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HEINZMANN®
Electronic Speed Governors

Analogue Generator Power Controller and Synchronizer

THESEUS AT 01

 <p>Warning</p>	<p>Read this entire manual and all other publications appertaining to the work to be performed before installing, operating or servicing your equipment.</p> <p>Practice all plant and safety instructions and precautions.</p>
 <p>Danger</p>	<p>Failure to follow instructions may result in personal injury and/or damage to property.</p> <p>HEINZMANN will refuse all liability for injury or damage which results from not following instructions</p>
 <p>Danger! High Voltage</p>  <p>Danger</p>	<p>Please note before commissioning the installation:</p> <p>Before starting to install any equipment, the installation must have been switched dead!</p> <p>Be sure to use cable shieldings and power supply connections meeting the requirements of the <i>European Directive concerning EMI</i>.</p> <p>Check the functionality of the existing protection and monitoring systems.</p>
 <p>Danger</p>	<p>To prevent damages to the equipment and personal injuries, it is imperative that the following monitoring and protection systems have been installed:</p> <p>Overspeed protection acting independently of the speed governor</p> <p>Overtemperature protection</p> <p>HEINZMANN will refuse all liability for damage which results from missing or insufficiently working overspeed protection</p> <p>Generator installation will in addition require:</p> <p>Overcurrent protection</p> <p>Protection against faulty synchronization due to excessive frequency, voltage or phase differences</p> <p>Reverse power protection</p>
	<p>Overspeeding can be caused by:</p> <p>Failure of the voltage supply</p> <p>Failure of the actuator, the control unit or of any accessory device</p> <p>Sluggish and blocking linkage</p>



Warning

Electronically controlled injection (MVC) will in addition require to observe the following:

With **Common Rail** systems a separate mechanical flow limiter must be provided for each injector pipe.

With **Pump-Pipe-Nozzle (PPN)** and **Pump Nozzle (PNE)** systems fuel release may be enabled only by the movement of control piston of the solenoid valve. This is to inhibit fuel from being delivered to the injection nozzle in case of seizure of the control piston.



Warning

The examples, data and any other information in this manual are intended exclusively as instruction aids and should not be used in any particular application without independent testing and verification by the person making the application.



Danger

Independent testing and verification are especially important in any application in which malfunction might result in personal injury or damage to property.

HEINZMANN make no warranties, express or implied, that the examples, data, or other information in this volume are free of error, that they are consistent with industry standards, or that they will meet the requirements for any particular application.

HEINZMANN expressly disclaim the implied warranties of merchantability and of fitness for any particular purpose, even if HEINZMANN have been advised of a particular purpose and even if a particular purpose is indicated in the manual.

HEINZMANN also disclaim all liability for direct, indirect, incidental or consequential damages that result from any use of the examples, data, or other information contained in this manual.

HEINZMANN make no warranties for the conception and engineering of the technical installation as a whole. This is the responsibility of the user and of his planning staff and specialists. It is also their responsibility to verify whether the performance features of our devices will meet the intended purposes. The user is also responsible for correct commissioning of the total installation.

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1 Safety Instructions and Related Symbols

This publication offers wherever necessary practical safety instructions to indicate inevitable residual risks when operating the engine. These residual risks imply dangers to

persons

product and engine

environment.

The symbols used in this publication are in the first place intended to direct your attention to the safety instructions!



Warning

This symbol is to indicate that there may exist dangers to the engine, to the material and to the environment.



Danger

This symbol is to indicate that there may exist dangers to persons. (Danger to life, personal injury)



Danger!
High
Voltage

This symbol is to indicate that there exist particular danger due to electrical high tension. (Mortal danger).



Note

This symbol does not refer to any safety instructions but offers important notes for better understanding the functions that are being discussed. They should by all means be observed and practiced. The respective text is printed in italics.

The primary issue of these safety instructions is to prevent personal injuries!

Whenever some safety instruction is preceded by a warning triangle labelled “Danger” this is to indicate that it is not possible to definitely exclude the presence of danger to persons, engine, material and/or environment.

If, however, some safety instruction is preceded by the warning triangle labelled “Caution” this will indicate that danger of life or personal injury is not involved.

The symbols used in the text do not supersede the safety instructions. So please do not skip the respective texts but read them thoroughly!

In this publication the Table of Contents is preceded by diverse instructions that among other things serve to ensure safety of operation. It is absolutely imperative that these hints be read and understood before commissioning or servicing the installation.

1.1 Basic Safety Measures for Normal Operation

- The installation may be operated only by authorized persons who have been duly trained and who are fully acquainted with the operating instructions so that they are capable of working in accordance with them.
- Before turning the installation on please verify and make sure that
 - only authorized persons are present within the working range of the engine;
 - nobody will be in danger of suffering injuries by starting the engine.
- Before starting the engine always check the installation for visible damages and make sure it is not put into operation unless it is in perfect condition. On detecting any faults please inform your superior immediately!
- Before starting the engine remove any unnecessary material and/or objects from the working range of the installation/engine.
- Before starting the engine check and make sure that all safety devices are working properly!

1.2 Basic Safety Measures for Servicing and Maintenance

- Before performing any maintenance or repair work make sure the working area of the engine has been closed to unauthorized persons. Put on a sign warning that maintenance or repair work is being done.
- Before performing any maintenance or repair work switch off the master switch of the power supply and secure it by a padlock! The key must be kept by the person performing the maintenance and repair works.
- Before performing any maintenance and repair work make sure that all parts of engine to be touched have cooled down to ambient temperature and are dead!
- Refasten loose connections!
- Replace at once any damaged lines and/or cables!
- Keep the cabinet always closed. Access should be permitted only to authorized persons having a key or tools.

- Never use a water hose to clean cabinets or other casings of electric equipment!

1.3 Before Putting an Installation into Service after Maintenance and Repair Works

- Check on all slackened screw connections to have been tightened again!
- Make sure the control linkage has been reattached and all cables have been reconnected.
- Make sure all safety devices of the installation are in perfect order and are working properly!

2 Application

2.1 General

The analogue generator power controller and synchronizer THESEUS AT 01 has been designed to work in conjunction with any of the HEINZMANN analogue electronic governors to make a complete generator management. It can also be used with competitors' electronic governors by the addition of a small interface card.

The new concept of the AT 01 is the introduction of integrating load sharing, synchronising and load ramping for soft switching load on and off inside one printed circuit card which utilises a common set of voltage and current transformers. Costly wiring between the single units are not necessary.

2.2 Load Measuring and Share Device

Isochronous load sharing is also incorporated using three phase voltage and current inputs which are multiplied together to produce a true kilowatt output about all three phases. The resultant kilowatt output is then fed into our standard load sharing concept that will allow up to 15 engines to be paralleled together at the same time and share load to within $\pm 2\%$. There is a meter output 0-5V or 0-1 mA indicating kilowatts and also a forward power and reverse power relay contact with LED indication. Standard load limiting inputs are available, along with a new soft loading function which will allow isochronous loading and unloading of an alternator parallel to an island or mains BUS with a base load facility.

2.3 Synchronizer Device

The analogue power controller has a full isochronous auto three phase synchroniser incorporating frequency and phase correction with LED indication of frequency, phase, capture angle and breaker closure. There is also a safety feature built into the synchroniser that detects phase rotation and will only allow the breaker to close if the generator is up to frequency, in phase (within a predetermined angle) and phase rotation in the correct direction.



Warning

The generator voltage has to be adjusted using a separate voltage matching unit before synchronization, because the synchronizer device can not influence the generator voltage.

2.4 Load Ramp Device

This facility allows a genset to soft load after closing the generator breaker without the island frequency deviating from the isochronous value. The load ramp is fully adjustable and will allow an engine to load from zero to the rated load on the load share line and unload down to either zero or a base load value. At the zero point, a relay contact closes, indicating that the engine can come off line.

The load ramp facility is ideal for a single engine application parallel to the mains when used in CHP mode. The base load can also be set to be equivalent to the rated load of the engine and the ramp generator can ramp up to this rated load and ramp off again as and when required.

3 Block Diagram

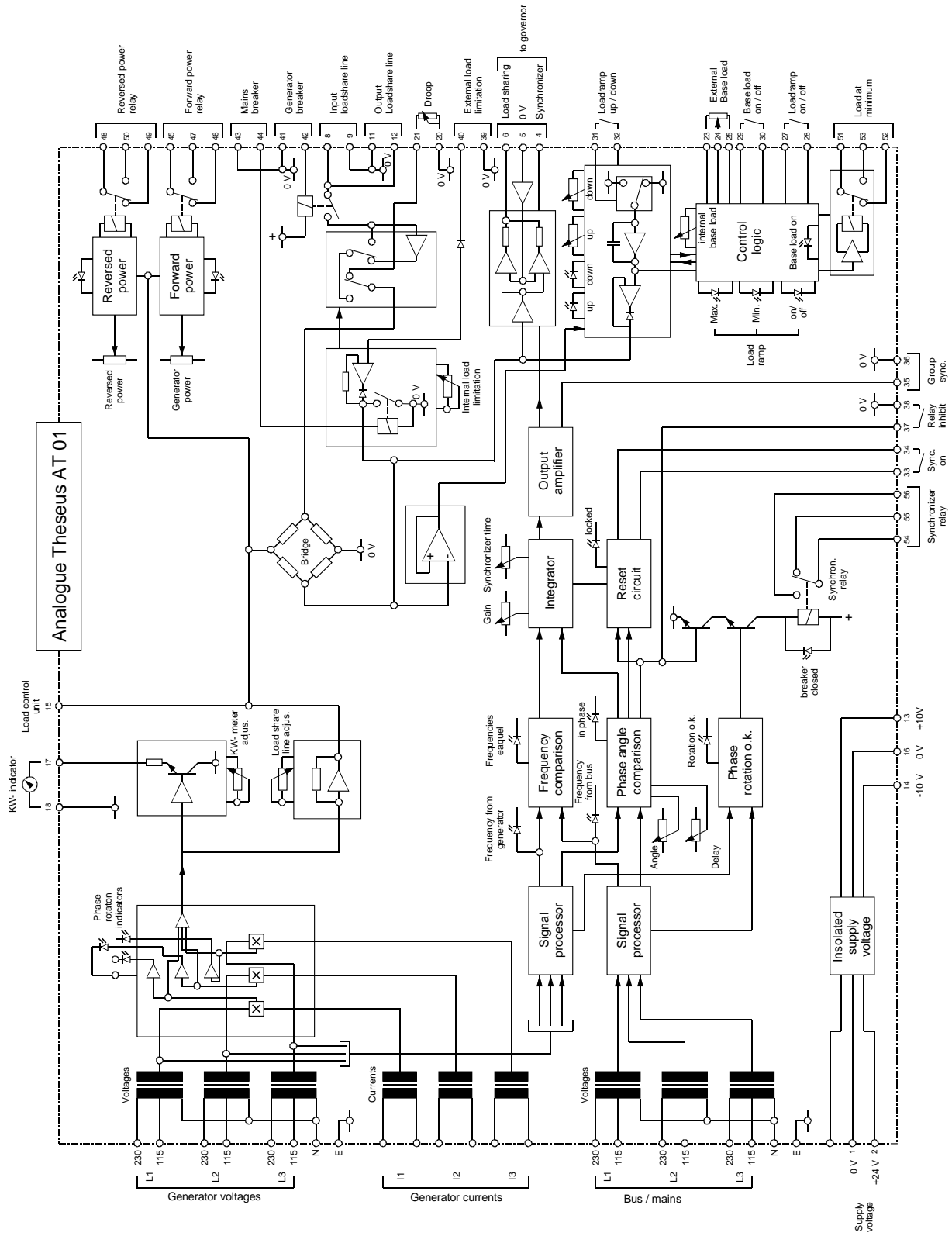


Figure 1: Block Diagram of Analogue THESEUS AT 01

4 Mode of Operation

4.1 General

Referring to the AT 01 block diagram, there are three sections incorporating load sharing, synchronising and load ramping; these can be used independently of each other or in combination.

The connection to the voltage and current inputs are made directly to the alternator outputs and require a three wire, three phase signal with appropriate current transformer inputs which can be specified to 1 A or 5 A CTs. The BUS voltage inputs on the secondary side of the generator breaker are used for synchronising and a comparison is made between the generator and the BUS frequencies and phases.

4.2 Load Measuring and Sharing Device

The three phase voltage inputs are conditioned and multiplied by the three phase current inputs and are first compared for phase acceptance. LED's indicate whether the phase of the current to the voltage is correct. There is 180° reversing link for each current input that can be changed when the engine is running, thus allowing easy reversal of current transformers terminals K and L without shutting the generator down.

The load sharing device measures the output power of an AC generator (3 phase voltage and current) and converts this to a DC voltage proportional to the generator load. This voltage is connected to a bridge circuit. In parallel operation, these bridge circuits are connected together by paralleling lines. If the power of the paralleled generators are not equal, there originates a little voltage difference between the bridges and then a small DC current will flow in the paralleling leads. This will normally cause a change in the speed setting of the connected generators, but, as they are all coupled electrically by the rotary field of the generators and have the same speed, their power output will be changed. When the generators are sharing the total load correctly there will be no current in the paralleling leads. This type of load sharing is very effective and can be accurate to within $\pm 1\%$ with power factors between ± 0.8 .

The generator power proportional signal is also used for external meter indication and forward/reverse power relay contacts. These contacts can be used for generator safety and also starting and stopping generator sets, depending upon load level.

4.3 Synchronizer Device

The auto synchronizer incorporates three phase voltage inputs which are conditioned and compared for frequency and phase alignment. The unit first compares the frequency of the BUS to the generator and gives an output signal to the governor speed that automatically aligns the frequency. Once alignment is achieved, LED indication is given and the next part of the circuit tries to align the phase. Once this is achieved, another LED confirms alignment and an adjustable timer is then brought into operation before the breaker signal is given. This delay time makes sure, that the generator breaker may be closed in constant operating conditions only.

The device has a gain and a stability control for frequency and phase correction and also an adjustable breaker delay and phase angle for optimum synchronisation time. The synchronizer can normally close the breaker from diesel engine stop in approximately 8 - 12 seconds.

There is also a sync lock facility that allows the generator to be synchronised to a BUS, but no breaker signal is given and is permanently synchronised in phase to a reference frequency, ie, the BUS. This is very useful for checking phasing of transformers, optimizing of parameters, etc, during commissioning or for stand-by synchronisation.

Under normal operation, once the breaker closure signal has been given, the unit is automatically reset and disconnected from the governor after one second. Then the synchronizer device is not controlling the speed of the engine anymore. Due to this fact, there is no need for any interposing relay between the synchroniser and governor speed input.

4.4 Load Ramp Device

The main function of the load ramp device is to soft load isochronously a single engine after closure of the generator breaker.

The device can offer a standard load ramp from zero with adjustable time to rated load equal to that of the paralleled engines offering a bumpless transfer and connection of load. Isochronous unloading is also possible with a simple opening of a contact and the engine will unload softly down to zero or a base load option which is internally or externally adjustable. The time constants are adjustable separately.

There is also an enhanced feature of a minimum load relay which is set approximately to 3% of rated load which allows the generator breaker to be opened automatically once the engine has ramped down to zero load. LED annunciation shows the state of the ramp generator and relay functions.

5 Technical Data

5.1 General

Input voltage		3 x 110 V or 415 V AC \pm 10% phase to phase
Input current	or	0 - 5 A per phase max. 2 VA 0 - 1 A per phase max. 2 VA select by resistor change
Current consumption		400 mA
Supply voltage		18 - 40 V DC 500 mA max.
Frequency range of generator		50/60 Hz
Temperature range		0 - 70° C
Protection grade		IP 00
Weight		1.8 kg

5.2 Load Measuring and Sharing Device

Load measuring		$U \times I \times \cos\phi$ with three phases
Load sharing		up to 15 gensets in parallel
Output signal		6 V at 100% generator power, adjustable
Output signal to kilowatt meter		0 - 1 V or 0 - 1 mA, adjustable
Forward power relay		adjustable 0 - 80% load
indication		with LED
contact load		30 V DC, 1 A
Reverse power relay		adjustable from 20% power up to 30% reverse power
indication		with LED
contact load		30 V DC, 1 A
Reverse power indication		1 LED per phase
Changeover of current transformer connections		link changeover without shutting down the engine
Load limitation		internal or external adjustable, 0 - 100%
Generator breaker closure		LED indication

Mains breaker closure LED indication

5.3 Synchronizer Device

Contact load of synchronizer relay	30 V DC, 2.5 A
Phase angle	± 1 up to $\pm 15^\circ$, adjustable
Synchronizer time	3 up to 15 sec. depends on plant, adjustable
Gain	adjustable
Output signal	± 4 V
max. frequency correction	± 2 Hz
Generator frequency o.k.	LED indication
Bus frequency o.k.	LED indication
Bus = generator frequency	LED indication
Phase angle o.k.	LED indication
Phase rotation o.k.	LED indication
Synchronizer inhibit	LED indication
Synchronizer relay closure	LED indication

5.4 Load Ramp Device

Base load setting	internal or external adjustable, 0 - 100%
Load ramp up	ramptime adjustable, LED indication
Load ramp down	ramptime adjustable, LED indication
Load at minimum relay indication contact load	with LED 30 V DC, 1 A
Load at maximum indication	with LED

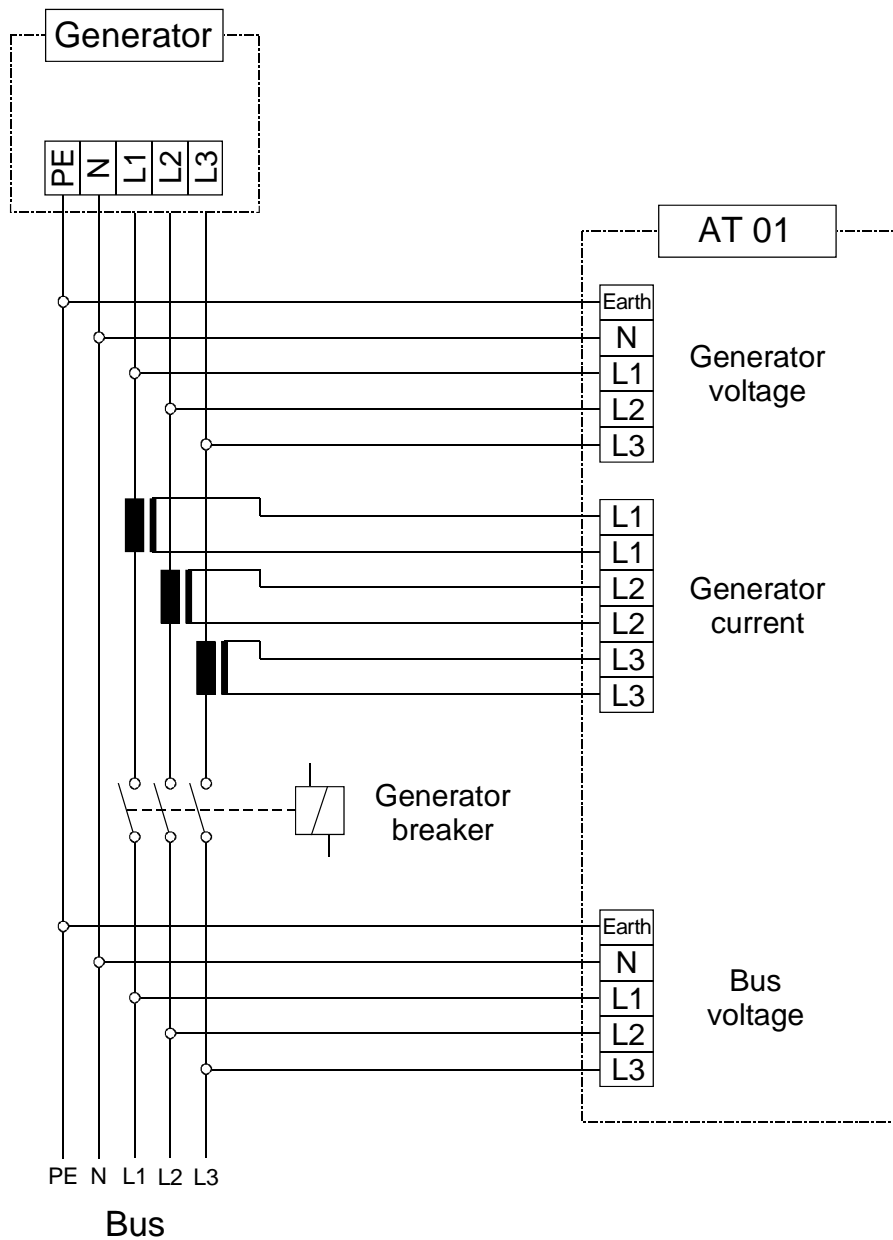
6 Electrical Connection

6.1 Table of Terminal Connections and their Functions

Terminal	Function	
1	0 V supply voltage	
2	+24 V supply voltage	
3	screen of lines on terminals 4, 5 and 6, 7	
4	signal synchronizer output to governor	
5	0 V synchronizer output to governor	
6D	signal load sharing output to <u>d</u> igital governor	
6A	signal load sharing output to <u>a</u> nalogue governor	
7	0 V load sharing output to governor	
8	input signal of load share line	
9	input 0 V of load share line	
10	screen of load share lines	
11	output 0 V of load share line	
12	output signal of load share line	
13	+10 V supply to load control unit and load setpoint potentiometer	
14	-10 V supply to load control unit	
15	output signal to load control unit	
16	output 0 V to load control unit and load setpoint potentiometer	
17	output signal to kilowatt meter, 0 - 5 V or 0 - 1 mA	
18	output 0 V to kilowatt meter	
19	0 V	
20	input 0 V for droop	
21	input signal for droop	
22	screen of lines on terminals 23, 24 and 25	
23	reference for external base load potentiometer	
24	signal of external base load potentiometer	
25	0 V for external base load potentiometer	
26	0 V	
27	switch input for load ramp	close = on
28	0 V	open = off

Terminal	Function	
29	switch input for base load	close = on
30	0 V	open = off
31	switch input to ramp up / down	close = up
32	0 V	open = down
33	switch input for synchronizer	close = off
34	+12 V via 100 Ohm	open = on
35	output for island / group synchronization	
36	0 V	
37	synchronizer relay inhibit	close = inhibit
38	+12 V via 100 Ohm	open = synch. possible
39	0 V	0 - 3 V or
40	external load limitation	10 kOhm potentiometer
41	0 V	
42	generator breaker closed	
43	0 V	
44	mains breaker closed	
45	Common	forward power relay
46	N/C	30 V DC, 1.5 A
47	N/O	
48	Common	reverse power relay
49	N/C	30 V DC, 1.5 A
50	N/O	
51	Common	load at minimum relay
52	N/C	30 V DC, 1.5 A
53	N/O	
54	Common	synchronizer relay
55	N/C	30 V DC, 2.5 A
56	N/O	

6.2 Connection of Bus Voltages and Current Transformers



Attention:

Take care that the right connections are made to the high voltage phases on the AT 01!

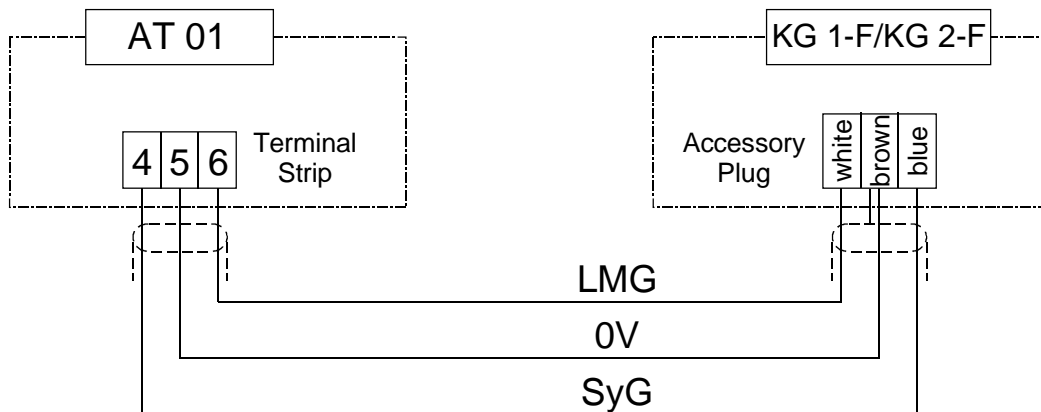
The connections are shown as a generator power control with synchronizer application.

When the unit is used as a group synchronizer and for controlled mains supply

- a) the generator terminals are replaced by the island group (bus bar),
- b) the bus bar terminals are replaced by the mains and
- c) the generator breaker is replaced by the mains breaker.

Figure 2: Connection of Bus Voltages and Current Transformers

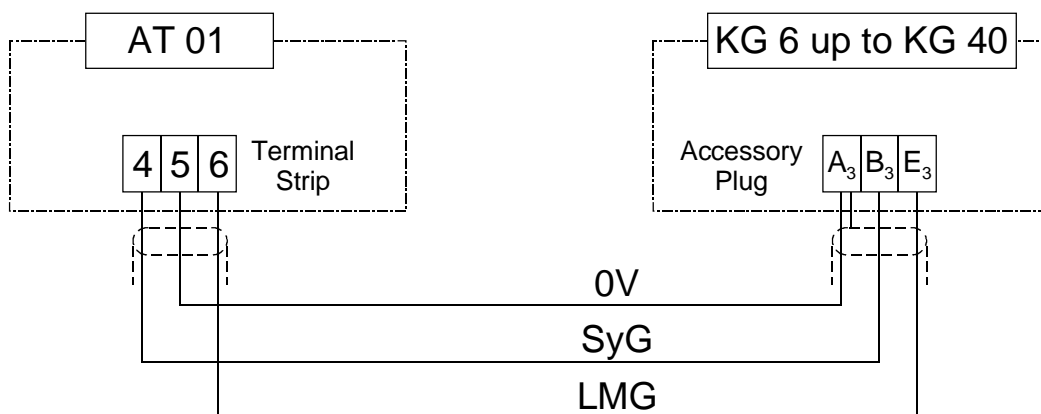
6.3 Connection with Control Unit of Series E 1 - F and E 2 - F



Cable 3 x 0,5 mm² with shielding
 max. length 50 m
 Shielding connected at control unit only

Figure 3: Connection with Control Unit of Series E 1 - F and E 2 - F

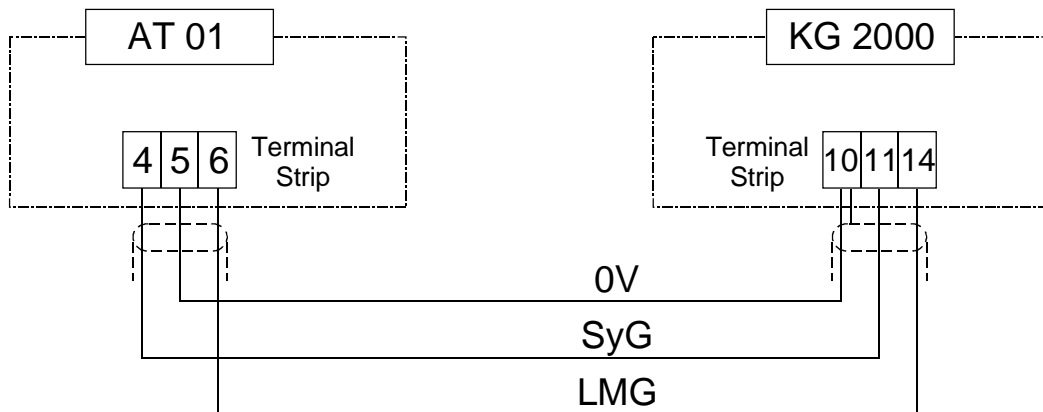
6.4 Connection with Control Unit of Series E 6 up to E 40



Cable 3 x 0,5 mm² with shielding
 max. length 50 m
 Shielding connected at control unit only

Figure 4: Connection with Control Unit of Series E 6 up to E 40

6.5 Connection with Control Unit of Series E 2000



Cable 3 x 0,5 mm² with shielding
max. length 50 m
Shielding connected at control unit only

Figure 5: Connection with Control Unit of Series E 2000

6.6 Connection to more THESEUS Units AT 01 in Parallel Operation

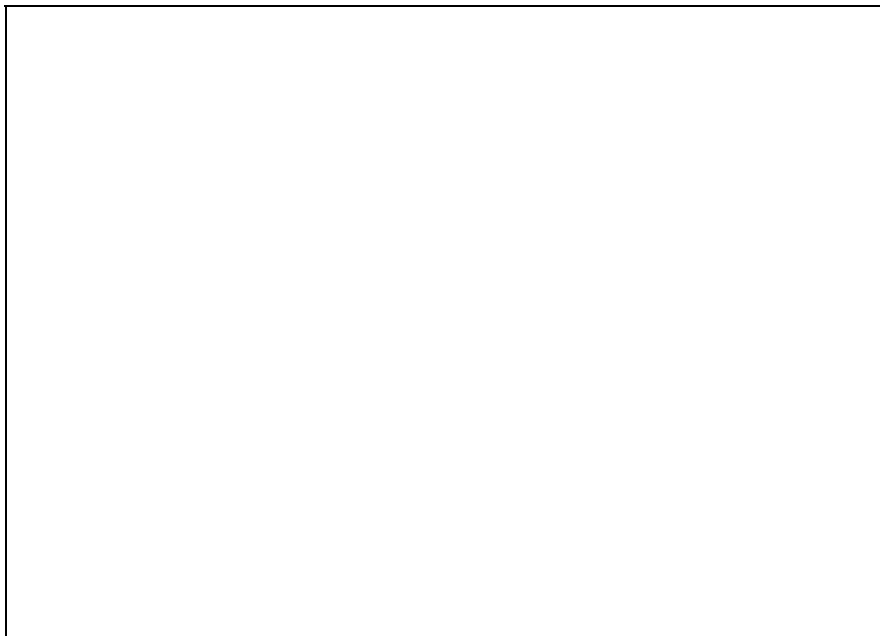


Figure 6: Connection to more THESEUS Units AT 01

6.7 Connection of Load Setpoint Potentiometer in Parallel Mains Operation

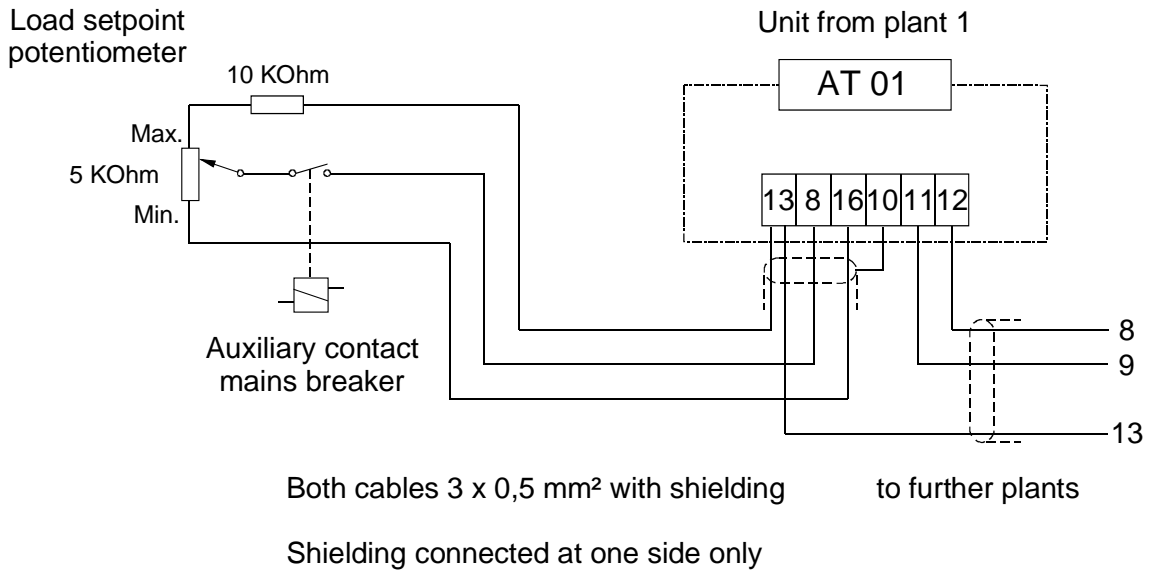


Figure 7: Connection of Load Setpoint Potentiometer

6.8 Connection of Load Control Unit in Controlled Mains Supply Operation

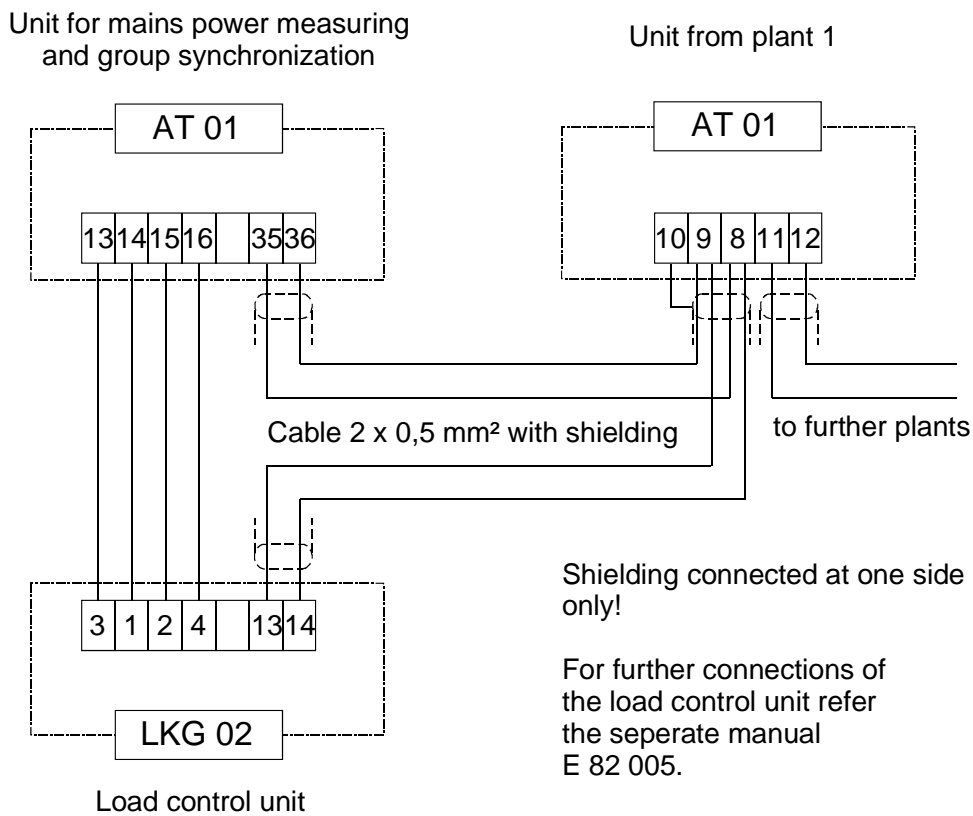
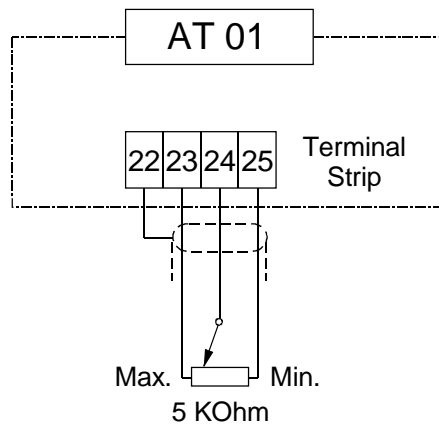


Figure 8: Connection of Load Control Unit LKG 02

6.9 Connection of External Base Load



Cable 3 x 0,5 mm² with shielding

Figure 9: Connection of External Base Load

6.10 Connection of External Load Limitation

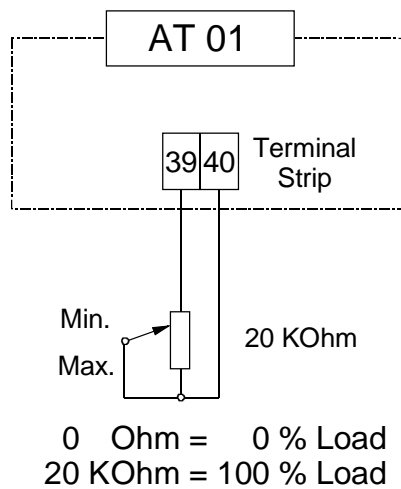


Figure 10: Connection of External Load Limitation

6.11 Connection of External Droop, if necessary

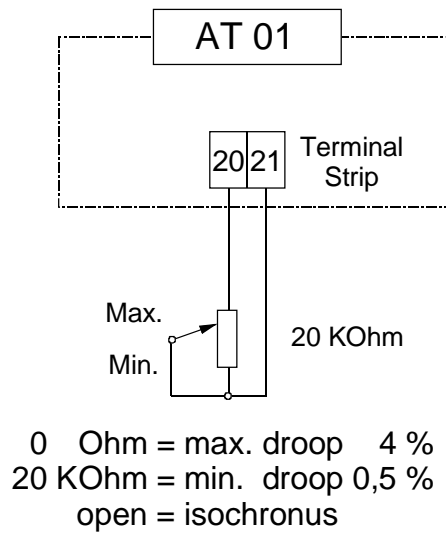


Figure 11: Connection of External Droop

7 Measurement

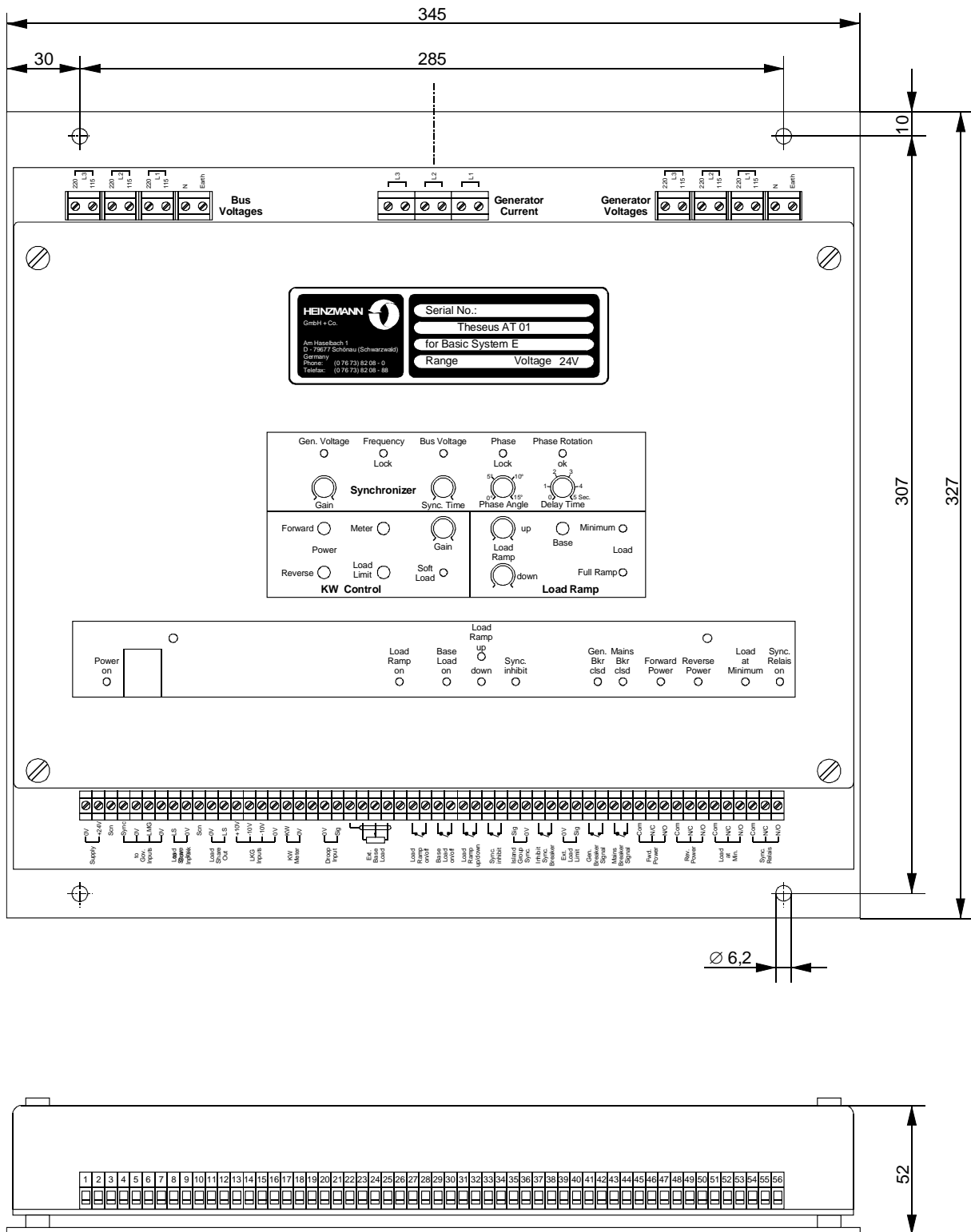


Figure 12: Measurement of Analogue THESEUS AT 01

8 Commissioning

8.1 Mean and Position of Adjusting Potentiometers and Testpoints

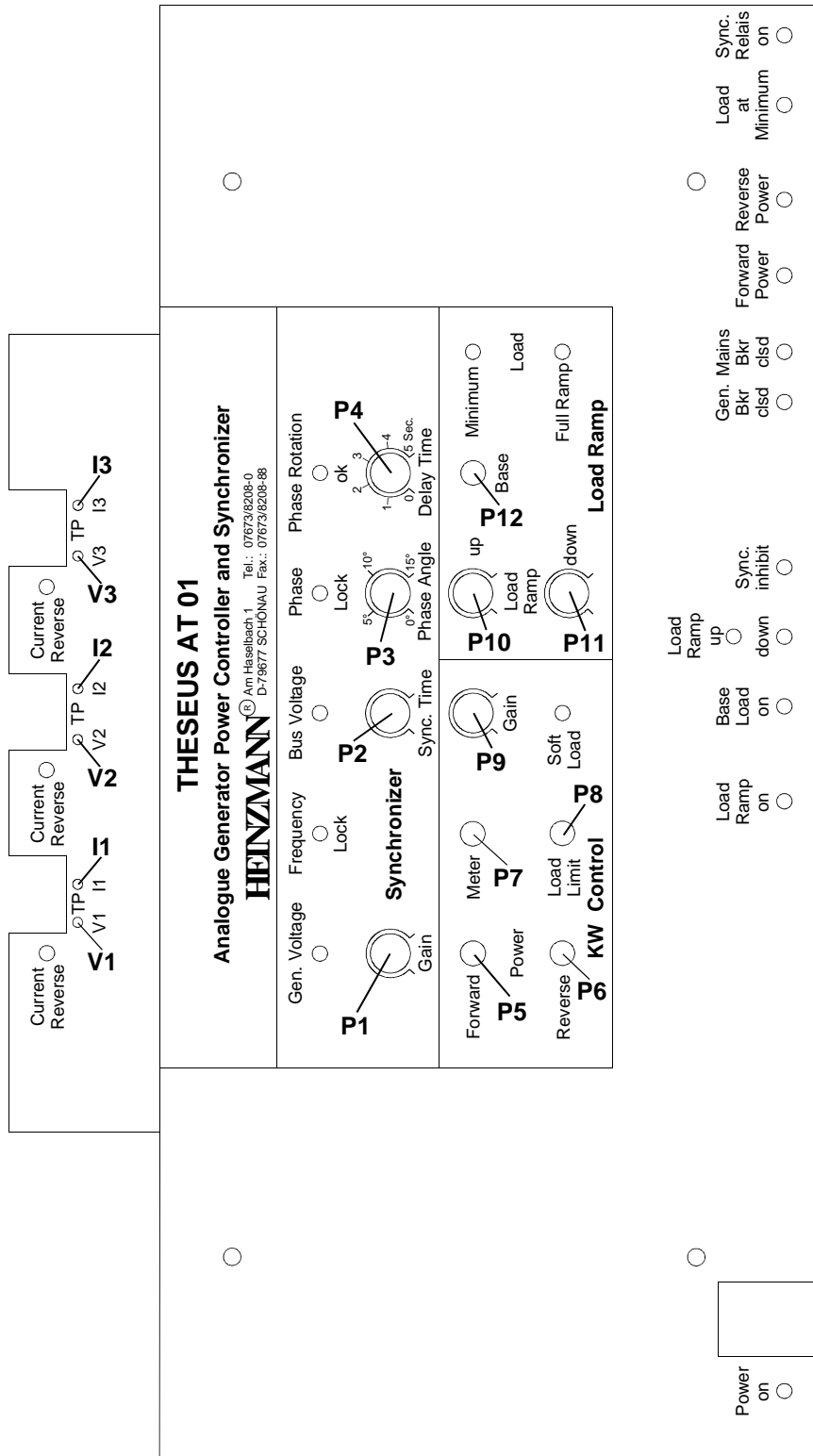


Figure 13: Position of Adjusting Potentiometers and Testpoints

Potentiometer	Function
P1	gain- adjustment for closed loop of synchronizer unit
P2	stability- adjustment for closed loop of synchronizer unit
P3	adjustment of allowed phase angle for synchronization
P4	adjustment of delay time to close generator breaker
P5	adjustment of forward power switch point
P6	adjustment of reverse power switch point
P7	adjustment of output to external kilowatt meter
P8	adjustment of internal fuel limitation
P9	adjustment for scaling of nominal power
P10	adjustment of time constant to ramp up
P11	adjustment of time constant to ramp down
P12	adjustment of base load

Testpoints	Function
V1	measuring of transformed voltage of phase L1 from generator
L1	measuring of transformed current of phase L1 from generator
V2	measuring of transformed voltage of phase L2 from generator
L2	measuring of transformed current of phase L2 from generator
V3	measuring of transformed voltage of phase L3 from generator
L3	measuring of transformed current of phase L3 from generator

8.2 Mean and Position of LED's

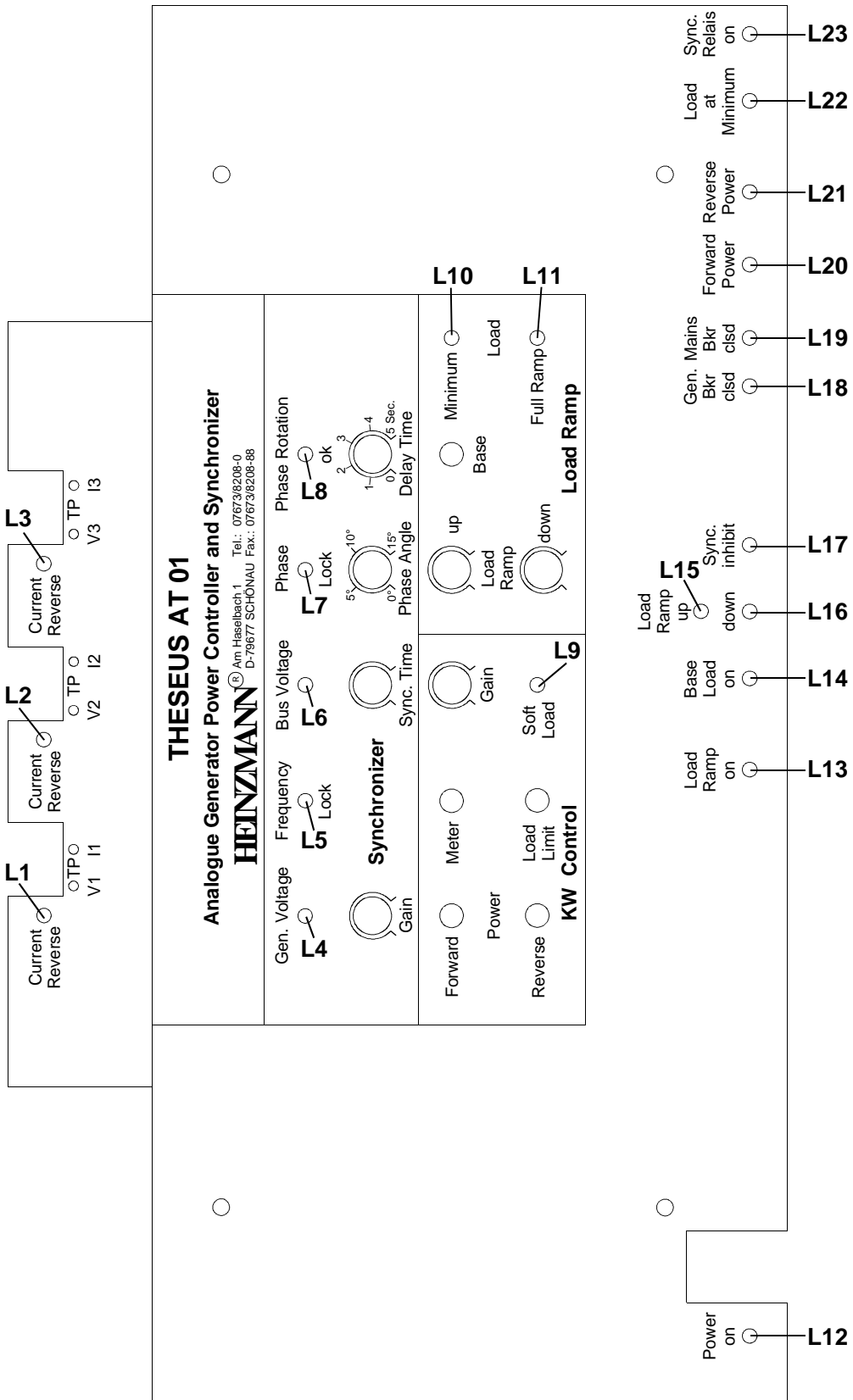


Figure 14: Position of LED's

LED	Function when LED is on
L1	reverse power on phase L1
L2	reverse power on phase L2
L3	reverse power on phase L3
L4	voltage on generator
L5	generator frequency = bus frequency
L6	voltage on bus
L7	phases angles on both sides of generator breaker are equal
L8	phase rotations on both sides of generator breaker are equal
L9	load is ramping up or down
L10	ramp reached at minimum load
L11	ramp reached at maximum load
L12	unit THESEUS is switched on
L13	load ramp unit is switched on
L14	base load is switched on
L15	switch in position to ramp up
L16	switch in position to ramp down
L17	synchronizer unit is switched off
L18	generator breaker is closed
L19	mains breaker is closed
L20	forward power more than adjusted value
L21	reverse power more than adjusted value
L22	load at zero load
L23	synchronizer relay is closed

8.3 Initial Setting Up Procedure

8.3.1 Wire the inputs of the generator voltages and the current transformers. Next, connect the BUS either or mains volt input connections (refer to fig. 2 page 12).



Warning

Care must be taken to connect the correct phase rotation for both, current and voltage inputs.

8.3.2 Connect the 24 V supply and the control unit (refer to fig. 3,4 or 5 page 13). Please check the correct connection of the accessory plug from control unit to the AT 01. The load controllers of the other gensets have to be connected together with load share lines (refer to fig. 6 page 14).

8.3.3 Connect all necessary switch inputs and relay outputs.

8.3.4 Link terminals 33 with 34 and terminals 37 with 38 before switching on power supply. This is to switch off the synchronizer device and to inhibit the synchronizer relay.

8.3.5 The contacts of the load ramp (27, 28), the base load (29, 30), the generator breaker (41, 42) and the mains breaker (43, 44) have all to be open.

8.4 Initial Setting of the Speed Governor

8.4.1 Switch the droop in the speed governor (control unit) to position zero.

8.4.2 Switch on supply voltage 24 V the LED L12 should be illuminated.

8.4.3 Start the engine and adjust the speed with the setpoint potentiometer to running speed.

8.4.4 With the gain, stability and derivative potentiometers in the control unit you adjust a optimum dynamic no load behaviour (refer to corresponding manuals). The generator frequency has to be adjusted with the speed setting potentiometer as exact as possible, e. g. 50 Hz.

8.5 Adjustment of Synchronizer Device

- 8.5.1 Set the potentiometer P3 for phase angle in middle position. The smaller the phase angle the longer the synchronization time.
- 8.5.2 Set the potentiometer P4 for required delay time of synchronizer relay. Gas engines must have short delay times, with diesel engines are delay times up to 5 seconds possible.
- 8.5.3 Set the potentiometer P2 for synchronization time and the potentiometer P1 for gain to middle position.
- 8.5.4 Start the genset.
- 8.5.5 Check the voltages on the generator breaker. LED L4 must illuminate when generator voltage is existing and LED L6 must illuminate when mains resp. bus voltage is existing.
- 8.5.6 Remove the link between the terminals 33 and 34 to switch on the synchronizer device.
- 8.5.7 If the phase rotations at both sides of the breaker are the same (when connections are o.k.), the LED L8 must illuminate.
- 8.5.8 The matching of the frequencies at both sides of the breaker is indicated by the illuminated LED L5 and the matching of the phase angles is indicated by the illuminated LED L7. Both LED's should be fully on when the dynamic behaviour of the synchronizer device is adjusted in optimum. By turning the gain potentiometer P1 and the synchronizer time potentiometer P2 you can adjust the best response. To check the response you can shortly link the terminals 33 and 34 to switch off and on again the synchronizer device. Please note that under these circumstances the synchronizer relay is still locked.



The generator voltage has to be adjusted before synchronizing with the voltage regulator of the generator or a voltage adjusting unit. The synchronizer device can only correct the frequency and the phase angle!



Before closing the mains breaker for the first time it has to be checked that the voltage over the breaker is near zero volt at all three phases. This is to ensure that there will be no phase mismatch over the mains breaker. Take care of high voltages.

- 8.5.9** When satisfied with synchronization, you can start the initial adjustment of the load sharing device. Make sure that immediately after synchronization there is only a minor take-up of load (refer to following chapters) before removing the link between terminals 37 and 38 so that the breaker can close. After closing the breaker, the synchronizer device will be automatically disconnected.

8.6 Adjustment of Load Sharing Device in Island Parallel Operation

- 8.6.1** Start one genset and set it to 20 % of rated load.
- 8.6.2** Connect a voltmeter with 10 V DC measuring range to terminals 15 and 16. A positive measured voltage is proportional the generator output power and it has to be adjusted with the potentiometer P9. If one of the reverse power LED's L1, L2 or L3 is illuminated, the corresponding link has to be reversed to change the current direction. The LED is extinguished and the measured voltage must increase.
- 8.6.3** Increase the generator power to 100 % and set the potentiometer in such a way, that the measured voltage between terminals 15 and 16 is 6 V DC. If full power is not available then the measured voltage has to be lower in accordance with the power (0 V DC equivalent 0 % power). If a kilowatt meter is connected, this has to be adjusted with the potentiometer P7.
- 8.6.4** The transformed generator voltages and generator currents have to be checked also. You can measure them between the testpoints V1, V2, V3 resp. I1, I2, I3 and 0V. At rated power these voltages should be approx. 6 V AC each.
- 8.6.5** Adjust further gensets like described in the points **8.6.1** up to **8.6.4** and switch off all gensets at the end.
- 8.6.6** Start genset 1, switch it to the bus bar by hand and load it with 50 %.



Danger!
High
Voltage

In this case the bus bar has not to be connected to the mains!

- 8.6.7** To synchronize further gensets to the started genset, all links between the terminals 37 and 38 have to be removed.
- 8.6.8** Start the second preadjusted genset and synchronize it to the first one. Each genset must now share the load equally.
- 8.6.9** Increase slowly the load to 100 %. If there is different load sharing, correct it with small readjustment of potentiometer P9.

- 8.6.10** Decrease the load to 0 %. If there is different load sharing, speed differences exist in governor speed adjustment. With readjustment of the external speed setting potentiometer of the governor of one genset you can correct this failure.
- 8.6.11** Proceed with installation 1 to 3, 1 to 4 etc. in the same way, thereby readjustments of the potentiometer P9 and the speed setting may only be made on the new added genset.
- 8.6.12** Now you can drive more gensets parallel together. If the adjustment described before was correct, now you have here a good load sharing also.

General: Differences at no load are to be corrected with the speed setting potentiometers of the speed governors and differences at full load are to be corrected with the gain potentiometers P9 of the load sharing devices.

8.7 Adjustment of Load Share Device in Base Load Mains Operation

In base load operation, adjustment of the power setpoint is achieved using an external load setting potentiometer which is connected to the gensets after the breaker has closed. The respective connection is shown in fig. 7, page 15. As the potentiometer is directly connected to the load sharing line it should be noted that in the case of several parallel gensets the potentiometer will be connected via the connecting lines to all of the gensets operating in parallel with the mains. By means of this potentiometer, power output is adjusted for all gensets working in parallel. In order to be able to adjust the total power range the internal power limitation potentiometer P8 has to be turned approx. 20 times clockwise. If necessary, the external power limitation potentiometer must also be turned clockwise to its rightmost stop.

If a motor potentiometer is used in place of the load setting potentiometer, this setup will also allow of controlled mains loading by using some appropriate external control.

It is also possible to replace the load setting potentiometer by a voltage source 0V up to 3V DC. This will allow power control by means of a CHP.

The adjustment of the load control devices is done as follows:

- 8.7.1** Set the droop switch in the speed governor to position droop, remove the connection from the load sharing device to the governor (terminal 6) and switch off the synchronizer device by linking the terminals 33 and 34.
- 8.7.2** Start the genset to be adjusted with middle position of the external speed setting potentiometer and set the generator frequency with the internal speed setting potentiometer equal to the mains frequency.

- 8.7.3** To synchronize, remove the link between the terminals 33 and 34.
- 8.7.4** After synchronization set the genset to partial load 20 % with the external speed setting potentiometer.
- 8.7.5** Connect a voltmeter with 10 V DC measuring range to terminals 15 and 16. A positive measured voltage is proportional to the generator output power and can be adjusted with the potentiometer P9. If one of the reverse power LED's L1, L2 or L3 is illuminated, the corresponding link has to be reversed to change the current direction. The LED is extinguished and the measured voltage must increase.
- 8.7.6** Increase the generator power to 100 % and set the potentiometer in such a way, that the measured voltage between terminals 15 and 16 is 6 V DC. If not all power is available the the measured voltage must be accordingly lower (0 V DC is equivalent to 0 % power). If a kilowatt meter is connected, this has to be adjusted with the potentiometer P7
- 8.7.7** The transformed generator voltages and generator currents have to be checked also. You can measure them between the testpoints V1, V2, V3 resp. I1, I2, I3 and 0V. At rated power these voltages have to be approx. 6 V AC each.
- 8.7.8** Disconnect the adjusted genset from mains and switch of the synchronizer device with linking the terminals 33 and 34.
- 8.7.9** Set the droop switch in the control unit to position zero and adjust the generator voltage as exact as possible when the external speed setting potentiometer is in middle position.
- 8.7.10** Switch the genset off, rebuild the connection from the load sharing device to the speed governor again (terminal 6) and remove the link between the terminals 33 and 34.
- 8.7.11** Adjust all other gensets like described in the points **8.7.1** up to **8.7.10**.
- 8.7.12** Start genset 1, synchronize to the mains and set with external load setting potentiometer partial load 50 %.
- 8.7.13** Start preadjusted genset 2 and synchronize to mains. Each genset must now share equal load.
- 8.7.14** Increase the load slowly to 100% with the load setting potentiometer. If there is differnt load sharing, correct it with small readjustment of potentiometer P9
- 8.7.15** Decrease the load to 0 %. If there is different load sharing, speed differences exist in governor adjustment. With readjustment of the external speed setting potentiometer of the governor of one genset you can correct this failure.

8.7.16 Proceed with installation 1 to 3, 1 to 4 etc. in the same way, thereby readjustments of the potentiometer P9 and the speed setting may only be made on the new added genset.

8.7.17 Now you can drive further gensets parallel together. If the adjustment described before was correct, now you have here a good load sharing also.

General: Differences at no load are to be corrected with the speed setting potentiometers of the speed governors and differences at full load are to be corrected with the gain potentiometers P9 of the load sharing devices.

8.8 Adjustment of Load Sharing Device with Controlled Mains Supply

With controlled mains supply, a generator power controller may also be used for group synchronization with the mains and for mains power setting. In this case, the synchronization output is not connected to some governor but to the load sharing line by means of a special output. A LKG 02 load control unit connected to the power signal will then replace the load setting potentiometer required for base load operation. The LKG 02 will compare the set and actual values of the power to be supplied from the mains and will in its turn transmit the resulting control signal to the load sharing line.

The load ramp and other functions are not used in the unit for import /export controlling. The connection of the load control unit LKG 02 with the generator power controller is shown in fig. 8, page 15.

The adjustment has to be like described in chapter **8.7.** Only then when all adjustments are satisfied, the external load setting potentiometer will be replaced by the connection of the load control unit LKG 02. For further informations refer the corresponding manual No. E 82 005.

8.9 Adjustment of Load Limitation

To protect the generator against overloading when in parallel with the mains, the maximum load may be limited by using an internal or external potentiometer. Thus, the set load will not be exceeded even if the actual power setpoint has been set to some higher value.

The load limitation can be used in mains operation only. Therefore it is necessary to connect the terminals 43 and 44 with the auxiliary contacts of the mains breaker.

8.9.1 Start the genset and parallel to the mains.

8.9.2 Set with the load setpoint potentiometer approx. 105 % of nominal load.

- 8.9.3** If you want an internal load limitation, slowly turn the potentiometer P8 counterclockwise until you reach the demanded maximum load.
- 8.9.4** If you want an external load limitation, turn at first the internal potentiometer P8 clockwise to maximum. Then slowly turn the external connected load limitation potentiometer as shown in fig. 10, page 16 counterclockwise until you reach the demanded maximum load
- 8.9.5** Check the adjustment by turning the load setting potentiometer counterclockwise and clockwise.

You can replace the external load limitation potentiometer by a voltage source 0V up to 3V DC. This is a control for CHP mode. The 3 V source must be able to both source and sink current of up to 50 mA.

8.10 Adjustment of Forward Power and Reverse Power Relays

The forward power relay can be used to give a power level if a preadjusted generator power is exceeded . The power level can be used to switch engines on/off for generator set control. The reverse power relay is to protect the generator and the engine. Both relays work without delay time and with a hysteresis of approx. 5 %.

- 8.10.1** To adjust the generator relay, load the engine up to the required load at the switch over point. With slowly turning of the potentiometer P5 you adjust the switch over point and check it after that with variation of the genset power.
- 8.10.2** To adjust the reverse power relay it is necessary to set the genset to reverse power in accordance with the power required. To do so, the genset is switched in parallel to the mains or to some other gensets, and the power setpoint is set to 0%. By slowly turning down the external speed setting potentiometer of the speed governor the genset will pass over to reverse power, and the required value can be set. By slowly turning the potentiometer P6 the switching point is being set and then checked by variation of reverse power. Finally , the speed setpoint potentiometer has to be set to its original value.

8.11 Adjustment of Droop, if necessary

If a load sharing with droop is necessary, the load share lines (terminals 8 up to 12) have not to be connected.

- 8.11.1** After initial setting, turn the connected droop potentiometer (shown in fig. 11, page 17) clockwise to maximum and load genset with 100 %.

8.11.2 With the speed drop by putting on load you can adjust the droop by turning the droop potentiometer.

The droop has to be adjusted the same for all gensets and should be about 4 %.

8.12 Adjustment of Load Ramp Device



Note

In island single operation the load ramp is not allowed, because the output power always depends on the unknown load level.

If in island parallel operation the load ramp device is activated, make sure that the power reduction on one genset caused by the load ramp can be balanced out by the other gensets without overload. Otherwise a speed drop would follow.

8.12.1 Start the genset to be adjusted, parallel to mains, set the power setpoint to 50 % and switch off the genset again.

If only island operation is possible, start at first a second genset and putting 100 % load on it. This genset is now looked on from the first genset to be adjusted as the mains. When load sharing is adjusted correct, the first genset takes over 50 % of the load after connecting to it.

8.12.2 To switch on the load ramp device, link the terminals 27 and 28.

8.12.3 Start the genset to be adjusted and synchronize to the bus bar resp. to the mains. Now the genset will not supply any power and stay at 0 KW.

8.12.4 To ramp up, link the terminals 31 and 32 and the LED 15 illuminates. During ramping up, the LED L9 (soft load) illuminates. When reaching the load setpoint corresponding to point **8.11.1** the LED L9 extinguishes again and the LED L11 (full load ramp) illuminates. The time constant can be adjusted with the potentiometer P10.

8.12.5 To ramp down again, remove the link between the terminals 31 and 32. During ramping down, the LED 9 illuminates. When reaching zero load the LED L9 extinguishes again, the LED L10 (minimum load) illuminates and the relay “Minimum Load“ switches also. This is indicated with LED 22. The time constant to ramp down can be adjusted with the potentiometer P11.

8.12.6 With several opening and closing the link between the terminals 31 and 32 ,that means ramping up and ramping down, you can adjust the time constants.

8.12.7 By linking the terminals 29 and 30, it is possible to ramp to an internally or externally fixed power setpoint, regardless of the externally set variable power setpoint and regardless of preselecting upward or downward ramping.. For

reasons of hardware design, however, this setting can only be achieved when the terminals 29 and 30 are open.

Set by opening the link between the terminals 31 and 32 to zero load. Turn the potentiometer P12 (base) 10 times counterclockwise and then 2 times clockwise. Link the terminals 29 and 30 to ramp up to the set value. At the same time the LED L14 illuminates. When on finishing ramping the desired value is too low, terminals 29 and 30 are opened in order to ramp back to zero load, and P12 is turned clockwise another time, otherwise in opposite direction (counterclockwise). By linking terminals 29 and 30 again, the newly set value will be ramped to. This procedure is to be repeated until the desired value is attained.

If adjustment is being made using an external potentiometer, it should be connected according to fig. 9, page 16. In this case P10 is to be turned clockwise 10 times, then the setting can proceed by means of the external potentiometer the same way as described above.

9 Ordering Specification

Please order: THESEUS Analog AT 01

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