ADVANCED ENERGY

THYRO-POWER MANAGER

DECEMBER 2014 EN - V2

1. NOTES TO THESE OPERATING INSTRUCTIONS

1.1. INFORMATION DUTY

The presented Operations Manual shall carefully be read by all persons deployed for work using and employing the Thyro-Power Manager (hereinafter called the “Unit”) prior to assembly and the initial start-up of the Unit.
This Operations Manual is a part of the Unit. The operator of the Unit is committed to provide this Operations Manual to all persons without limitation, who transport the Unit, start it up, maintain it, or perform other work tasks to it.

1.2. VALIDITY

This Operations Manual resembles the technical status of the Unit at the time of publication. Advanced Energy reserves the right to implement content and technical changes in comparison to the information of these operating instructions.

1.3. LOSS OF GUARANTEE

Our supplies and services are based on the General Delivery Terms for Products of the Electro-Technical Industry, as well as on our General Sales Terms. Changes made to the information of this Operations Manual, especially to technical data, operational instructions, dimensions and weights, shall remain our reserved right at all times. We request that complaints regarding delivered products shall be put forward within eight days upon receipt of the products including the package notes as attached. Claims made later cannot receive consideration. Advanced Energy shall annul all possible obligations, such as guarantee commitments, service agreements etc., which may be agreed upon by Advanced Energy and its distributors, without prior notice, if purchased spare parts other than original Advanced Energy or such other than those purchased via Advanced Energy are used for maintenance and repair.

1.4. HANDLING

This operations manual is structured in a manner so that according expert personnel may perform all work necessary for commissioning, maintenance, and repair. Certain process steps are related to figures in order to clarify and to ease necessary work. 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 for safety regulations may be extracted (see chapter 3.3).

1.5. CONFORMITY

The Unit is designed for presently applicable DIN and VDE regulations in accordance to the protection class IP 00, and is intended for assembly into according casings or switch cabinets.

1.6. MANUFACTURER

Advanced Energy Industries GmbH
Emil-Siepmann-Straße 32
D-59581 Warstein

1.7. CONTACT

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

COMMERCIAL QUERIES
If you have any commercial queries on power controllers, please get in touch with:
Phone: +49 (0) 2902 763-558

SERVICE-HOTLINE
Our team is at your service on the following hotline:
Phone: +49 (0) 2902 763-600

INTERNET
Further information about our company or products please visit:
http://www.advanced-energy.com

1.8. COPYRIGHT

1.9. FURTHER INFORMATION ON COPYRIGHT

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2. GENERAL DESCRIPTION

The Thyro-Power Manager possesses numerous functions. The unit can also be deployed for peak load network monitoring next to its use for network optimization (as a substitute for the previously deployed SYT9 module). The measuring functions register the effective values of up to three electrical currents (or voltages), and deliver their effective values as DC signals (as a substitute for three previously deployed ZME modules). In the course of this, the integration-time feature is capable for adjustment so that measurements can be made during full frequency operations. Power and energy consumption may also be measured. Furthermore, the measurement of mains voltage, temperature, and three DC inputs is performed. These values may also be displayed. A monitoring function is available for the most of these measurement values. The unit possesses a serial interface for the purpose of PC connection, and an interface to the bus modules of the Thyro-Family. Thus, the capability is provided for the query of all measurement values via a PC or bus system. Next to the easily performed adjustment capability via a switch or potentiometer, the Unit can also be configured via a comfortable PC program (or via a bus). In the operations mode “I/O Module”, the analog inputs and outputs, as well as the digital outputs, may be set or read via a bus (or via a PC). Furthermore, an operations time counter is integrated into the unit.
Basically the unit is composed of the following components:

- Voltage supply 110V /230V
- Automatic frquency recognition
- Terminal to bus module (PROFIBUS)
- 10x Syt-type potential-free terminals
- RS232-PC terminal
- Error and alarm output
- 6x analog outputs for 0 – 10V
- 3x analog inputs, energy levels are selectable
- 3x converter inputs 1V~ / 100%
- Potentiometers, switches, LEDs

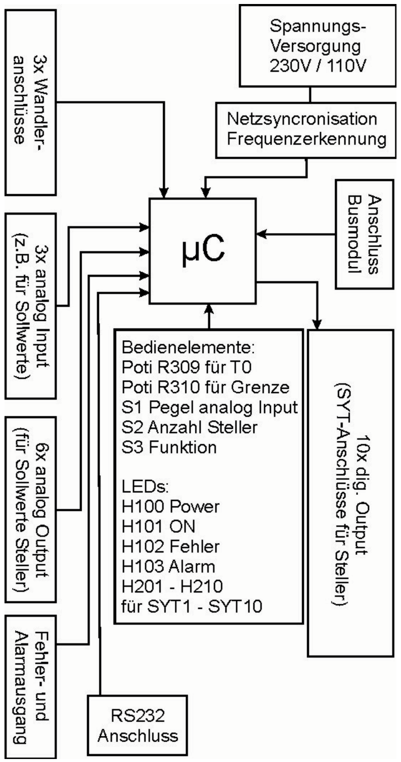

Figure 1: Block diagram

The unit is designed for extreme easy operations. Thus, the number of connected power controllers can directly be adjusted via the rotary switch S2, and the operating mode can directly be adjusted via the rotary switch S3.

In its delivery status, operating mode 1 for “Automatic Static Network Distribution” is set to be activated (rotary switch S3 = 1). In this application case, the user must then only set the number of connected power controllers or power controller groups, respectively, via the rotary switch S2. Further settings are not necessary.

The unit is designed for assembly to an overhead rail. The connection is implemented via screw / plug terminals. Voltage supply may selected to either 230V~ or 110V~. The network frequency is automatically recognized, and all according times are adapted.

3. INTENDED USE

3.1. APPLICATION

This unit has the purpose for the network load optimization of power controllers, for use as measurement map for analog measurement values, and for use as bus I/O module. The unit is permitted to be used only for these purposes.
Any other application is an abuse of use, and can endanger persons. Any liabilities of the manufacturer become void upon abuse of use. The operator and the user of the unit shall solely burden the risks for abuse of use.
Intended use includes the observation of the operations manual and compliance with inspection and maintenance intervals. All malfunctions must be remedied immediately, especially those that impact the safety of the unit.

3.2. LIABILITY

No liability is burdened for non-intended use of the unit. The operator and user shall burden the responsibility for possibly necessary measures for the prevention of people and asset damage. In case of complaints regarding the unit, please contact us immediately and include the following information:

- Type designation
- Fabrication number
- Complaint description
- Duration in operation
- Envirnmental conditions
- Operation mode

3.3. DEPLOYED SYMBOLS

The following warning, prohibition, command, and notice symbols are used in the operations manual, around and within the unit, and at the entrance to the switch room:

Symbol	Description
	Mains Voltage - Danger! This warning note refers to an especially endangering situation. Upon non- compliance, death or major injuries may occur due to electric shock. Please adhere to the described work and process procedures exactly, in order to avoid damage to people or to the unit.
	Danger! This warning note refers to an especially endangering situation. Upon non-compliance, death or major injuries are risked. Please adhere to the described work and process procedures exactly, in order to avoid damage to people or to the unit.
	Caution! This warning note refers to a possibly endangering situation. Upon non-compliance, minor or medium-level injuries or damage may occur.
	Warning about Electro-Magnet Field! Electrical devices, clocks, magnetic storage cards etc. may malfunction or be uncharged.
	Hot Surfaces! Danger of burning. Prevent touching or wear protection clothes.
	Information, Note Notes regarding technical requirements and additional information are provided here, which the user shall observe.

3.4. SAFETY INSTRUCTIONS

3.4.1. ACCIDENT PREVENTION REGULATIONS

Please unconditionally observe the accident prevention regulations of the host country as deployed within, and the generally valid safety instructions in accordance with IEC 364.

The following 5 safety rules must be complied with, prior to the beginning of all work performed to the unit:

	Attention Mains Voltage! Safety rules for work performed to electrical facilities: 1. Disconnect equipment from the mains (establish a voltage free status) 2. Secure equipment against re-activation 3. Determine voltage free status of equipment by measurement 4. Ground and short-circuit equipment 5. Cover or establish borders to neighboring parts under voltage

3.4.2. GENERAL SAFETY NOTES

Important instructions stand out by the use of warning symbols, prohibition symbols, command symbols, or notice symbols.

	The unit is designed in accordance with state-of-art technology and accepted technical safety rules. In spite of this, dangers for the user or third parties and impairments to the unit and other assets may unfold in the course of its use.
	Poor knowledge about operations and maintenance may create damage to persons or assets. Operations and maintenance within the set rule boundaries, as well as compliance with the following listed safety regulations, are necessary for the protection of personnel and for the conservation of operational readiness.
	Personnel, who assemble, dis-assemble, start-up, operate, and maintain the units, must know and observe these safety regulations. All work may only be performed by expert personnel trained for the task assigned using those tools, fixtures, inspection means, and materials for consumption as designed for.
	Please observe all legal or otherwise committing regulations for accident prevention and environmental protection. Prior to task start-up, personnel assigned for tasks to the Unit must have read the general and special safety notes, and have sufficiently become acquainted with the operations of the unit.

	No changes, assemblies, and re-fittings, which impact the safety of the Unit, are allowed to be performed to the Unit without approval of the manufacturer.
	Please secure that only personnel, who are accordingly assigned for work on the unit, are deployed. Third parties shall be held away from the unit, and also be pointed to the possible dangers. Work performed to the unit may only be performed by an electronic technician expert or by vocationally trained persons under the management and peer-overview of an electronic technician expert in accordance with technical electronic regulations.
	The user must install the unit within a casing or switch cabinet so that no dangers exist due to touching and that those applicable standards and safety regulations are complied with.

	For all maintenance and repair work, the unit must be completely de-activated and secured against unintended re-activation in accordance with the 5 safety rules (see chapter 3.4.1.). Existing safety switches are not permitted to be by-passed, de-activated, or be manipulated in any manner within any operational mode of the unit whatsoever.

3.4.3. FIRE PROTECTION

	Danger of fire! In the case of smoke or smell development, as well as in case of fire, the unit shall immediately be switched free of voltage, and a report shall be made to maintenance personnel. Smoking or open fire is forbidden.

3.4.4. QUALIFIED PERSONNEL

	The unit may only be transported, be assembled, be connected, be started up, be maintained, and be operated by expert staff members who master the respectively valid safety and assembly regulations. Safety regulations shall unconditionally be complied with! All work performed shall be controlled by responsible expert personnel.

The duly responsible manager for Unit safety with regard to the necessary tasks envisioned must authorize expert personnel. Expert personnel are those staff members, who:

- Possess the vocational training and experience within the according work area,
- Are knowledgeable about the respectively valid legal regulations (laws and codes), standards, rules, instructions, and accident prevention rules,
- Are vocationally trained as to the functional features and operational conditions of the unit,
- Recognize dangers, and are capable of implementing measures in order to prevent dangers,

Regulations and definitions regarding expert personnel are contained within DIN EN 50110-1:2004 (DIN EN 50110-1:2004 substitutes DIN 57105-1 and DIN VDE 0105 part 1).

3.4.5. SAFETY CONSCIENTIOUS WORK BEHAVIOR

Qualified personnel as defined in chapter 4.2.6 are responsible for safety. These personnel are also responsible that only accordingly qualified persons are located at the unit or within the safety area. Observe the following items:

	Caution! Refrain from any kind of working behavior, which impacts the safety of persons and the function of the Unit in any form. Operate the Unit only in a proper condition. No safety fixtures are allowed to be dis-assembled or be put out of function. Operationally contingent measures shall be implemented prior to the removal of safety fixtures for the execution of maintenance and service, or other work tasks. Always work in compliance with the 5 technical electrical safety regulations!

4. INSTALLATION

4.1. SAFETY NOTES

The following 5 safety rules must be complied with, prior to the beginning of all work performed to the unit:

Attention Mains Voltage!

Safety rules for work performed to electrical facilities:
1. Disconnect equipment from the mains (establish a voltage free status)
2. Secure equipment against re-activation
3. Determine voltage free status of equipment by measurement
4. Ground and short-circuit equipment
5. Cover or establish borders to neighboring parts under voltage

4.2. SCOPE OF DELIVERY, ASSEMBLY

4.2.1. SCOPE OF DELIVERY

The delivery is comprised of the following parts:

- Thyro-Power Manager
- Pouch with screws/ plug terminals
- Operating instructions

4.2.2. ASSEMBLY

The units must be assembled on the overhead rail within a switch cabinet / casing. Voltage supply is performed at terminal X1. In the course, the connection voltage must be selected there, and the according jumpers must be set (230V~ jumper X1.5 – X1.6; 110V~ jumper X1.4 –X1.6 and jumper X1.5 – X1.7).
Grounding shall be performed at X1.1 or X1.2 in accordance with local regulations! For this, see also chapter 4.5.4.1 connection for voltage supply.

4.3. STORAGE

The Unit may be stored in rooms, which are dry, ventilated, and equipped with a fixed protection roof, and originally packaged.

- Permissible ambient temperature: -25°C to +55°C
- Permissible relative air humidity: max. 85%

For longer storage durations, the Units should be contained in airtight plastic skins with the use of commercially available drying agents.

4.4. REQUIREMENTS FOR INSTALLATION

4.4.1. DIMENSIONS / WEIGHTS

The Unit possesses the following dimensions and weight:

Unit	Width	Height	Depth	Weight
Thyro-Power Manager	150mm	95mm	60mm	0.35kg

Consider the following necessary free space upon assembly:

- 20 mm upwards
- 20 mm downwards

4.4.2. GENERAL REQUIREMENTS

The units may be assembled next to each other without a sideward gap.
The user must install the Unit within a casing or switch cabinet so that no dangers exist due to touching and that those applicable standards and safety regulations are complied with!

4.5. INSTALLATION

4.5.1. COOLING

It shall be observed that the maximum ambient temperature of 55°C is not exceeded.

4.5.2. GROUNDING

Grounding shall be performed in accordance with the local regulations (terminal X1.1 / X 1.2)! Grounding is also achieved via EMC facilities (Y – capacitor 4.7nF).

4.5.3. ELECTRO TERMINALS

The unit shall only be connected to the voltage supply, and to further external components (power controllers, measuring transformers), which are contingent to the application. For this, the following connections are necessary:

- Voltage supply: 110V~ / 230V~ at terminal X1
- Mains load optimization: power controller at terminals X3, X4
- Network peak load monitoring / measurements:
  - up to 3 converters (1V~) at terminal X5
  - up to 6 DC outputs (10V-) at terminals X7, X8
  - Error / alarm message at terminal X8
- I/O mdoule:
  - up to 10 digital outputs at terminals X3, X4
  - up to 6 analog outputs (10V-) at terminals X7, X8
  - up to 3 analog DC-inputs at terminals X5, X6
  - up to 3 analog AC-inputs at terminal X5
- PC-connection: at terminal X9 (RS232)
- Bus module interface connection: at terminal X2

As different applications can also be deployed simultaneously, it is necessary to connect the most various of terminals, in part. E.g., network load optimization (connection of the power controllers to X3 and X4) and simultaneously network peak-load monitoring (connection of three electrical current converters to X5) could be deployed, as well as electrical current measurement (connection of three measurement instruments to X7), and the output of three analog values (connection of further equipment to X7 and X8). Additionally, three further analog inputs could be used for reading, and be evaluated via a bus (connection of analog inputs to X5 and X6, and a bus module connection to X2).
An overview of connection opportunities is displayed in the following figure:

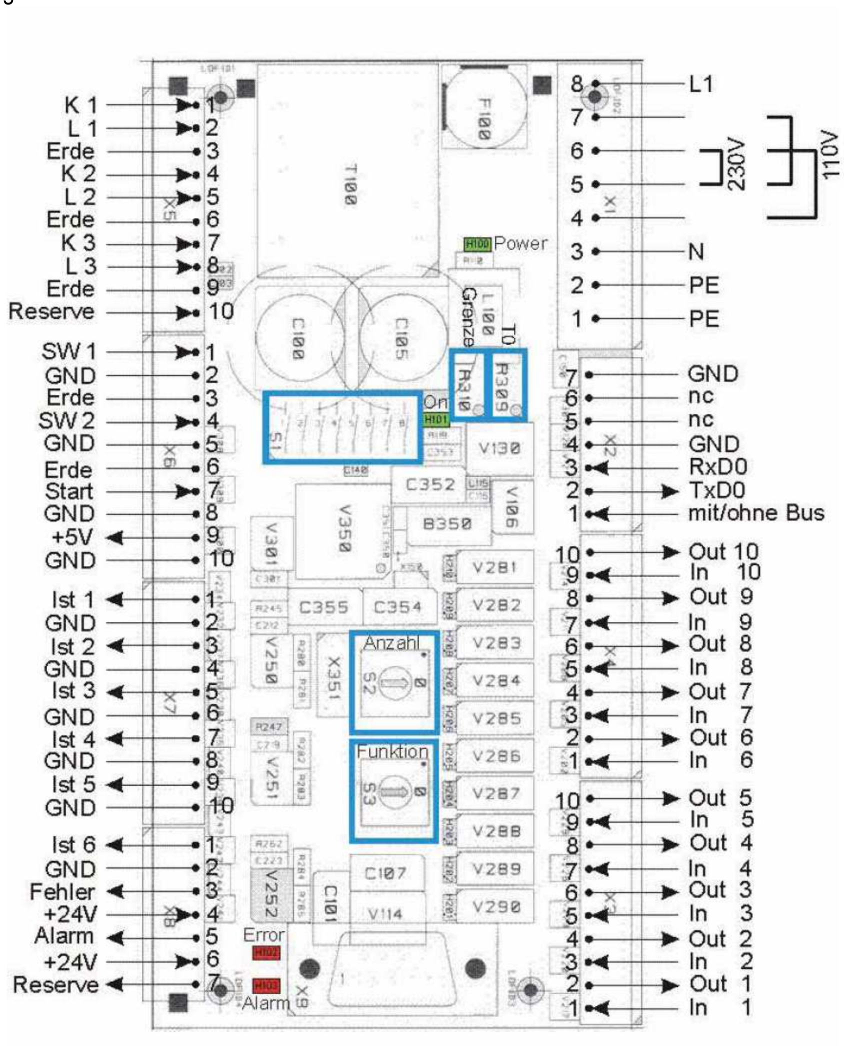

Figure 3: Connection overview

4.5.4. CONNECTION DIAGRAMS

As different connections may be necessary as contingent to the application, the connection diagrams are illustrated in groups.

4.5.4.1. CONNECTION FOR VOLTAGE SUPPLY

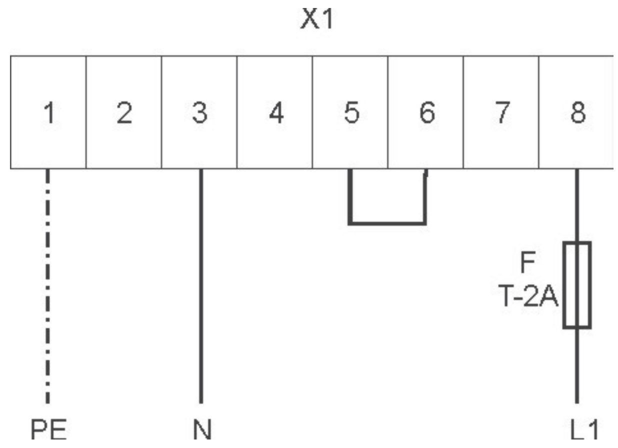

Figure 4: Connection diagram for voltage supply 230V~; 50/60 Hz

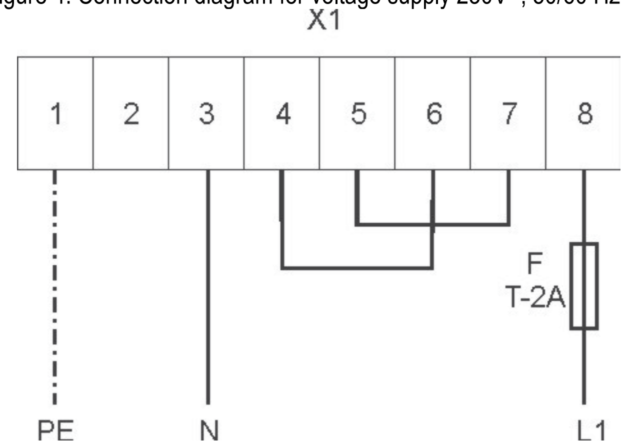

Figure 5: Connection diagram for voltage supply 110V~; 50/60 Hz

4.5.4.2. CONNECTION FOR NETWORK LOAD OPTIMIZATION / POWER CONTROLLER

The unit possesses 10 digital outputs at the terminals X3 and X4, in total. These are designed as potential-free optical coupler outputs. They are deployed as synchronization outputs (SYT) for the connected power controllers or power controllers groups during the network load optimization process. Up to 10 Power Controllers can be connected per channel. To operate a 2-wire shielded cable is required between Thyro-Power Manager and each power controller.

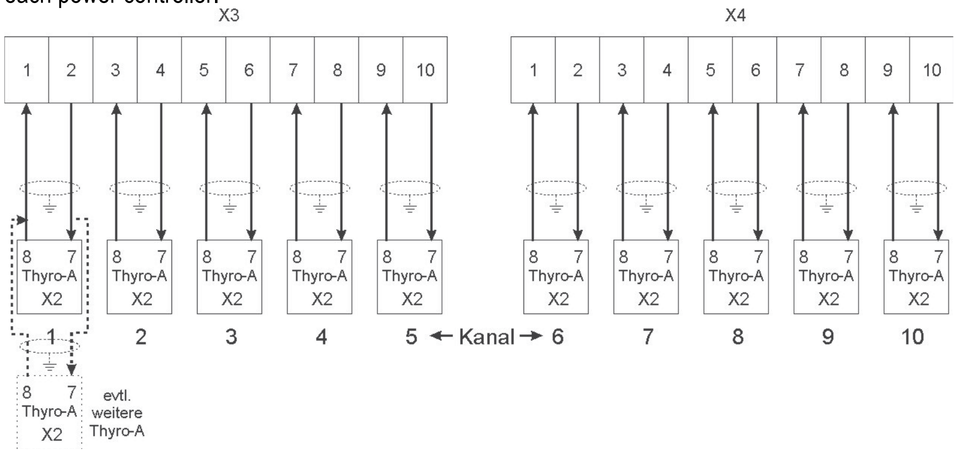

Figure 6: Connection diagram for main load optimization using Thyro-A

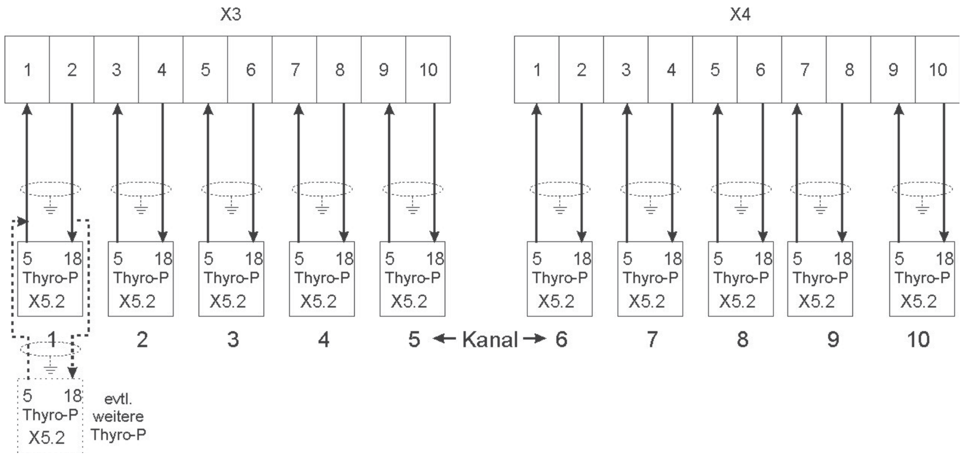

Figure 7: Connection diagram for main load optimization using Thyro-P

4.5.4.3. CONNECTION FOR NETWORK PEAK VALUE MONITORING / MEASUREMENTS

External electrical current converters including load resistances are necessary for network peak-value monitoring and current measurement. Such must be designed so that a measurement voltage of 1V~ unfolds as operating at a nominal electrical current (voltage at the load resistance). These converters must be assembled into the network supply of the facility for the purpose of network peak-value monitoring. The converter

type (for electrical current or for voltage), as well as their nominal values, should be configured using a PC program!

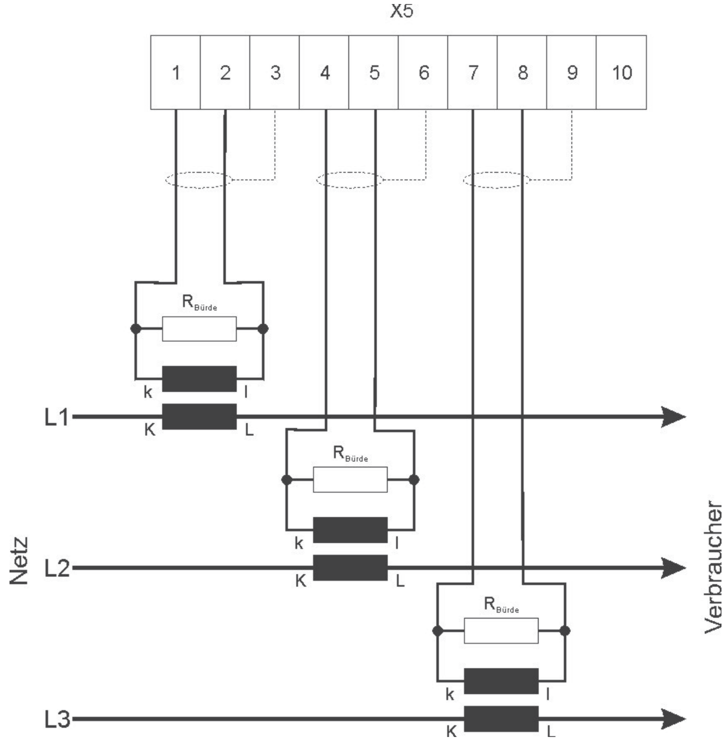

Figure 8: Connection diagram for network peak load monitoring / Electrical current measurement

An external electrical current converter (input 1) and an external voltage converter (input 2) are needed for (single-phase) power and energy measurement. Input 3 may further be deployed, additionally. Again, both converters must be configured in a manner so that a 1V~ measurement voltage is generated at a nominal electrical current and at a nominal voltage. For this reason, the electrical current converter must be equipped with an adequate load resistance, and possibly, an adequate series resistance must deploy together with the voltage converter. The internal resistance of the measurement device is 7540 Ohms.

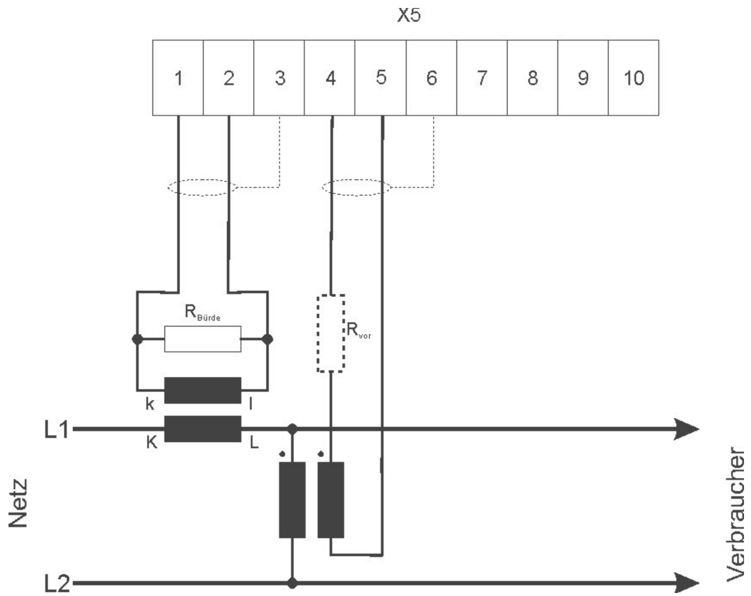

Figure 9: Connection diagram for power and energy measurement

An Advanced Energy voltage converter (order no. 2 000 000 399) can be deployed as voltage transformer. This device possesses a transformer ratio of 16:1, and can primarily be used up to 690V. If this converter is deployed, the following series resistance values result:

		Series resistance [Ohm]:		
Mains voltage [V]:	Secondary voltage. [V]	Calculatec :	Selected:	Note:
110	6,875	44298	44000	22k + 22k
230	14,375	100848	101000	100k + 1k
400	2	180961	181000	180k + 1k
500	31,25	228087	228200	220k + 8k2
690	43,125	317625	320000	220k + 100k

Table 3: Series resistance values for Advanced Energy voltage converter

4.5.4.4. CONNECTION FOR ANALOG OUTPUTS

All measurement values may be read from one (or more) of the six analog outputs (0 – 10V).

Standard setting:

Output no.:	Terminals	Standard output:
1	X7.1 / X7.2	Converter 1
2	X7.3 / X7.4	Converter 2
3	X7.5 / X7.6	Converter 3
4	X7.7 / X7.8	Mains voltage
5	X7.9 / X7.10	Temperature
6	X8.1 / X8.2	Bus value 6 / adjustment support

Table 4: Standard output values for analog outputs

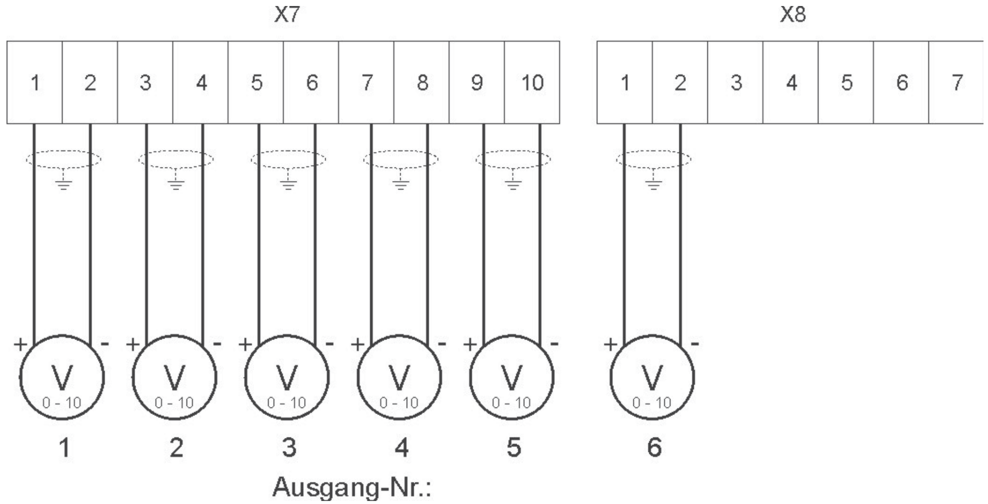

Figure 10: Connection diagram for analog outputs

4.5.4.5. CONNECTION FOR ERROR AND ALARM OUTPUT

The unit possesses an error and alarm output at the terminal X8. These are designed as potential-free optical coupler outputs.

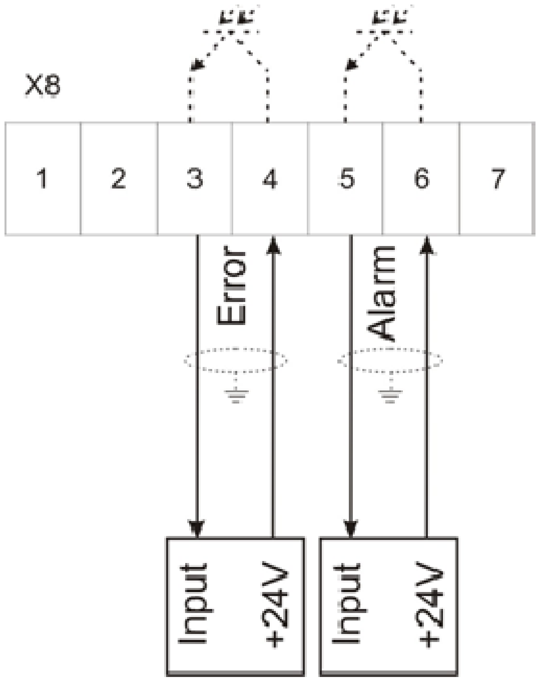

Figure 11: Connection diagram for the error and alarm output

The positive potential of voltage (e.g. +24V) has to be connected to terminals X8.6 and X8.4. This voltage will than eventually be released at terminal X8.5 (Alarm) and X8.3 (Error) and for example can be transmitted to the input of a SPS.

4.5.4.6. CONNECTION FOR DIGITAL OUTOUTS

If the unit is not deployed for network load optimization, but as I/O module, the 10 SYT outputs at the terminals X3 and X4 may be used as digital outputs. These are designed as potential-free optical coupler outputs.

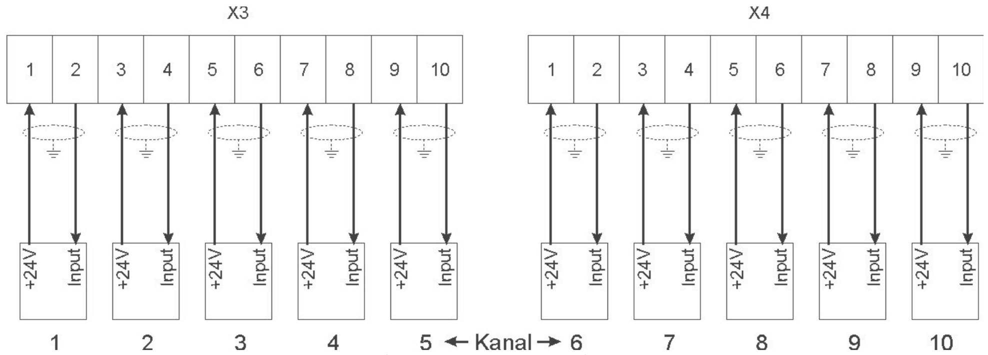

Figure 12: Connection diagram for digital outputs

4.5.4.7. CONNECTION FOR ANALOG DC INPUTS

The Unit possesses 2 analog DC inputs, whose input values can be dip-switch selected. Three range intervals can be selected by the help of the dip-switches S1.1 to S1.4.

	Input 1		Input 2		
Interval range	S1.2	S1.1	S1.4	S1.3	Ri
0-10V	Off	Off	Off	Off	88 kOhm
0-5V	On	Off	On	Off	44 kOhm
0-20mA	On	On	On	On	250 Ohm

Table 5: Range interval selection for the connection of analog DC inputs

The third analog input does not possess this selection opportunity; it has a fixed input voltage range of 0 – 10V.

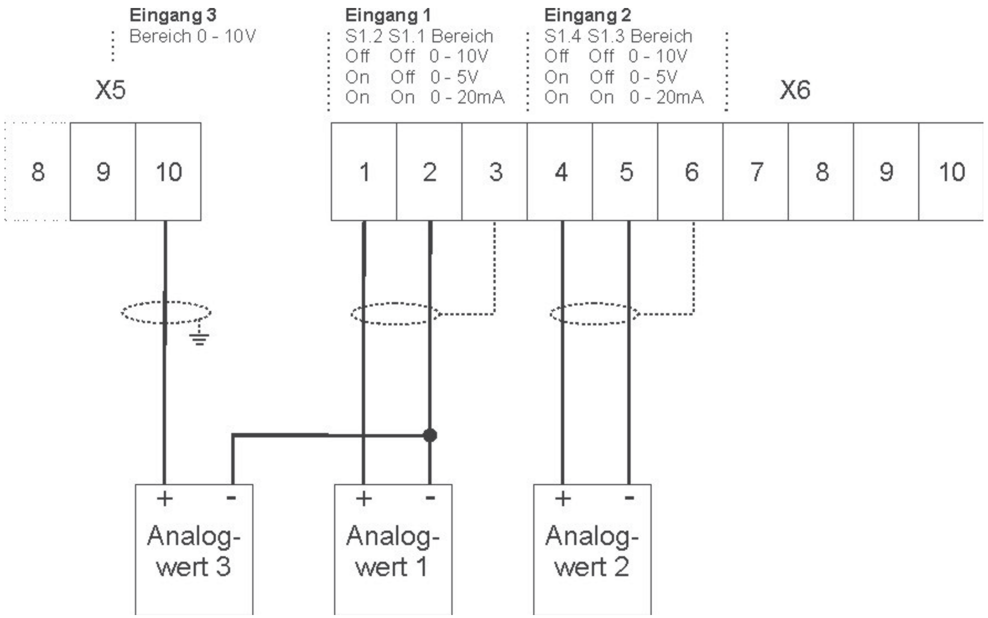

Figure 13: Connection diagram for analog DC inputs

Note:
The initial value of the analog inputs can be increased to 4mA (and 1V or 2V, respectively) by deploying the dip-switch S1.7.
This is necessary if e.g. a range interval of 4- 20mA is desired.

4.5.4.8. CONNECTION OF ANALOG AC INPUTS

If the unit is not deployed for network peak-load monitoring, but as I/O module, the 3 transformer inputs at the terminal X5 may be used as analog AC inputs. The measurement range interval is 0 – 1V~.

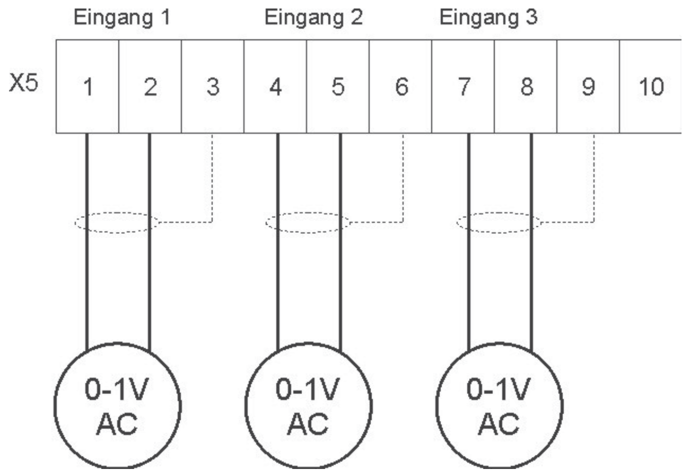

Figure 14: Connection diagram of analog AC inputs

5. SHUT DOWN, DISASSEMBLY

Shutdown and disassembly of the unit may be performed for the reason of venue change or for disposal purposes.

5.1. SAFETY NOTES

The following 5 safety rules must be complied with, prior to the beginning of all work performed to the unit:

	Attention Mains Voltage! Safety rules for work performed to electrical facilities: 1. Disconnect equipment from the mains (establish a voltage free status) 2. Secure equipment against re-activation 3. Determine voltage free status of equipment by measurement 4. Ground and short-circuit equipment 5. Cover or establish borders to neighboring parts under voltage

5.2. ELECTRO TERMINALS

For disassembly, perform the following steps:

1. Separate the Unit from the voltage supply 230V~, respectively 110V~.
2. Separate all other connections.

Electrical connections are thus disassembled

5.3. SEPERATION

Now, the Unit can be completely removed by dis-assembly from the overhead rail.

6. FUNCTIONAL DESCRIPTION

6.1. GENERAL INFORMATION

Basically, the Unit possesses the following functions:

- Network load optimization
- Network peak load Monitoring
- Measurement capability
- I/O module

These shall be described in detail as follows.

6.2. MAINS LOAD OPTIMIZATION

If the power controllers operate according to the principle of full frequency package control (TAKT), this can lead to increased network load due to an unfavorable distribution of ON and OFF switching times. This then results into negative impacts, such as a higher power loss, and flicker effects etc.

If load elements are deployed, whose resistance increases in the course of time (ageing), even a converter with enhanced design performance must possibly be implemented (for this, see chapter 6.2.3).

All of these negative effects may be avoided and be reduced to minimum measure by use of the Thyro-Power Manager. The following figure displays the worst case, in which all power controllers activate and de- activate at the same time:

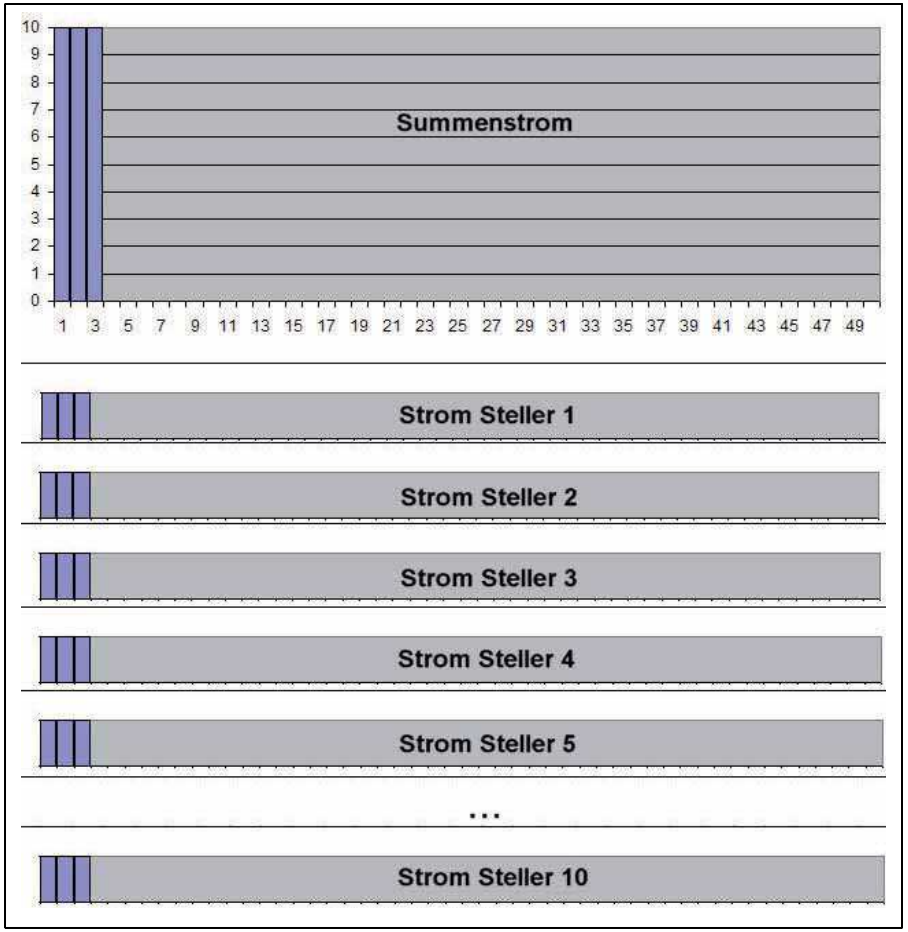

Figure 16: Current distribution in worst case

As one may notice, a 10-fold electrical current flow results simultaneously (in case of 10 power controllers having the same load), whereas no electrical current flows during the other times.

If the elementary period duration T0 = 1s or 50 network periods, respectively, the effective electrical current computes as follows:

$$I_{eff} = 10 \times Io \times \sqrt{\frac{Ts}{To}}$$

If one assumes the electrical current of an power controller to be I0 = 1, the start-up time to be Ts = 3, and the elementary period duration to be T0 = 50, the following may be computed:

$$I_{eff} = 10 \times \sqrt{\frac{3}{50}} = 2{,}45$$

If the Thyro Power Manager is deployed in replacement, each power controller is switched into series operations. This is displayed in the following figure:

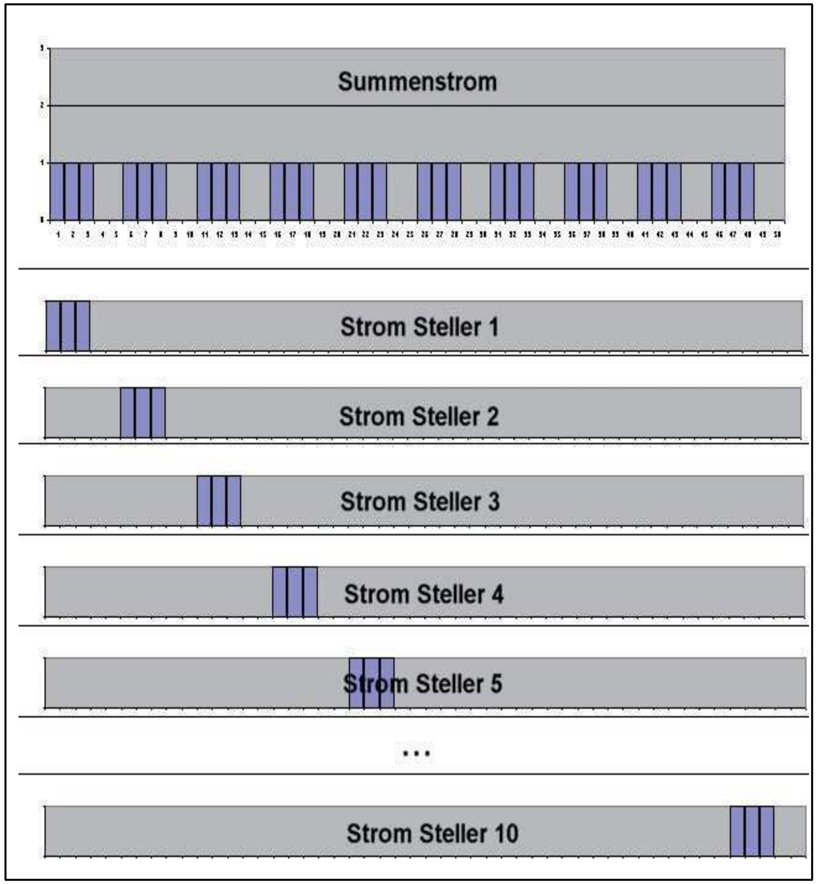

Figure 17: Current distribution with mit Thyro-Power Manager

The maximum electrical current value is thus now that of a single power controller, and the start-up time Ts is now 10 * 3 = 30 periods. Thus, the formula may be derived to be:

$$I_{eff} = Io \times \sqrt{\frac{10 \times Ts}{To}}$$

If one again assumes the electrical current of a power controller to be I0 = 1, the start-up time to be Ts = 3 and the elementary period duration to be T0 = 50, the following may be computed:

$$I_{eff} = \sqrt{\frac{30}{50}} = 0{,}77$$

In a worst case, the effective value for the electrical current would be 3.18 times higher as compared to network load optimization using the Thyro-Power Manager.

6.2.1. AUTOMATIC STATIC MAINS LOAD OPTIMIZATION

In operations mode 1, the set elementary period duration T0 (Poti R309) is evenly distributed onto the number of power controllers (S2).
The start-up time point of each controller is shifted by 5 periods (100ms) in each single case, as the situation displayed above for e.g. T0 = 50 periods (1s) and 10 power controllers.
Thus, it results in a more even distribution of electrical power current.
Even groups of power controllers may be connected to an output instead of a single power controller (see also chapter 4.5.4.2 on page 9). In the course, each controller / group should provide equal power and carry equal load.

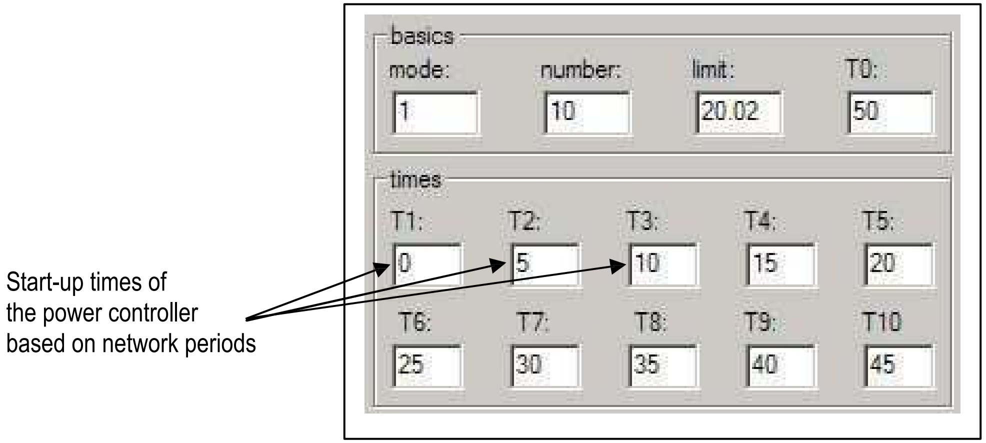

Figure 18: Automatic time allocation

6.2.2. MANUAL STATIC MAINS LOAD OPTIMIZATION

In operations mode 2, the elementary period duration T0 (Poti R309) can be set manually and in various manners contingent to the number of power controllers (S2). Yet, a respective PC program or a bus connection is necessary for this. This type of manual optimization makes sense if each single power controller accommodates strongly differing target values, or if strongly differing loadings per power controller is deployed, whereby the working point remains relatively stable, meaning the target values are held relatively constant. In order to be able to perform optimization, the start-up times Ts of each single power controller and their load I0 should be known (Thyro-Tool Family). The following figures display an example deploying 6 power controllers:

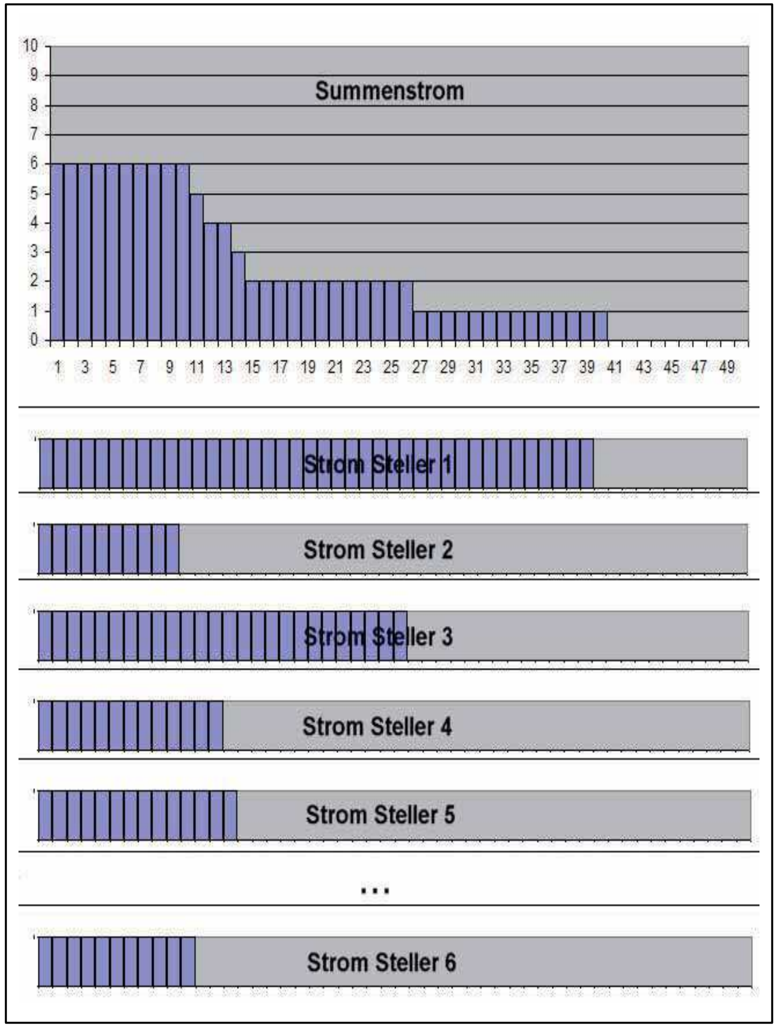

Figure 19: Power controller without mains load optimization with different Ts

The following Ts selections are provided here:

Ts1 = 40, Ts2 = 10, Ts3 = 26, Ts4 = 13, Ts5 = 12, Ts6 = 10, accordingly as network periods

As the amount of electrical current I0 is equally high, one can optimize the start-up times as follows:

T1 = 0 (from 0 – 39 ON), T2 = 40 (from 40 – 49 ON), thus 1 x 50 periods are fully accommodated,

T3 = 0 (from 0 – 24 ON), T4 = 25 (from 25 – 37 ON), T5 = 38 (from 38 – 49 ON, thus 2 * 50 periods are fully accommodated,

T6 = 0 (from 0 – 9 ON), the time point is not capable for optimization.

Thus, the electrical current distribution changes as follows:

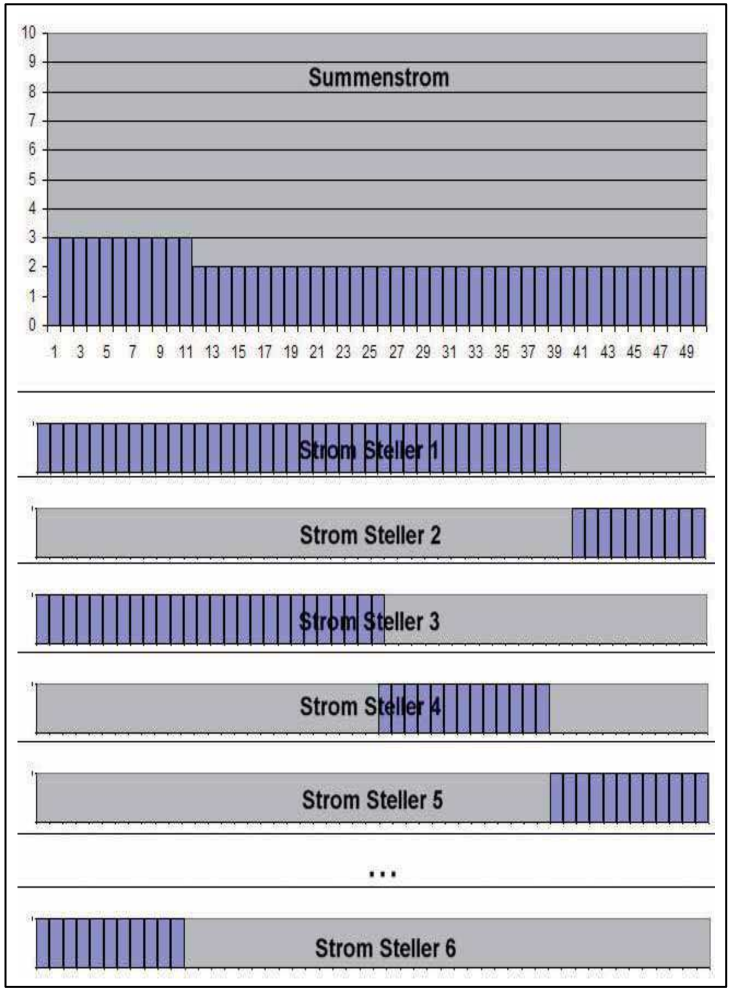

Figure 20: Power controller with manual mains load optimization employing different Ts

The adjustment of the start-up times is performed via a PC program as follows::

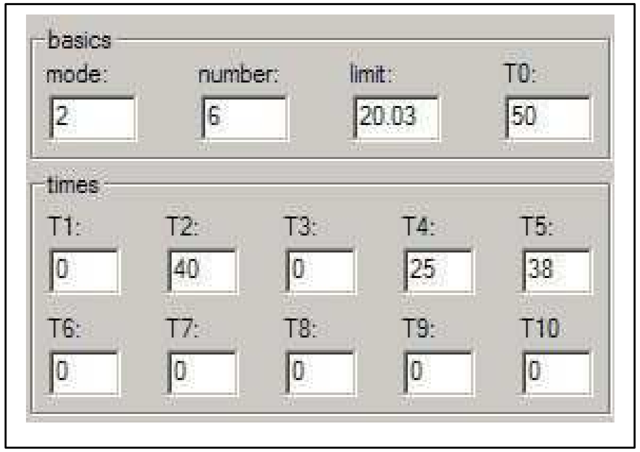

Figure 21: manual time allocation

6.2.3. REDUCTION OF CONVERTER TYPE PERFORMANCE VIA NETWORK LOAD OPTIMIZATION

f strongly-changing load resistance and heating elements are deployed, e.g. with a large Rwarm/Rcold or Rold/Rnew ratio, and a group of power controllers are deployed to an input transformer under the use of the zero cross principle, the implementation of the Thyro-Power Manager can reduce and optimize the type performance of this transformer.

The circuit diagram is displayed in the following figure:

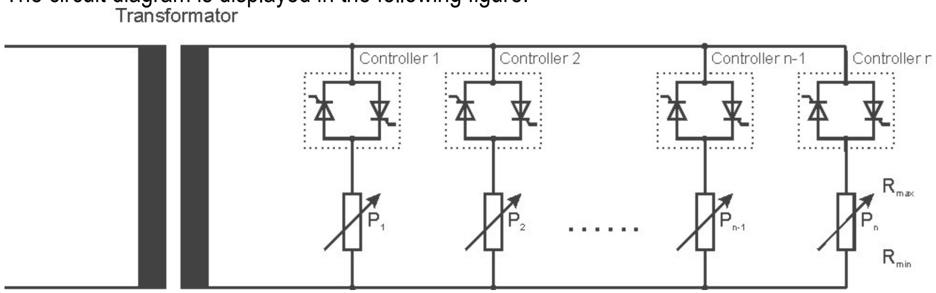

Figure 22: Input transformer and mains load optimization

Requirement: **PLoad = P1 = P2 = Pn-1 = Pn = constant**

If the power controllers (controllers) operate with a subordinately embedded power controlling, the maximum transformer type power can roughly be computed as follows, assuming they operate with phase-angle firing (VAR) and full frequency package control (TAKT) at equally set start-up times Ts:

$$P_{Tr} = P_{Load} * n * \sqrt{\frac{R\max}{R\min}}$$

P_{Tr}	= Power of transformer
P_{Load}	= Power of a load
n	= Number of loads or power controllers
R_{max}	= Highest resistance value
R_{min}	= Lowest resistance value

Under the deployment of full frequency package control (TAKT), network load optimization enables time cascading of the start-up time Ts for each single power controller with the help of the Thyro Power Manager. The transformer type power is then determined using:

$$P_{Tr} = P_{Load} * \sqrt{n} * \sqrt{\frac{R\max}{R\min}}$$

Conditions:

$P_{Tr} > n * P_{Load}$, thus it is derived that: $n \leq \frac{R\max}{R\min}$

The facility must be designed (configuration of the voltage and the load resistance) so that the cycle ratio Ts/T0 almost achieves the value 1 upon attaining the maximum load resistance value Rmax (e.g. due to ageing at the end of the life cycle or due to achieving operational temperature).

6.3. ADDITIONAL MEASUREMENT DEVICE

The Thyro-Power Manager can also be deployed as additional measurement device (ZME). In the course, the Thyro Power Manager substitutes the ZME cards as used up to now. If electrical currents are measured using common measurement instruments upon deployment of full frequency package control (TAKT), a significantly fuzzy display results. This does not occur if using the Thyro-Power Manager.
The Thyro-Power Manager possesses three AC measurement inputs, which are designed for the connection of electrical current or voltage converters (see also chapter 4.5.4.3 page 9 for more). Principally, alternating voltages ranging from 0 – 1V~ may be measured using these three inputs (see also chapter 4.5.4.8 page 9 for more). The time measurement interval and the integration time for measurement can be adjusted (standard value = T0 = 1s, Poti R309).

6.3.1. ZME FUNCTION

If electrical current or voltage converters are connected to the measurement inputs, the effective value is measured (throughout the integration time interval), and furthermore outputted as DC signal (0 – 10V) to the three analog outputs (see also chapter 4.5.4.4). Additionally, the measurement values are also internally available, and may be queried via a PC or bus system.

For electrical current converters, the load resistance must also be connected externally, and the voltage converters must be configured accordingly (see also chapter 4.5.4.8 for this). Generally, the output value can be freely adjusted at each of the six analog outputs; for standard settings the measurement value 1 is read out to output 1, the measurement value 2 is read out to output 2, and the measurement value 3 is read out to output 3. A change of standard settings can only be performed via a PC program or via a bus system (see also chapter 4.5.4.4 for this). The following figure displays the principle structure and the connection diagram upon use of the ZME function.

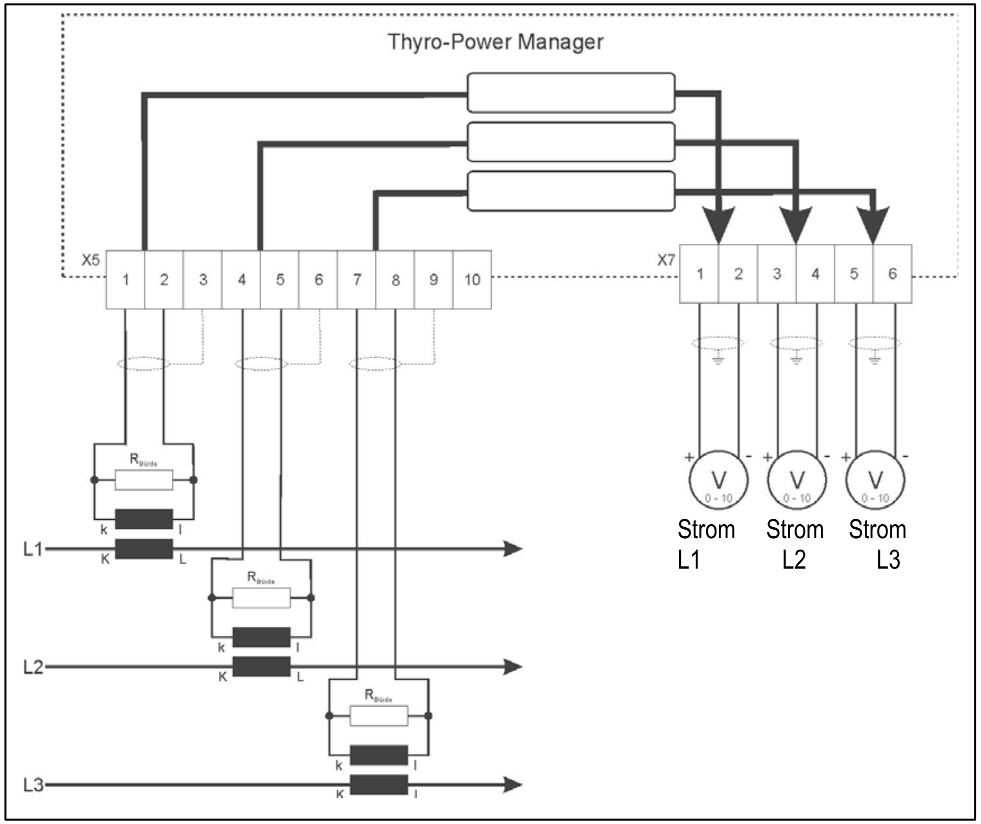

Figure 23: Connection diagram for ZME function

6.3.2. MONITORING OF NETWORK PEAK LOAD

For the monitoring of network peak-load, the connecting process of the electrical current converters is performed in the same manner as with the ZME function (see above). For this, the three current converters should be located within the supply facility of the monitoring unit.

The under-stepping of the set electrical current limiting value is the focus of monitoring and subsequent reporting. Without deployment of a PC mode, the limiting value is equal for all three measurement values, and can be set via the Poti R310 (standard setting = 200%). With deployment of a PC mode, a different limiting value can be set for each of the three measurement values via the help of a PC program or of a bus system.
If the limiting value is over-stepped, a message occurs at the alarm output (standard setting), as well as via PC program and via bus system. The message remains as long as the limiting value is over-stepped, if the value again falls below the limiting value, the message is also automatically reset.
If the measurement integration time is set to T0 (standard setting for T0 = 1s), the measurement process is terminated for each T0, and a comparison is then performed. Thus within the standard setting, the shortest time for a message = 1s, and the shortest time for a message duration is 1s. Instead of T0, also 1 network period can be set via a PC program or bus system. This would possibly result in fuzzy displays, yet a message could then be performed already after 20 ms (at 50Hz).

6.3.3. VOLTAGE MEASUREMENT

If voltage converters are deployed instead of electrical current converters, also voltages can be measured (see also chapter 4.5.4.3 page 9 for this). Voltage converters must then be designed so that a nominal voltage of 1V~ results on the secondary side. The internal resistance of the measurement inputs is 7540 Ohms; this information can also be utilized for voltage converters using an accordingly computed series resistance. The converter type and the converter sizes may be set via a PC program and bus system.

6.3.4. POWER AND ENERGY MEASUREMENT

If one electrical current converter is connected to measurement input 1, and a voltage converter is connected to measurement input 2, and both are correctly configured via a PC program and bus system, one may also execute a (single-phase) power and energy measurement (see also chapter 4.5.4.3). The reset of the energy counter and also of the operating time counter is possible via a PC program. Furthermore, the third measurement input can also be used in a random manner.
The following figure displays the actual value window box of the PC program for power and energy measurements.

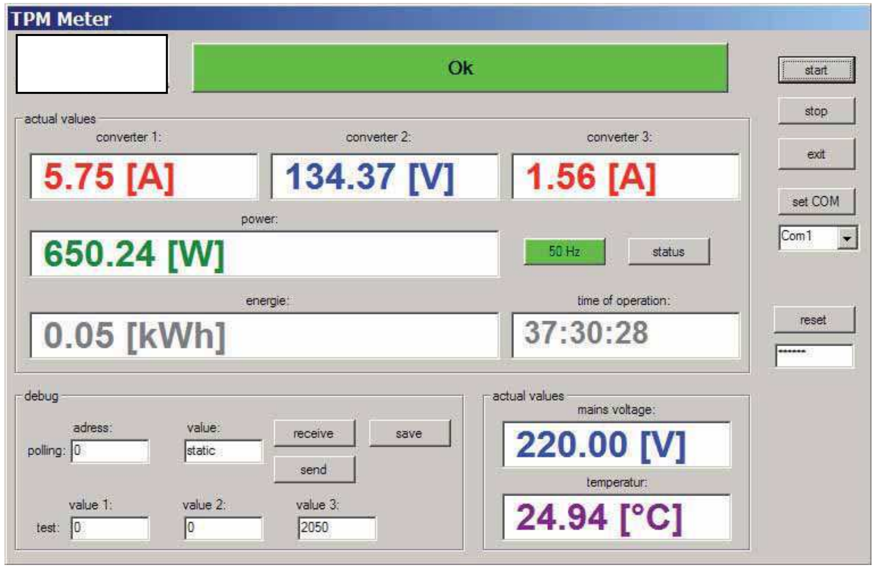

Figure 24: Actual value window box of the PC program for power and energy measurements

6.3.5. TEMPERATURE MEASUREMENT

The Thyro-Power Manager possesses a temperature sensor, e.g. the temperature inside the switch cabinet can be measured and monitored with its help. The temperature value can be read via a PC program or bus system. Within the standard settings, it is also read out at analog output 5 (X7.9 / X7.10), whereby 10V = 100°C. Only temperatures > 0°C are read out. A monitoring limiting value can also be set, if this limiting temperature is over-stepped (or under-stepped, it is capable for setting), a message occurs at the error output via a PC program and via a bus system.

6.3.6. MEASUREMENT OF THREE ANALOG INPUTS

The Thyro-Power Manager also measures the mains voltage or supply voltage, respectively. This measurement can be read via a PC program or bus system. Within the standard settings, it is also read out at analog output 4 (X7.7 / X7.8), whereby 10V = 230V.

6.3.7. MEASUREMENT OF THREE ANALOG INPUTS

The Thyro Power Manager also measures the values of three analog inputs (see also chapter 4.5.4.7, page 9 for this). Input ranges can be selected between 0 – 5V, 0 – 10V, 0 – 20mA for two input terminals. The third input terminal possesses a fixed range of 0 – 10V. Upon demand, the starting default value 0 can be changed to 4mA, 1V, and 2V (an offset value and live zero). All input terminals can be read via a PC program or bus system.

6.4. I/O MODULE (BUS/PC)

The Thyro-Power Manager can also be used as I/O module for a bus system and from a PC. In this operational mode, 10 SYT potential-free outputs are used as digital outputs for network load optimization. They may be set or deleted from a bus or PC. The values of the analog outputs (AC and DC), as well as the mains voltage and temperature may (furthermore) be read out via a bus or PC. The values of the six analog outputs may then be read out from the bus or PC, so that a voltage range of 0 – 10 V may be created for 6 cases (configure the output to default "bus value").

If the Thyro-Tool Family is installed on a PC, the communication server program is thus also installed, from which the communication between PC and Thyro Power Manager is executed. Via the help of this server program, it is also possible to simply implement the communication from other programs, thus to enable the query and setting of values from the Thyro-Power Manager (Excel, LabView, Visual Basic, C++ etc.) See also the examples contained on the Thyro-Tool Family CD.

6.5. MESSAGES

In general, messages are performed via LED, error and alarm output, PC program, or via the bus system. It can be adjusted via the PC program if a message should be read out via the error or alarm output.

6.5.1. MESSAGES AT THE ERROR OUTPUT

Within standard default settings, the following messages are read out at the error output:

- Mains frequency outside of 47 – 63 Hz
- Error temperature monitoring
- Invalid parameters
- Undervoltage within the network
- Overvoltage within the network

The error output can also be configured individually via a PC program or bus system.

6.5.2. MESSAGES AT THE ALARM OUTPUT

Within standard default settings, the following messages are read out at the alarm output:

- Measurement value monitoring of converter 1
- Measurement value monitoring of converter 2
- Measurement value monitoring of converter 3

The alarm output can also be configured individually via a PC program or bus system.

6.5.3. FURTHER MESSAGES

An LED is also installed at each of the 10 SYT outputs for the purpose of network load optimization, from which one can recognize if the output is set or not.

6.5.4. FUSE TRIGGERING

The Thyro-Power Manager possesses an internally built-in fuse (T 1A 250V). Yet, this only serves the purpose for the internal protection of electronics and is not for power line security. If this fuse responds, the green power LED H100 goes out, and the Unit does not operate any more.

7. DISPLAY AND OPERATING ELEMENTS

The Thyro-Power Manager possesses three switches and two potentiometers, from which all basic functions can be adjusted. Significantly more parameters / functions can be set by help of the PC program and via the bus system.

7.1. SWITCH S1

Switch S1 is a simple 8-fold dip-switch. Each of the 8 dip-switches can be activated or deactivated. If the according dip-switch is pushed to the right (label „open“), then it is open; in contrast, if it pushed to the left, it is then closed. The following figures display the according dip-switch position:

Dip switch open:

Dip switch closed:

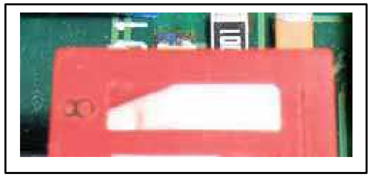

Figure 25: Dip switch position of S1

The following table displays the function of each dip-switch:

Dip switch	**function**	**open**	**closed**	**default**
S 1.8	PC mode	OFF	ON	open
S 1.7	Live-Zero (4mA)	Without	With	open
S 1.6	Test mode	OFF	ON	open
S 1.5	Without function/ reserve	OFF	ON	open
S 1.4	Level input 2: 5V, 10V, 20mA	Combination	Combination	closed
S 1.3	Level input 2: 5V, 10V, 20mA	Combination	Combination	closed
S 1.2	Level input 1: 5V, 10V, 20mA	Combination	Combination	closed
S 1.1	Level input 1: 5V, 10V, 20mA	Combination	Combination	closed

Table 9: Switch S1

The input ranges for the input terminals 1 and 2 can be set as follows:

	Input 1		Input 2		
Range:	S 1.2	S 1.1	S 1.4	S 1.3	Ri
0-10V	Off	Off	Off	Off	88 kOhm
0-5V	On	Off	On	Off	44 kOhm
0-20mA	On	On	On	On	250 kOhm

Table 10: Input range for the input terminals 1 and 2

7.2. SWITCH S2 – QUANTITY

For network load optimization, the number of connected power controllers or power controller groups can directly be set via the help of the rotary switch S2. The following table displays the adjustment possibilities:

Switch position	Number of power controllers
0	Not permitted
1	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
9	9
A	10
B	Not permitted
C	Not permitted
D	Not permitted
E	Not permitted
F	Not permitted

Table 11: Switch position S2

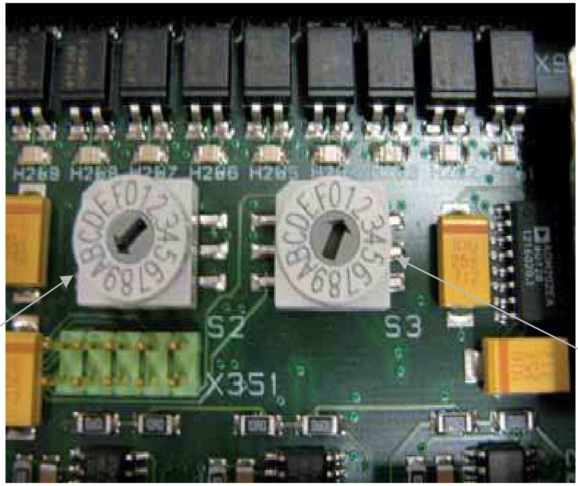

Figure 26: Switch S2 and S3

7.3. SWITCH S3 – OPERATING MODE

The desired function or operating mode can directly be set via the help of the rotary switch S3. The following table displays the adjustment possibilities:

Switch position	Operating mode
0	Not permitted
1	Automatic static network load optimization
2	Manual static mains load optimization*[1]
3	Reserve
4	Reserve
5	Reserve
6	Reserve
7	Reserve
8	Reserve
9	Reserve
A	Reserve
B	Reserve
C	Reserve
D	I/O module*[1]
E	Reserve
F	Reserve

*[1] additionally S1.8 = PC mode must be activated

Table 12: Switch position S3

7.4. POTENTIOMETER R309

If the Thyro Power Manager is configured without a PC program and bus system (S1.8 OFF), the elementary period duration T0 can thus be set via Poti R309. Yet, the standard default setting is already set to 50 network periods (1s / 50Hz), and usually does not need to be changed. If network load optimization is deployed, the set T0 must resemble the elementary period duration of the deployed power controllers exactly. The standard default settings of Thyro A and Thyro P are also 50 network periods (1s / 50Hz).

At the same time, the set T0 is also used as measurement integration time for the ZME function (standard setting). If another measurement integration time is desired, such can be set via a PC program, e.g. directly to one network period (20ms / 50Hz). Other values may be set via a change of R309. As the potentiometer does not possess a scale, one can deploy analog output 6 (X8.1 / X8.2) as help for the setting (connect the voltmeter, range 0 – 10V). If the potentiometer is changed, (no PC mode) the analog output is automatically switched over to the output of the potentiometer value.

The setting range of R309 is relatively large, and extends from 1 – 1500 network periods. For this reason, the setting help is divided into two intervals:

Interval 1: 0 - 100 periods

0 - 5V, meaning 5V = 100 periods, 2.5V = 50 periods, 1 period = 0.05V

Interval 2: 101 - 1500 periods

5 - 10V, meaning 5V = 100 periods, 10V = 1500 periods, 1 period = 0.00357V (+5V)

The following figure and the table display the respective values:

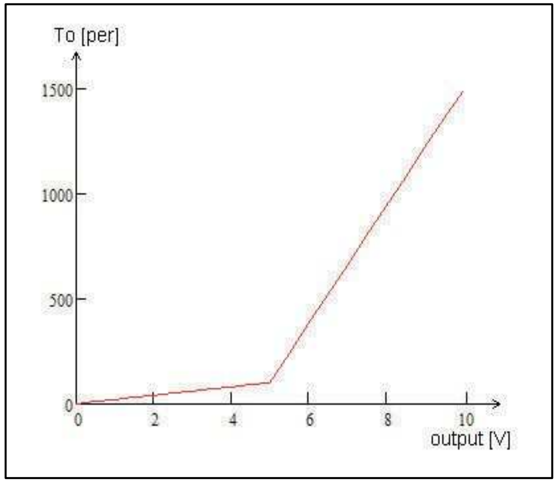

Figure 27: Characteristic curve of the setting help R309

T0[s] (50Hz):	T0[Periods]:	Analog[V]:
0.2	10	0,5
0.4	20	1
0.6	30	1.5
0.8	40	2
1	50	2.5
1.2	60	3
1.4	70	3.5
1.6	80	4
1.8	90	4.5
2	100	5
4	200	5.36
6	300	5.71
8	400	6.07
10	500	6.43
15	750	7.32
20	1000	8.21
25	1250	9.11
30	1500	10

Table 13: Output possibilities at the analog output terminals

The T0 time (in PC mode) can be set easily and precisely via the help of the PC program or via the bus system.

7.5. POTENTIOMETER R310

If the Thyro-Power Manager is configured without a PC program and bus system (S1.8 OFF), the limiting value for network load optimization and for the three converter inputs can thus be set via Poti R310. The standard default setting is 200% and the Poti is turned to its right-hand blocked position. The same limiting value is used for all three inputs per Poti. A unique limiting value can be determined for each one of the 3 converters via a PC program or via the bus system (in PC mode).

As the potentiometer does not possess a scale, one can deploy analog output 6 (X8.1 / X8.2) as help for the setting (connect the voltmeter, range 0 – 10V). If the potentiometer is changed, (no PC mode) the analog output is automatically switched over to the output of

the potentiometer value. In the course, meaning here 5V = 100% (type value of converter), the adjustment interval ranges between 0 – 200% (0 – 10V).

In PC mode (S1.8 = closed), the switches and potentiometer settings are mostly ignored and only those values are used, which are stored and set via a PC program. In this case, a potentiometer change e.g. does not incur a change of values and the setting help is not activated!

7.6. ANALOG OUTPUTS

The Thyro-Power Manager possesses six analog output terminals (0 – 10V). Different values may be read out from them (see also chapter 4.5.4.4 for this).
The following values may be read out:

Value:	**Output:**
Effective value converter 1	10V = 100% = Type value of converter (at 1V~)
Effective value converter 2	10V = 100% = Type value of converter (at 1V~)
Effective value converter 3	10V = 100% = Type value of converter (at 1V~)
Mains voltage	10V = 100% = 230V~ or 115V~
Analog input 1	10V = 100% = 10V / 5V / 20mA
Analog input 2	10V = 100% = 10V / 5V / 20mA
Poti R309	Setting help: see chapter 7.4
Poti R310	Setting help: 5V = 100% (Type value of converter)
Temperature	10V = 100
Bus value 1	10V = 4096
Bus value 2	10V = 4096
Bus value 3	10V = 4096
Bus value 4	10V = 4096
Bus value 5	10V = 4096
Bus value 6	10V = 4096

Table 14: Output options at the analog output terminals

However, the desired output value can only be set via a PC program or bus system. The standard default setting is as follows:

Output no.:	Standard default output
1	Converter 1
2	Converter 2
3	Converter 3
4	Mains voltage
5	Temperature
6	Bus value 6 / setting help

Table 15: Standard default output of analog output terminals

7.7. LEDs

The Thyro-Power Manager possesses 14 LEDs, which display different messages:

LED	Color	Designation	Message
H100	Green	POWER	Electric current supply available
H101	Green	ON	Operation
H150	Red	ERROR	Error
H151	Green	ALARM	Alarm
H201-210	Green	SYT1-SYT10	SYT outputs

Table 16: LEDs, messages

Blinking LEDs have the following message meanings:

LED:	H101 ON	H150 ERROR	H151 ALARM
Message:			
Frequency error	Slow	Off	Off
Parameter fault	Fast	Fast	Fast

Table 17: LEDs, extended messages

Meaning:	
Off	LED is OFF continuously
On	LED is ON continuously
Slow	LED blinks slowly (1Hz or 3.3Hz)
Fast	LED blinks fast and flickers (14.7Hz)
-	Random status of LED
	LEDs blink synchronously

Table 18: LEDs, meanings

7.8. PC PROGRAMM

The Thyro-Power Manager can also be connected to a PC, and simply and comfortably be operated and set via the help of a PC program. A requirement for this is that a connection

between PC and Thyro-Power Manager exists. Therefore it is necessary to use either a RS232 data line (order no. 0048764) and/or an adaptor cable USB 1.1 to RS232 (order no. 8.000.019.086).

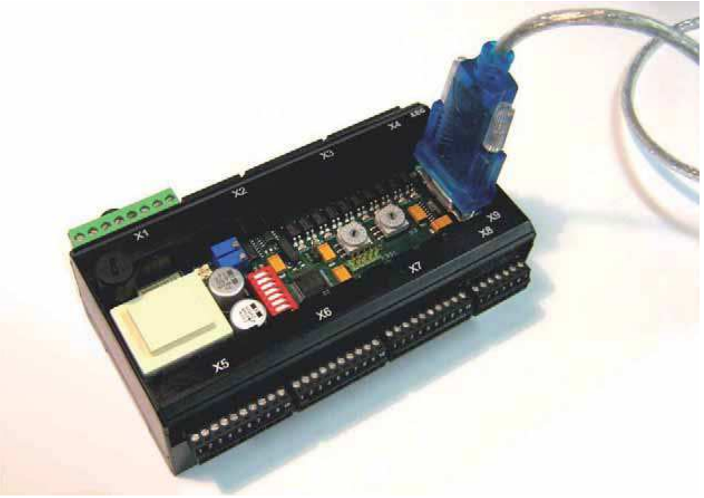

Figure 28: PC interface connection

8. COMMISSIONING

⚠	Mains voltage - danger! Activate the Unit only if it is secured that parts under voltage cannot be touched.

8.1. PROCESS OF COMMISSIONING

The commissioning of the unit is performed upon expert installation (see chapter 4). The according connections must be executed contingent to the deployed functions (see chapter 4.5.4).

8.1.1. SETTING OF THE OPERATING MODE

The selected function must be set using the switch S3 (see chapter 8.3). In PC mode, the setting can also be performed by help of the PC program.

8.1.2. SETTING THE NUMBER OF DEVICES DEPLOYED

If network load optimization is used, the number of power controllers or power controller groups must be set using the switch S2 (see chapter 8.2). In PC mode, the setting can also be performed by help of the PC program.

8.1.3. SETTING THE LIMITING VALUE FOR MONITORING

If network peak load monitoring is used, limiting value must be set via the help of the potentiometer R310 (see chapter 8.5). In PC mode, the setting can also be performed by help of the PC program.

8.1.4. SETTING THE ELEMENTARY PERIOD DURATION T_0

The elementary period duration T0 can be set by help of the potentiometer R309 (see chapter 8.4). In PC mode, the setting can also be performed by help of the PC program.

Caution!
The elementary period duration T0 is default set to 50 periods = 1s ex works. Usually, this setting does not have to be changed. Thus, the potentiometer can remain unchanged in most cases!

9. OPERATION

Mains voltage - danger!
Activate the Unit only if it is secured that all necessary measures for protection against electric shock are implemented.

9.1. REGULAR OPERATION

Enabling mains voltage during regular operation activates the Unit. Subsequently, the green power LED H100 and the green ON LED H101 should burn. If network load optimization is used, the LEDs H201 - H210 turn ON one after another (contingent to the selected number of devices deployed). All measurements and functions are performed as selected.

9.2. SERVICE OPERATION

If the switch S1.6 is closed, the Thyro-Power Manager operates within an internal testing mode. This is only used at the manufacturer's works. If the testing mode is active, the regular functions are not executed anymore!

9.3. END OF OPERATION

The end of operations is achieved by de-activation of the mains voltage. Within standard default settings, the operating time counter is then stopped, and the according value is stored (auto save = ON). This possibly also happens for an energy measurement.

10. MAINTANANCE

In general, no maintenance measures are necessary for the Thyro-Power Manager. Yet, one shall observe that the level of contamination is held in limits and that the permissible ambient temperatures are not exceeded.

Advanced Energy shall annul all possible obligations, such as guarantee commitments, service agreements etc., which may be agreed upon by Advanced Energy and its distributors, without prior notice if no maintenance is performed to the Unit, and if purchased spare parts other than OEM Advanced Energy or such other purchased by Advanced Energy are used for maintenance and repair.

10.1. REPAIRS

Expert personnel of the company Advanced Energy may only perform repairs made to the unit. Only OEM spare parts are allowed to be used. Repairs performed by personnel of the user require approval of the manufacturer.

11. TECHNICAL DATA

Type	
	Thyro-Power Manager
Technical data	
Voltage supply X1:	
Mains voltage:	230V~ -15% +10%
	110V~ -15% +10%

Power consumption:	1.5W	
Internal fuse:	T 1A 250V	
Mains frequency:	47Hz – 63Hz	

Digital outputs X3 and X4:	Galvanic separated optical coupler outputs	
	External supply necessary	
	Max. voltage:	30V
	Max. current:	7mA

Error and alarm output X8:	Galvanic separated optical coupler outputs	
	External supply necessary	
	Max. voltage:	30V
	Max. current:	7mA

Analog outputs X7 and X8:	
Output range interval	0-10V
Max. current:	1mA
Output percentage	+/- 1% (with reference to the final value)

Analog DC outputs X5 and X6:		
Input 1 and 2:	Interval range	Ri
(X6.1 and X6.4)	0-10V	88kOhm
Switch selectable	0-5V	44kOhm
	0-20mA	250kOhm
Input 3:	Interval range	Ri
(X5.10)	0-10V	88kOhm

Analog AC input X5:		
Inputs 1 to 3:	Interval range	Ri
	0-1V~	7540Ohm

Measurement precision	
Mains voltage:	+/- 3%
DC inputs:	+/- 1%
AC inputs:	+/- 2%
With reference to the final value accordingly	

Temperature ranges:	
Storage temperature:	-25°C to +55°C
Transport temperature:	-25°C to +70°C
Operation temperature:	-10°C to +55°C

11.1. APPROVAL AND CONFORMITY

- Quality standard in accordance with DIN EN ISO 9001
- CE Conformity
- EC Low Voltage Directive 2006/95/EG
- EMC Directive 89/336/EEC & 92/31/EEC
- CE marking Directive 93/68/EEC

Directives

The CE sign attached to the Unit confirms compliance with the EC framework directives for 2006/95/EG/EEC Low Voltage and 89/339/EEC Electro-Magnetic Compatibility, if the installation and commissioning instructions described within Operations Manual are followed.

In detail:

Conditions for unit operations		
Build-in unit (VDE0160)		DIN EN 50178
General requirements		DIN EN 60146-1-1:12.97
Conditions of operation		DIN EN 60146-1-1; K.2.5
Venue of operation	Industrial sector	CISPR 6
Temperature behavior		DIN EN 60146-1-1; K.2.2
Storage temperature	D	-25°C - +55°C
Transport temperature	E	-25°C - +70°C
Operation temperature	(better than B)	-10°C - +55°C
Humidity classification	B	DIN EN 50178 Tab.7 (EN60721)
Pollution level	2	DIN EN 50178 Tab. 2
Air pressure	900mbar	Resembles max. 1000m elevation above sea level
Safety type	IP00	DIN EN 69529
Safety classification	III	DIN EN 50178 chapter. 3
Mechanical pulse impact		DIN EN 50178 chapter 6.2.1
Inspections in accordance with		DIN EN 60146-1-1 4.
EMC disturbance emission		EN 61000-6-4
Radio interference stability	Class A	DIN EN 55011.3.91 CISPR11
EMC interference stability		EN 61000-6-2
ESD	8kV (A)	EN 61000-4-2.3.96
Burst control lines	1kV (A)	EN 61000-4-4
Line bound		EN 61000-4-6

World Headquarters
1625 Sharp Point Drive
Fort Collins, CO 80525 USA

970.221.4670 Main
970.221.5583 Fax

www.advanced-energy.com

Specifications are subject to change without notice.