER:
Energized parts.

The device shall immediately be disconnected from the power supply
before installation.
The Thyro-AX is designed according to IP20 protection code. To ensure
protection during operation, the correct mounting is necessary of the
added protection devices at each electric connection.
Please see chapter 5.2 "IP20 Protection" for detailed information.

ELECTRONIC SUPPLY
The (additional) control voltage supply serves to supply the internal
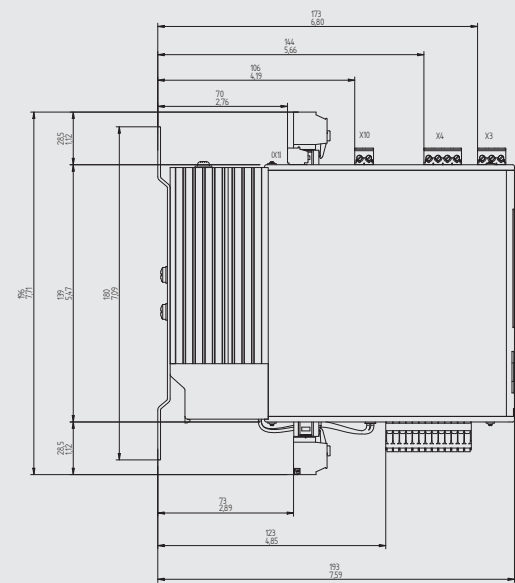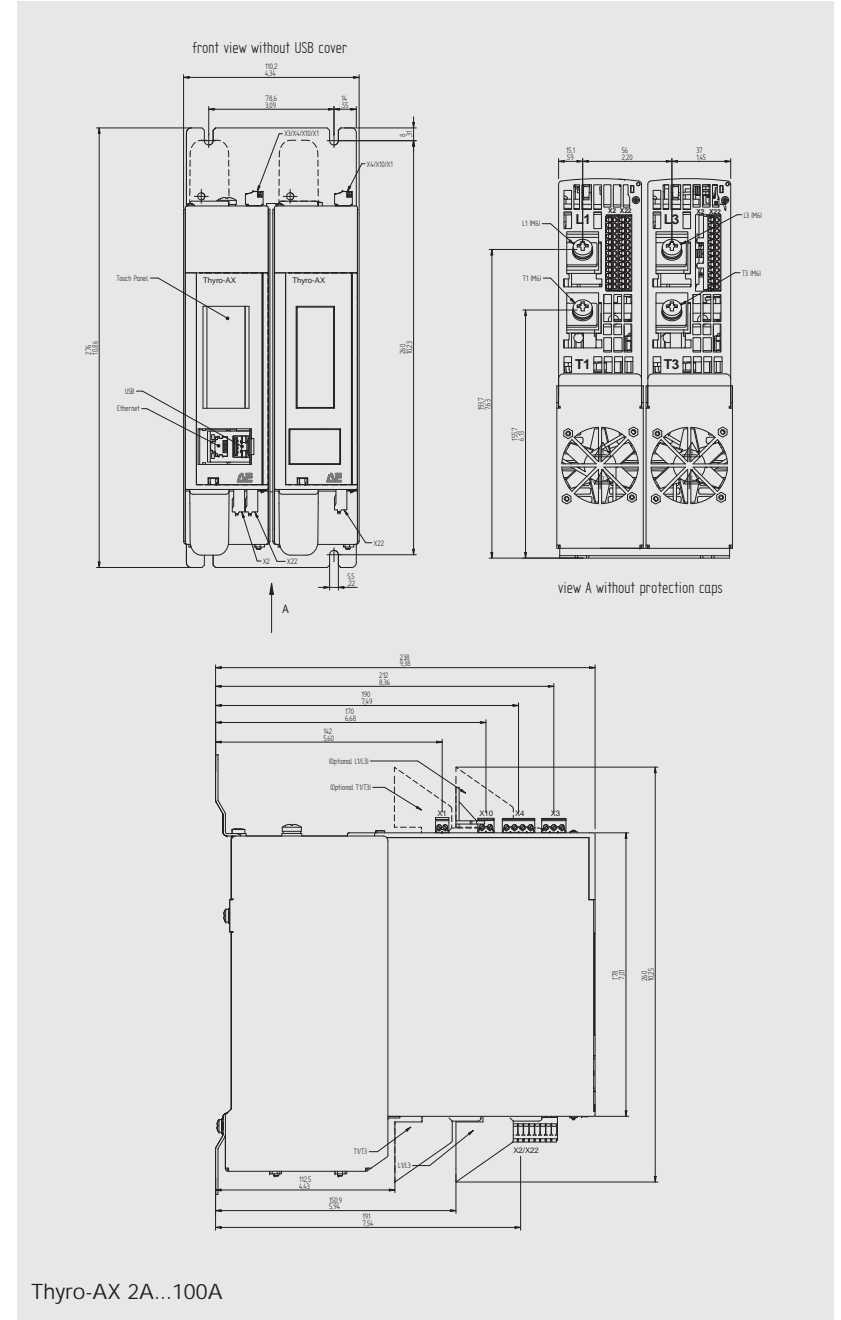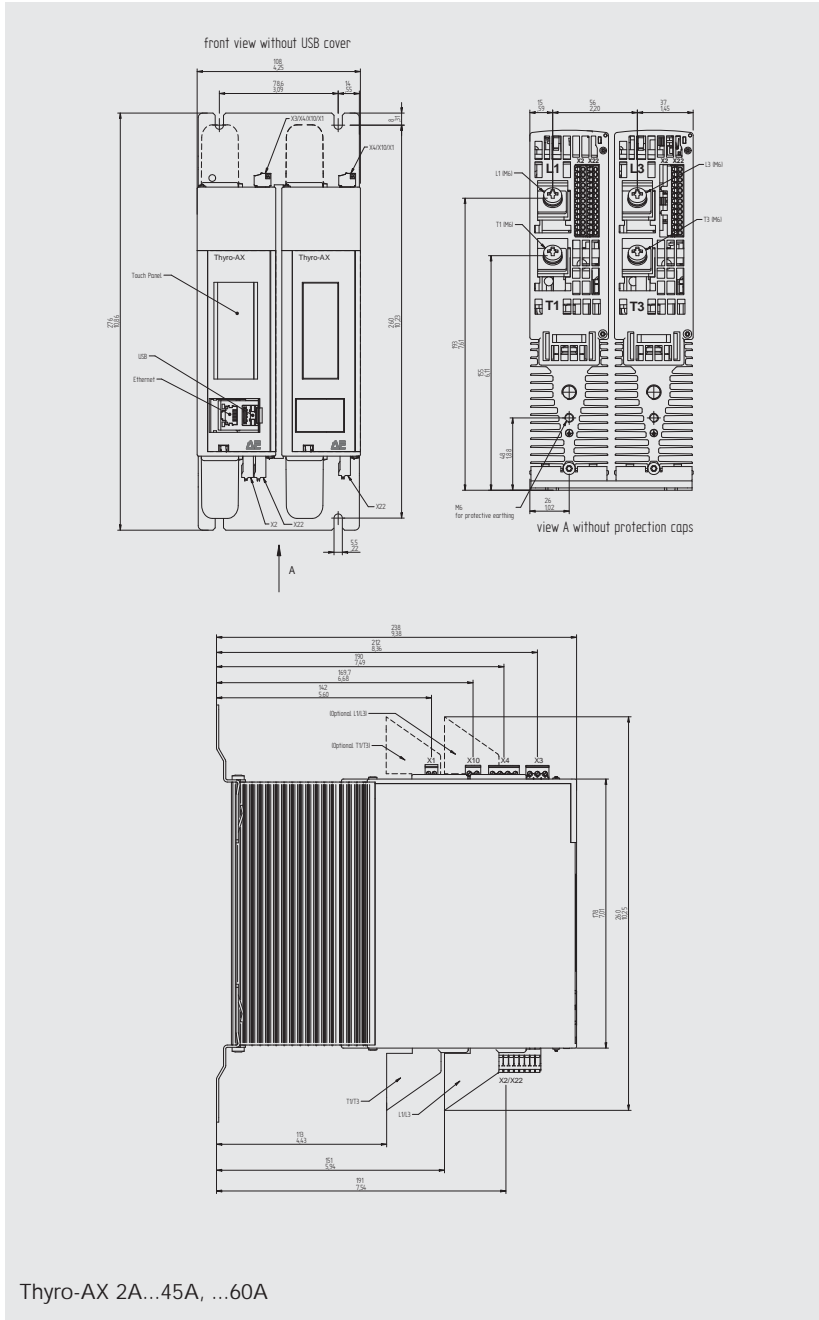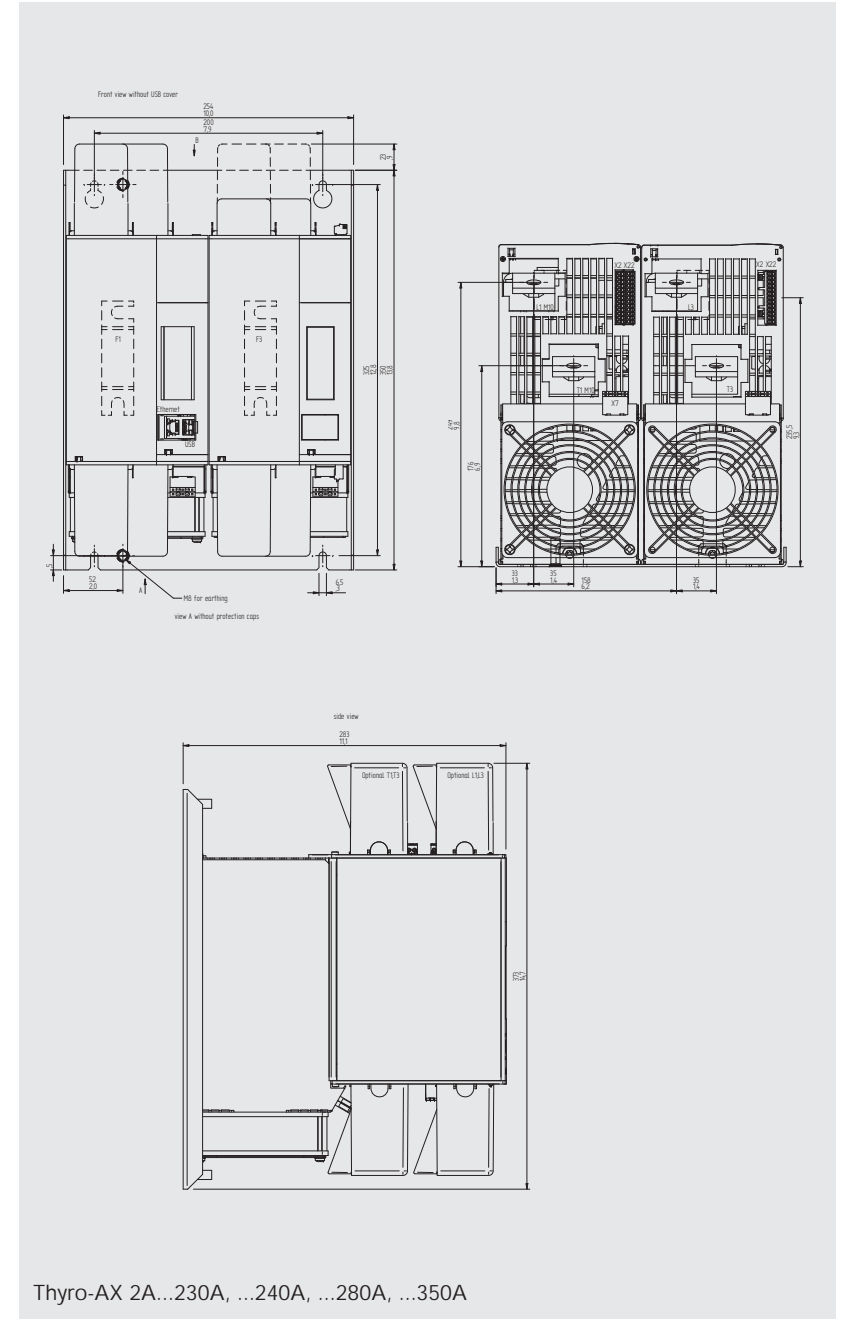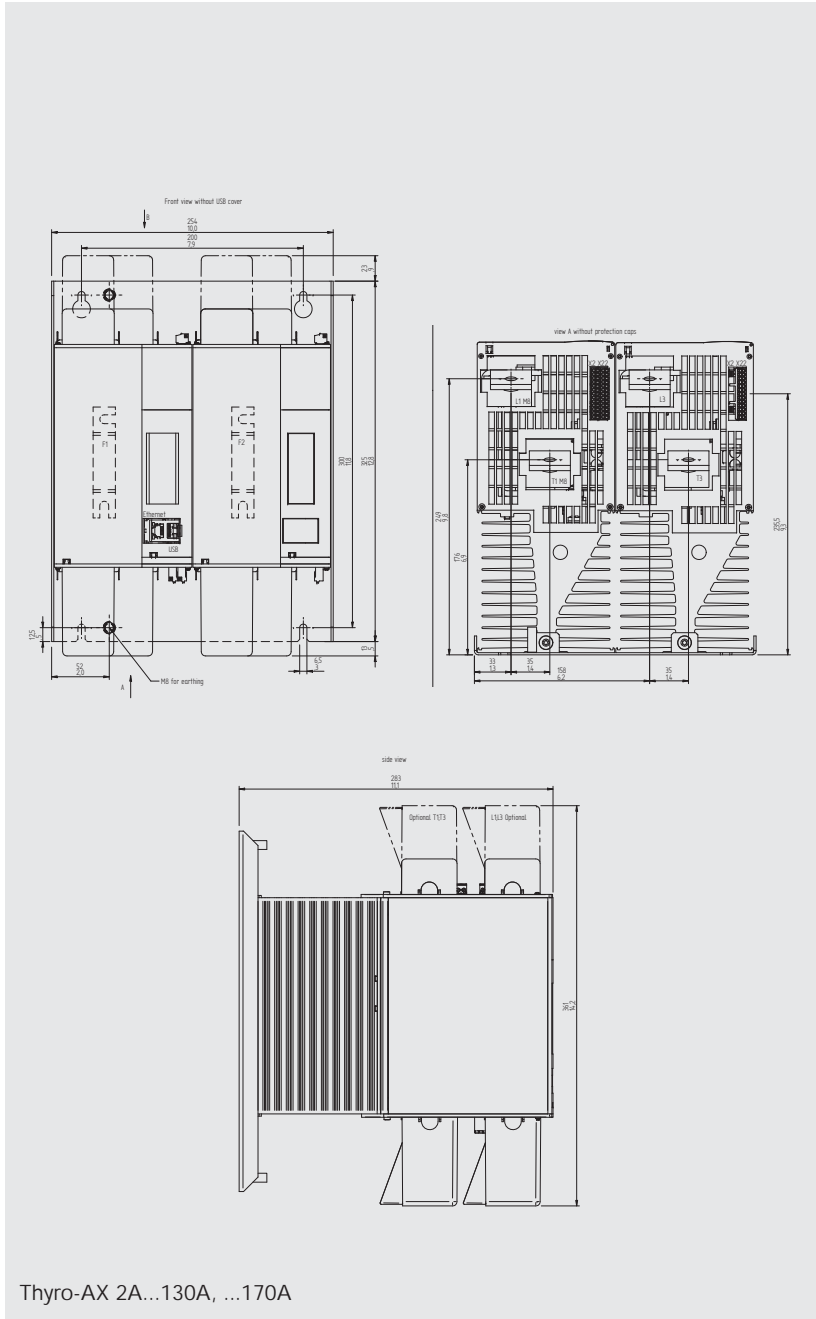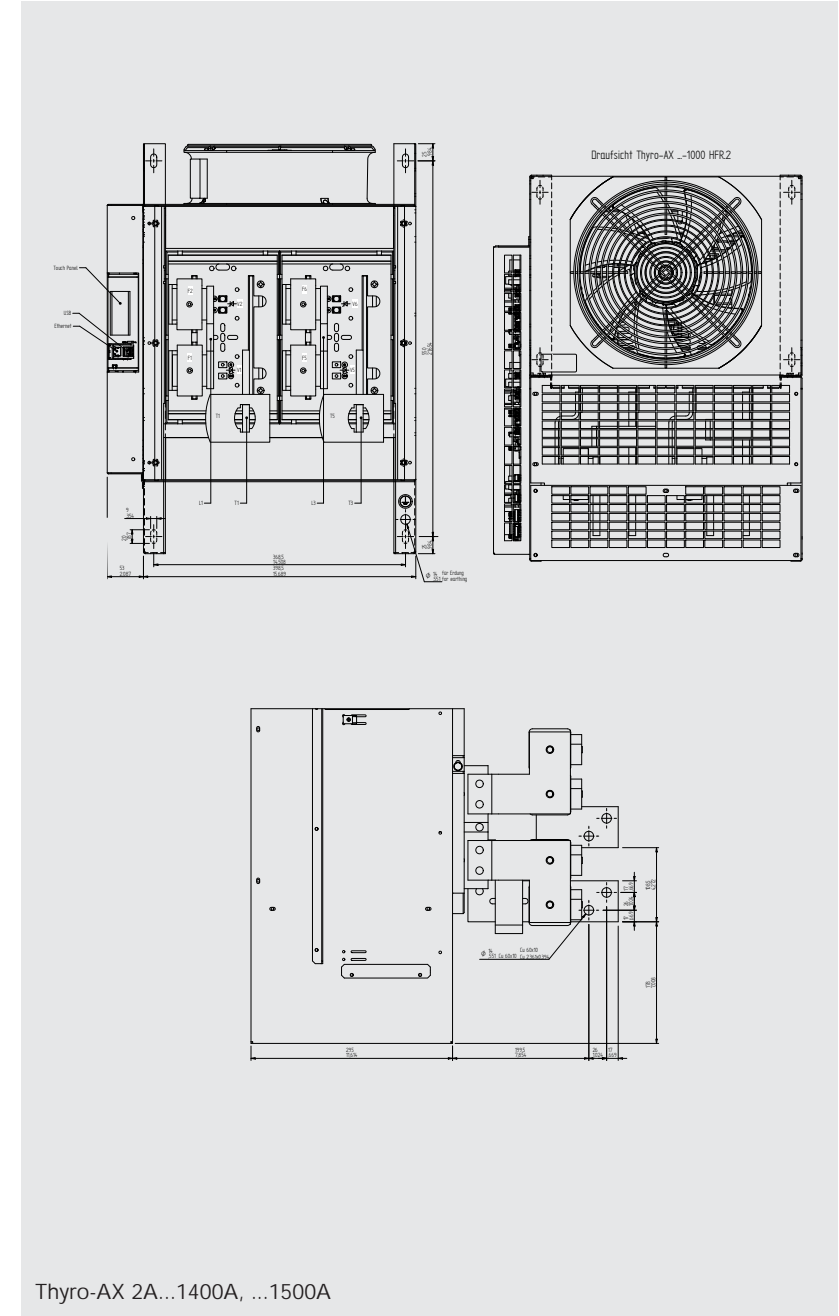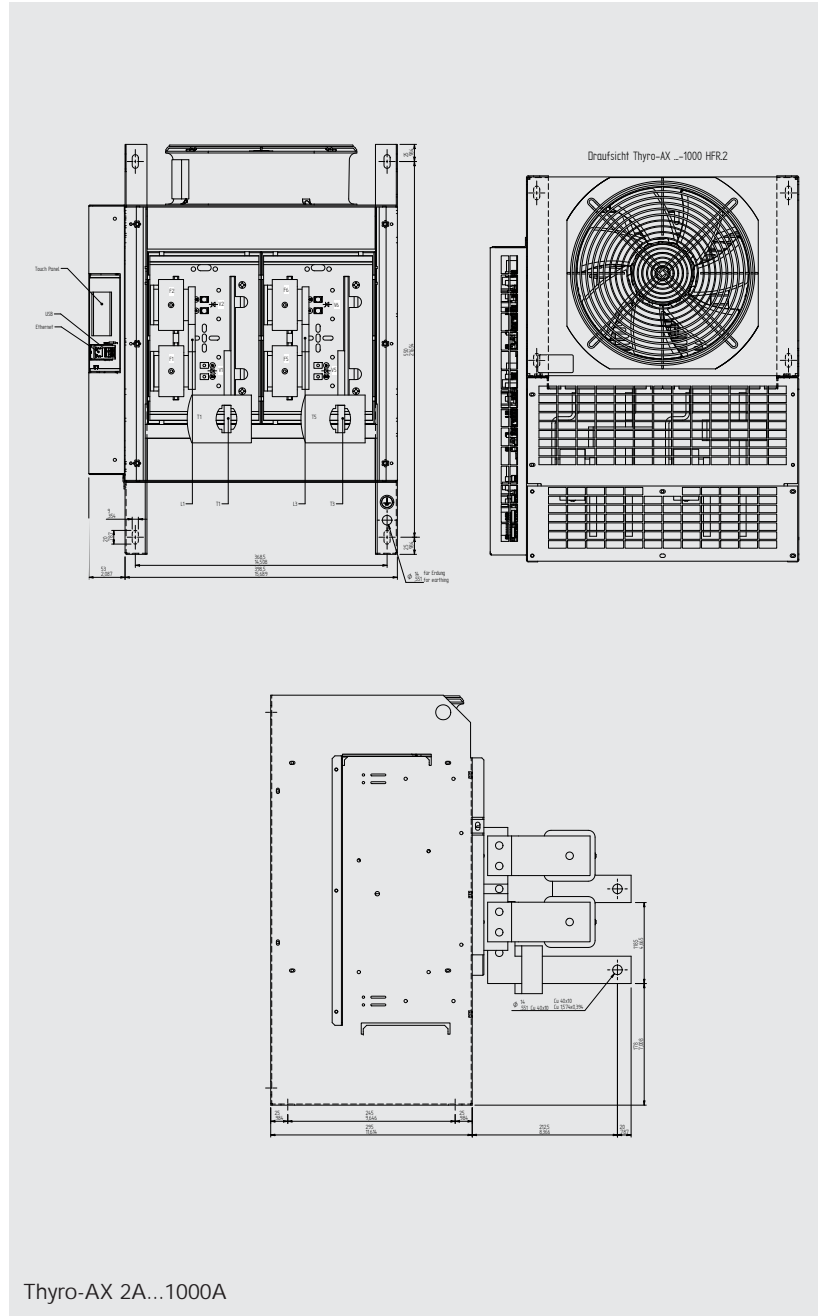electronics max. 10W or 27VA respectively (typically 5.5W or 16VA
respectively) for each supplying power unit (Please consider that for
2-phase device the information has to applied 2-times and for 3-phase
operation respectively 3-times), 230 V~/110 V~ (85 V - 265 V).

MAINS FREQUENCY
all types 47 Hz to 63 Hz;
maximum frequency alteration 55% per half wave

LOAD TYPE
- Ohmic load
  ohmic load with R_{warm}/R_{cold} relation to 6, peak current limitation to
  $\hat{\imath}=3xI_{Nom}$ (in VAR)
- Transformer load

CAUTION

The induction of the downstream transformer should not exceed 1.45 T
in case of mains overvoltage in use (grain-oriented, cold rolled sheets)
= 1.2 T nominal induction.

OPERATING MODES
TAKT = full wave mode
VAR = phase angle firing (only for types Thyro-AX 1A and Thyro-AX 3A)
QTM = quick half wave cycle operation (only for type Thyro-AX 1A)
SWITCH = switch mode

SETPOINT INPUTS
4 setpoint inputs (SELV, PELV), separated from the mains.
- setpoint 1 and 2: analog setpoint input signal ranges:
    - 0(4) - 20 mA Ri = circa 250 Ω
    - 0(1) -   5 V Ri = circa 14.7 kΩ
    - 0(2) -   10 V Ri = circa 11 kΩ
- setpoint 3: digital potentiometer
- setpoint 4: optional bus interface, connection of overriding PC or
  automation system.

CONTROL CHARACTERISTICS
Any controller (e.g. temperature controller), whose output signal lies in
the range 0-20 mA/0-5 V/0-10 V, is adaptable to the power controller.

CONTROL INPUT FOR SWITCH MODE OPERATION
maximum switching frequency 5 Hz
$t_{on\ min}$ = 100 ms
$t_{off\ min}$ = 100 ms

ANALOG OUTPUTS
signal level 0-10 V, 2-10 V 0-20 mA, 4-20 mA
maximum output load voltage 10 V

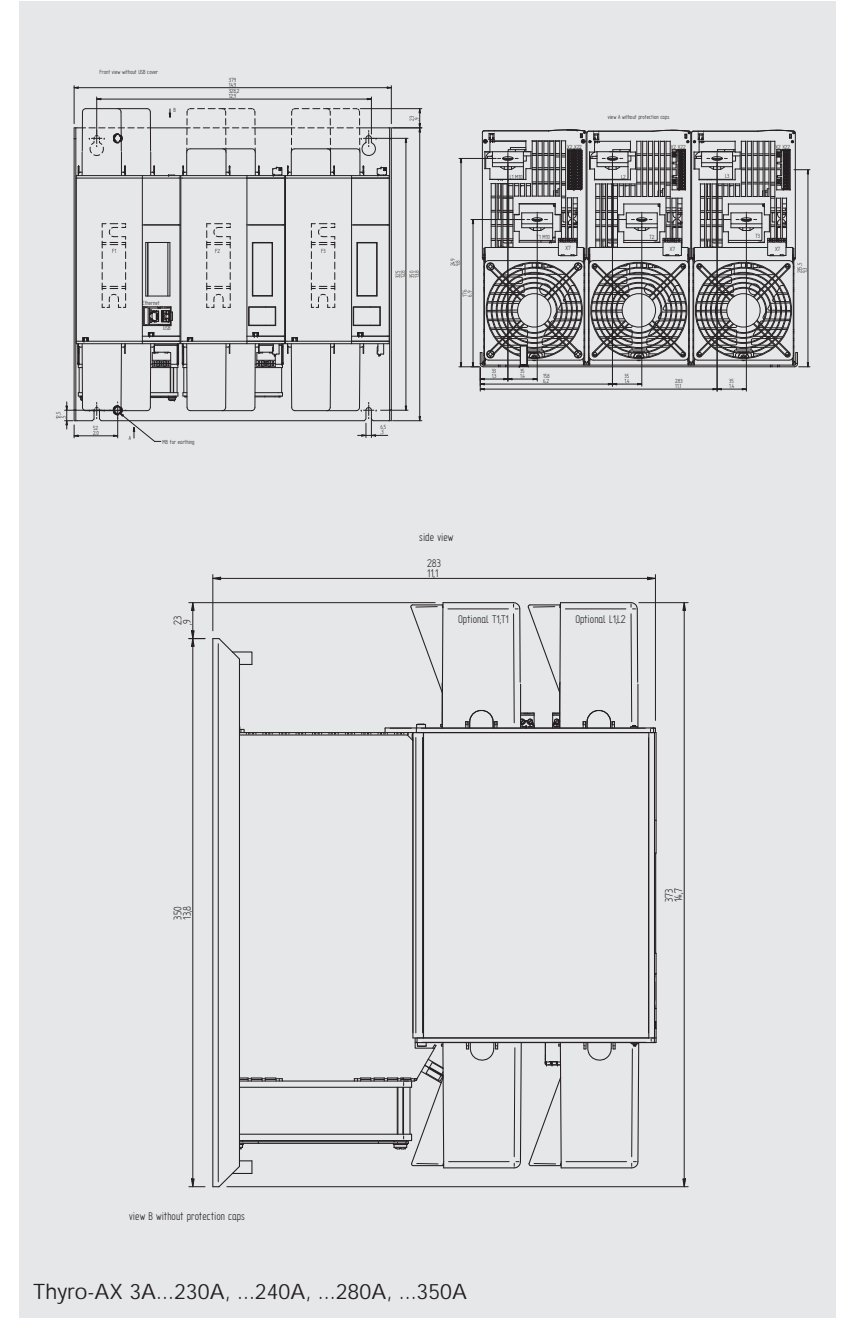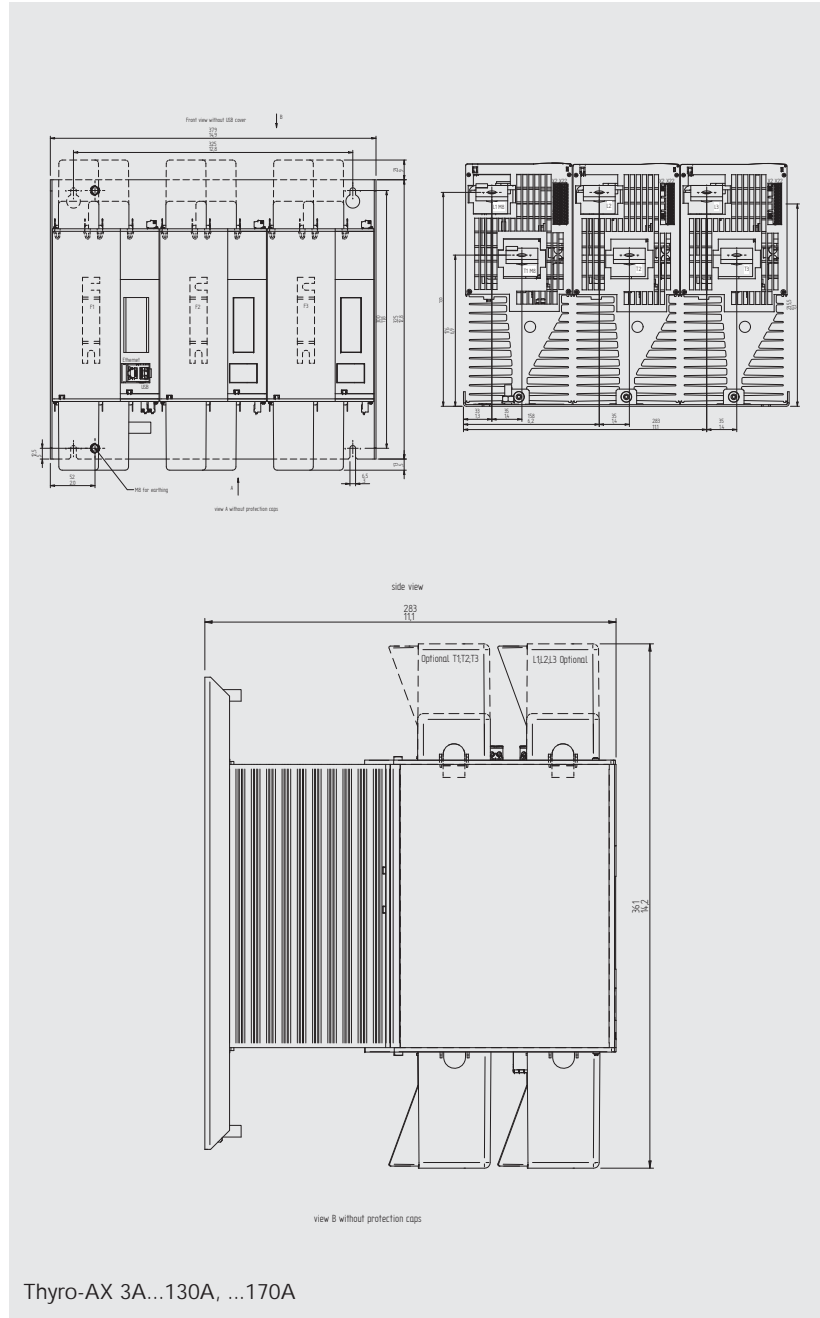**CONTROL MODES**
… H RLP2:   voltage control U_{eff}, U^2_{eff}

                        current control I_{eff}, I^2_{eff}

                        power control P

ACCURACY OF THE CONTROL:
voltage ± 1,5%* in range -15% to +10% of the type voltage.
current ± 1,5%*
* in relation to the respective end value(based on the digital set point)

DATA LOGGING

Phase power and phase resistances are measured. Therefore also asymmetrical loads and changes are recorded precisely. As an option for pure inductive loads, the measurement can be set to an virtual star point.

LIMITATIONS

voltage limitation U_{eff}
current limitation I_{eff}
power limitation P
peak current limitation to $\hat{i}=3xI_{Nom}$ in phase angle firing

RELAY OUTPUTS

changeover, contact material: $AgSnO_2$/Au coated
The relay can be used for low load circuits (> 5 V 20 mA), however, not if it is preloaded with 230 V~.
Maximum values: 250 V, 4 A, 180 W, 1500 VA

MULTI I/O

NUMBER	I/O	CONNECTION	DEFAULT VALUE	LOGIC LEVEL	SIGNAL LEVEL
Multi I/O 1 (Direction selectable by jumper)	Input	X22.9 (default: input active)	SWITCH	High active	0-30 V, R_i = 3,3 kΩ
	Output	X22.9	-	Low active	12 V, R_i = 3,5 kΩ
Multi I/O 2	Input	X2.7	Syt-In	High active	0-24 V, R_i = 10 kΩ
	Output	X2.6	Syt-Out	Low active	12 V, R_i = 34 kΩ, max 359 µA toward GND
Multi I/O 3	Input	X22.1	Bus connection/ set point remote	Low active, only for SYT_ IN feature high active	Bridge to GND, R_i = 10 kΩ
	Output	green LED next to Ethernet plug	-	High active	-
Multi I/O 4	Input	X2.4	Analog SW1	High active	(see range of set point inputs)
	Output	-	-	-	-
Multi I/O 5	Input	X2.11	Analog SW2	High active	(see range of set point inputs)
	Output	-	-	-	-

TAB. 12 MULTI I/O SIGNALS

optional for digital setpoint 2 with external switches

| X2 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |

Switch up　　Switch down
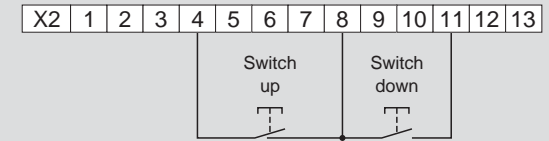
FIG. 24 DIGITAL SET POINT 2 VIA EXTERNAL BUTTONS

AMBIENT TEMPERATURE

40 °C at ...F... (with forced cooling)
40 °C in case of natural air cooling (without fans)
If the maximum ambient temperature is reduced the maximum load current can be increased up to 110% of the nominal current. Here the following applies: 1% more current requires a temperature reduction of 1 °C.
The maximum ambient temperature can be increased up to a maximum of 55 °C if the maximum load current is reduced. Here the following applies: 1°C more ambient temperature requires a current reduction of 2%. Device usage for UL applications up to a maximum ambient temperature of 40 °C.

CONNECTION DATA OF THE POWER CONNECTION

Grounding screw/bolt for protective conductor connection to the heat sink. The grounding also serves EMC means (Y - capacitor 4.7 nF).

	CONNECTION L1, T1, L2, T2, L3, T3	GROUNDING SCREW	CONDUCTOR CROSS-SECTION
16 / 30 A	lug / M4	lug / M4	maximum 6 mm²
45 A*	M 6	M 6 maximum	50 mm²
60* / 100 A*	M 6	M 6 maximum	50 mm²
130 / 170 / 230 A	M 8	M 10	95 / 120 mm²
240 / 280 A	M 10	M 10	150 / 185 mm²
350 A	M 10	M 10	185 mm²
495 A	M 10	M 10	Cu 48x3; 2xø11
650 A	M 10	M 10	Cu 48x3; 2xø11
1000 A	M12	M12	Cu 60x10; 2xø14
1400 A	M12	M12	Cu 60x10; 2xø14
1500 A	M12	M12	Cu 60x10; 2xø14

TAB. 13 CONNECTION DATA OF THE POWER CONNECTION

With UL applications only use 60 °C or 60 °C/75 °C copper conductors (with the exception of control cables).

* With UL applications only use 75 °C copper conductors (with the exception of control cables).

1 Pound-Force Inch =   0.112985 Newton Meter

Tightening torques for electric connections in Nm

SCREW	MIN. VALUE [NM]	NOM. VALUE [NM]	MAX. VALUE [NM]	POWER CONNECTION	GROUND CONNECTION	FUSE	CONTROL WIRE
					TYPE IN [A]		
M2	0.2	0.25	0.3				Phoenix terminals
M3	0.6	0.75	0.9	16;30			Phoenix terminals
M4	1.0	1.2	1.4		16;30		
M5	1.7	2.0	2.3			16;30	
M6	2.6	3.0	3.5	45;60;100	45;60;100	45;60;100	
M8	5.1	6.0	6.9	130;170;230	130;170;230; 240;280;350	130;170;230;	
M10	8.5	10.0	11.5	240;280;350		240;280;350	
M12	13.2	15.5	17.8				

Tightening torques for electric connections in pound inches

SCREW	MIN. VALUE [POUND INCHES]	NOM. VALUE [POUND INCHES]	MAX. VALUE [POUND INCHES]	POWER CONNECTION	GROUND CONNECTION	FUSE	CONTROL WIRE
					TYPE IN [A]		
M2	1.9	2.2	2.5				Phoenix terminals
M3	5.6	6.6	7.6	16;30			Phoenix terminals
M4	9.0	10.6	12.2		16;30		
M5	15.0	17.7	20.4			16;30	
M6	22.6	26.6	30.5	45;60;100	45;60;100	45;60;100	
M8	45.1	53.1	61.1	130;170;230	130;170;230; 240;280;350	130;170;230;	
M10	75.2	88.5	101.8	240;280;350		240;280;350	
M12	116.6	137.2	157.8				

TAB. 14 TIGHTENING TORQUES

12.2 APPROVALS AND CONFORMITY

The standards are subject to an adaptation and renumbering process which will continue for years as a result of European harmonization and international alignment. That is why in the detail listings norms to date are stated even if their expiry date has already been decided.
There is no product norm for thyristor power controllers so that a sensible norm framework must be created from the corresponding fundamental norms in order to facilitate safe application and comparison possibilities.

Thyristor power controllers are not devices to be used for disconnecting purposes in the sense of DIN EN 50110-1 and as a result may only be operated in connection with an appropriate upstream mains disconnecting device (e.g. breaker, observe VDE 0105 T1).

The Thyro-AX has the following approvals and conformities:
• Quality standard in accordance with EN ISO 9001
• Approval in accordance with UL 508, File No. E 135074 Investigated under consideration of the Canadian National Standard C22.2 No. 14-95
• UL Markings:
  - Tightening torque (in pound inches) see Chapter 12.1. (only for devices rated 16A or 30A)
  - Wiring details: „Use 60/75°C wires" and specified tightening torque (pound inches) (only for devices rated 45A, 60A or 100A)
  - „Max. surrounding air temperature 40°C"
  - Suitable For Use On A Circuit Capable Of Delivering Not More Than 100kA rms Symmetrical Amperes, xxx Volts Maximum, When Protected by RK5 Class Fuses"

NOTE:
xxx = max. allowable voltage depending upon rating of the device

  - „Branch circuit protection must be provided and sized according National Electrical Code and any additional local codes"

• CE conformity
  - Low voltage directive 2006/95/EEC; EMC directive 2004/108/EEC

In detail

DEVICE APPLICATION CONDITIONS

Built-in device			DIN EN 50 178
General requirements			DIN EN 60146-1-1
Installation position		vertical	
Operating location		industry sector	
Storage temperature		-25 °C - +55 °C	
Transport temperature		-25 °C - +70 °C	
Operating temperature		-10 °C - +40 °C with forced cooling	
		-10 °C - +40 °C with natural air cooling	
		-10 °C - +55 °C with reduced type current -2%/°C	
with UL applications		up to +40 °C	
Load category	I	100% permanent operation	DIN EN 60 146-1-1
Damp heat		EN 600721-3-3	93%
Overvoltage category	III		DIN EN 50 178
Degree of pollution	2		DIN EN 50 178
Altitude		≤ 1000 m above sea level	
Safe isolation up to 600 V mains voltage			DIN EN 50 178
EMC interference immunity			EN 61000-6-2
Test in acc. with			DIN EN 60 146-1-1
EMC emission standard			EN 61000-6-4
Compatibility level	Class 3		EN 61000-2-4

12.3 TYPE OVERVIEW

CURRENT [A]	TYPE POWER [KW]				POWER LOSS [W]		DIMENSIONS [MM]			WEIGHT [KG]	FUSE F1
	230 V	400 V	500 V	600 V	Thyro-AX	FAN	W	H	D		
16	3	6	8		25		45	196	193	1.1	20
30	7	12	15		40	1	45	196	193	1.1	40
45	10	18	22		51		52	276	238	2.2	63
				27	61		52	276	238	2.2	63
60	14	24	30		66		52	276	238	2.2	80
				36	72		52	276	238	2.2	80
100	23	40	50		116	1	54	276	238	2.8	200
				60	130	1	54	276	238	2.8	200
130	30	52	65		159		129	361	283	7.8	200
				78	182		129	361	283	7.8	200
170	39	68	85		180		129	361	283	7.8	315
				102	211		129	361	283	7.8	315
230	53	92	115		280	*19/18	129	373	283	8.3	315
240				138	332	*19/18	129	373	283	8.3	315
280	64	112	140	168	352	*19/18	129	373	283	8.3	350
350	80	140	175	210	399	*19/18	129	373	283	8.3	500
1000		400			1317	24	285	600	527.5	33.5	2 x 1000
			500	600	1401	24	285	600	527.5	33.5	2 x 1000
1400			700	840	1721	*64/80	285	600	537.5	33.5	4 x 900
1500		600			1761	*64/80	285	600	537.5	33.5	4 x 900

* 50/60 HZ

TAB. 15 Thyro-AX 1A ...H RLP2

CURRENT [A]	TYPE POWER [KW]			POWER LOSS [W]		DIMENSIONS [MM]			WEIGHT [KG]	FUSE F1
	400 V	500 V	600 V	Thyro-AX	FAN	W	H	D		
16	11	14		49		90	196	193	2.2	20
30	21	26		80	2	90	196	193	2.2	40
45	31	39		101		108	276	238	4.4	63
			47	121		108	276	238	4.4	63
60	41	52		131		108	276	238	4.4	80
			62	144		108	276	238	4.4	80
100	69	86		231	2	110,2	276	238	5.6	200
			104	260	2	110,2	276	238	5.6	200
130	90	112		318		254	361	283	15.6	200
			135	368		254	361	283	15.6	200
170	117	147		360		254	361	283	15.6	315
			176	422		254	361	283	15.6	315
230	159	199		600	*38/36	254	373	283	16.6	315
240			239	664	*38/36	254	373	283	16.6	350
280	194	242		702	*38/36	254	373	283	16.6	350
350	242	303	363	79	*38/36	254	373	283	16.6	500
1000	693			2654	39	451.5	600	527.5	53.0	2 x 1000
		866	1039	2822	39	451.5	600	527.5	53.0	2 x 1000
1400		1212	1455	3462	*127/180	451.5	600	537.5	53.0	4 x 900
1500	1039			3542	*127/180	451.5	600	537.5	53.0	4 x 900

* 50/60 HZ

TAB. 16 Thyro-AX 2A ...H RLP2

CURRENT [A]	TYPE POWER [KW]			POWER LOSS [W]		DIMENSIONS [MM]			WEIGHT [KG]	FUSE F1
	400 V	500 V	600 V	Thyro-AX	FAN	W	H	D		
16	11	14		73		135	196	193	3,3	20
30	21	26		121	3	135	196	193	3,3	40
45	31	39		151		164	276	238	6,6	63
			47	182		164	276	238	6,6	63
60	41	52		197		164	276	238	6,6	80
			62	216		164	276	238	6,6	80
100	69	86		346	3	164	276	238	8,4	200
			104	390	3	164	276	238	8,4	200
130	90	112		475		379	361	283	23,4	200
			135	544		379	361	283	23,4	200
170	118	147		540		379	361	283	23,4	315
			176	632		379	361	283	23,4	315
230	159	199		840	*57/54	379	373	283	24,9	315
240			239	995	*57/54	379	373	283	24,9	315
280	194	242	291	1054	*57/54	379	373	283	24,9	350
350	242	303	363	1194	*57/54	379	373	283	24,9	500
1000	693			3891	*64/80	618	600	527.5	72,0	2 x 1000
		866	1039	4143	*64/80	618	600	527.5	72,0	2 x 1000
1400		1212	1455	5102	*127/180	618	600	537.5	72,0	4 x 900
1500	1040			5223	*127/180	618	600	537.5	72,0	4 x 900

* 50/60 HZ

TAB. 17 Thyro-AX 3A ...H RLP2

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