SAM Electronics

Projection Manual

Generator Protection Module

GPM500

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SAM Electronics GmbH
D - 22763 Hamburg

Phone: + 49 (0) 40 8825-0
Fax: + 49 (0) 40 8825-4000
E-mail: info@sam-electronics.de

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List of Abbreviations

AO	Analog Output
AC	Alternating Current
AI	Analog Input
ANSI	American National Standards Institute
BAT	Operating and indicating panel (Bedienungs- und Anzeige-Tableau)
CAN	Controller Area Network
CPU	Central Processing Unit
DG	Diesel Generator
DO	Digital Output
DC	Direct Current
DCC	DC/DC-Converter
DI	Digital Input
DIF	Differential-Current Detection (Differenzstrom-Erfassung)
DIO	Digital-I/O card
GOV	Governor-Motor Control
GPM	Generator Protection Module
IP	Internet Protocol
LCD	Liquid Crystal Display
MBM	Modbus master unit (Modbus Masterbaustein)
NEG	Power supply unit (Netzgerät)
OV	Object directory (Objektverzeichnis)
PCB	Printed Circuit Board
PDO	Process data object (Prozessdatenobjekt)
RMS	Root mean square
RTU	Remote Transmission Unit
SDO	Service Data Object (Servivedatenobjekt)
SLE	Current and Power Acquisition (Strom und Leistungserfassung)
SPS	Storage-programmable logic controller (Speicherprogrammierbare Steuerung)
TCP	Transmission Control Protocol
TRV	Isolated Voltage Acquisition (Trennverstärker)
USS	Voltage Backup for Undervoltage Coils (Unterspannungsspulenstützung)
ZKG	Central unit (Zentralkarte)
ZM	Central Module (Zentralmodul)

1 General Functional Description

The generator protection module GPM500 is a microprocessor-controlled system being used to protect low-voltage and medium-voltage generators and electrical power nets on ships and for other applications. The GPM500 can be operated as "stand-alone" unit or in combination with other GPM500 devices (the communication taking place via a data bus).

Generally each protective application (e.g. generator, coupler circuit-breaker, consumer etc.) requires an own GPM500.

A complete power management system (PMS) is realised by connecting the GPM500 via the GPM bus, two redundant CAN bus systems. Then all PMS main functions can be selected.

Thanks to the modular design of the GPM500 its functions and possible connections can be easily extended because the modules are directly interconnected via plug-in connections.

The GPM500 can be connected to external power management systems and (optionally) to the Internet (Modbus / TCP) via an interface (Modbus). The authorisation for the external access to display and parameterisation can be restricted.

Operation, parameterisation and monitoring of the GPM500 are effected via the operator control and display panel (BAT500). The graphical representation on the main picture enables the immediate survey of the status of e.g. a generator and the connected generator circuit-breaker including the relevant data such as current, voltage and power. For control / modification purposes the parameters are combined according to the protection function (protected by a password). Faults are displayed in an alarm list and can be acknowledged on the BAT500.

An integrated programmable logic controller (PLC) allows the free programming of additional protection functions and switchpanel controls. The PLC can be graphically programmed on a PC using functional blocks in accordance with IEC1131.

2 Scope of Functions

The GPM500 makes available the following functions:

Protection Functions for:

- Diesel generators
- Shaft generators
- Emergency generators
- Coupler circuit-breakers
- Transfer line circuit-breakers
- Transformers
- Motors
- Shore connection
- Filters
- High-resistance earthing

Protection Functions in Detail are:

- Short-circuit
- Stator protection
- Overcurrent
- Phase current asymmetry
- Under- and overvoltage
- Phase failure
- Under- and overfrequency
- Reverse power
- Circuit-breaker failure
- Excitation monitoring
- Load shedding
- Differential protection (optional)
- Earth-fault protection (optional)
- Voltage displacement protection (optional)

Control and Power Management Functions:

- Blackout start
- Automatic start and synchronising
- Frequency control
- Active power control incl.
  - Symmetrical load sharing
  - Asymmetrical load sharing
  - Relieving of the generator prior to shutdown
- "Topload" function
- Load monitor function (optional)
  - Load-dependent start of DG sets
  - Load-dependent stop of DG sets
  - Load-dependent start of big consumers

2.1 Protection Functions, ANSI Codes

In the following the protection functions are listed according to the monitored variable each (current, voltage, frequency, active power and reactive power). Their internationally standardised ANSI code is indicated in round brackets () each, the numbers of the respective parameters in square brackets [ ].

Usually, three parameters can be set for the protection functions:

– Operating value (mostly in % of the nominal value)
– Delay time (s, ms and *x ms respectively)
– Function (function code hexadecimal $...)

The following functions can be parameterised by function codes (several at the same time, too):

Alarm, trip, de-excitation, stop engine, interlock deactivation by local quit required, start passing-on/ relay, blocking until reset, busbar blocking against switching-on.

2.1.1 Short-circuit Protection (ANSI 50)

For the short-circuit protection the GPM500 offers two levels with different settings ranges.

This protection mainly serves the net protection. It works as an independent overcurrent-time protection with time-delay tripping after exceeding of the operating value.

The short-circuit protection is to be adjusted such that the equipment concerned only is shut down, if possible. The time selectivity is usually used for this purpose. The delay times are to be selected in a “graded” manner such that the switching device being closest to the place of fault is opened first:

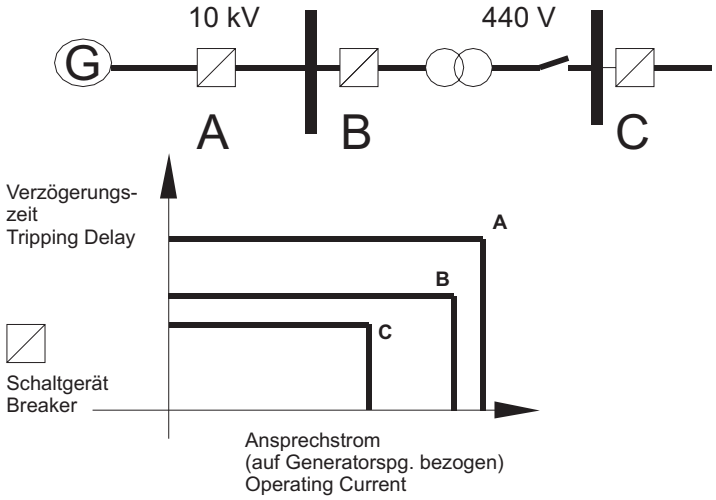


Fig. 2-1 Example of a Short-circuit Protection Setting with Several Items of Protective Equipment

Two levels can be parameterised.

Adjustable Parameters:

Level 1:	
Operating value [Par. 1]:	100% ... 800% * I_N
Delay [Par. 2]:	0 s ... 10 s
Function, preset [Par. 101]:	Alarm, circuit-breaker tripping, local acknowledgement required, blocking until acknowledgement, busbar blocking (function code $D3)
Level 2:	
Operating value [Par. 3]:	0% ... 800% * I_N
Delay [Par. 4]:	0 s ... 10 s
Function, preset [Par. 102]:	Alarm, circuit-breaker tripping, local acknowledgement required, blocking until acknowledgement, busbar blocking (function code $D3)

When adjusting the protection the relation between overcurrent protection and undervoltage protection is to be taken into account, too.

Autonomous Short-circuit Protection and Lockout Relay (ANSI 86)

Regardless of the parameterisable, microprocessor-controlled protections functions described the GPM500 ensures an autonomous short-circuit and differential protection by means of the SLE500A module. In case of a short-circuit this tripping equipment being independent of auxiliary energy and processor trips with a transformer current of 2.5 A after 250 ms. This setting can be adapted by changing the components provided.

By means of this protection function there is thus realised a backup protection in case of a failure of the protective equipment.

2.1.2 Stator Protection (ANSI 50S)

The stator protection is an overcurrent-time protection with a reduced operating value being active with an open circuit-breaker only. It protects the starting generator in the event of internal faults. For this purpose, three current transformers being installed at the star point of the generator must be evaluated.

As far as generator applications are concerned, it is recommended to de-excite the generator in case of this fault and to stop its propulsion.

Adjustable Parameters:

Operating value [Par. 5]:	3% ... 100% * I_N
Delay [Par. 6]:	0 s ... 10 s
Function, preset [Par. 103]:	Alarm, circuit-breaker tripping, de-excitation, stop of the diesel-generator set, local acknowledgement required, blocking until acknowledgement (function code $5F)

2.1.3 Independent Overcurrent-time Protection (Overcurrent Definite Time (DT), ANSI 51)

The independent overcurrent-time protection corresponds to the short-circuit protection, in principle, but the settings for the delay times are considerably larger and the operating values are lower. The purpose of the protection is primarily to protect an equipment.

With respect to generators it is recommended to let trip the load shedding, i.e. the switching-off of unimportant consumers, prior to the operation of the overcurrent-time protection.

Adjustable Parameters:

Operating value [Par. 7]:	100% ... 400% * I_N
Delay [Par. 8]:	0 s ... 240 s
Function, preset [Par. 104]:	Alarm, circuit-breaker tripping, blocking until acknowledgement, (function code $43)

Pre-alarm, Warning:

Operating value [Par. 9]:	100% ... 400% * I_N
Delay [Par. 10]:	0 s ... 240 s
Function, preset [Par. 105]:	Exclusively alarm (function code $01)

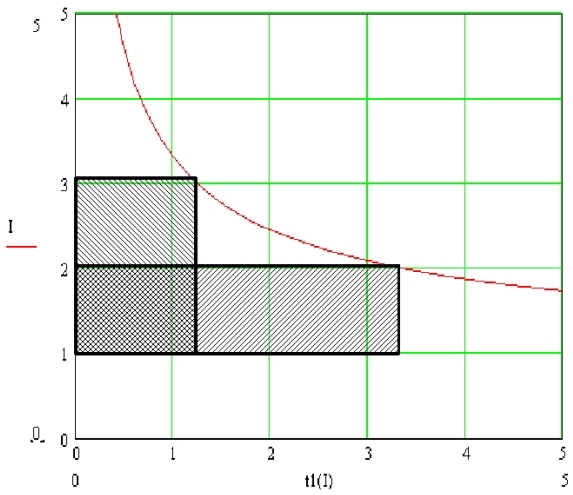
2.1.4 Dependent Overcurrent-time Protection (Overcurrent Inverse Time (IDMT), ANSI 51)

The dependent overcurrent-time protection trips after a period of time depending on the current intensity (inverse or protection characteristic).

In detail the time to trip is calculated according to the "very inverse" characteristic. In doing so, there is used only one parameter (time factor K):

$$t_{trip} = \frac{K}{\frac{I^2}{I^2_{nom}} - (1,05)}$$

For this purpose the GPM calculates the load integral, which decreases again only when the basic current value of approx. 1.025*I_N is fallen below.



NOTE:
Due to the fact that very high currents lead to short times to trip, the selectivity is to be checked.

Adjustable Parameters:

Basic time [Par. 81]:	0 ... 3000 *10 ms
Function, preset [Par. 141]:	Alarm, circuit-breaker tripping, blocking until acknowledgement, (function code $43)

Pre-alarm, Warning:

Basic time [Par. 82]:	0 s ... 65.53 s
Function, preset [Par. 142]:	Exclusively alarm (function code $01)

2.1.5 Current Asymmetry (ANSI 46)

To protect electrical machines from a too high asymmetry of the phase currents.

Adjustable Parameters:

Operating value [Par. 11]:	10% ... 120% * I_N
Delay [Par. 12]:	0 s ... 240 s
Function, preset [Par. 106]:	Alarm, circuit-breaker tripping, blocking until acknowledgement, (function code $43)

Pre-alarm, Warning:

Operating value [Par. 13]:	10% ... 120% * I_N
Delay [Par. 14]:	0 s ... 240 s
Function, preset [Par. 107]:	Exclusively alarm (function code $01)

2.1.6 Undervoltage (ANSI 27)

This protection serves as net protection and as equipment protection.

For generators being operated as stand-alone units the undervoltage protection is very important to disconnect an underexcited generator from the net and to make it possible to connect a spare DG set. It is recommended to start a spare DG set with the aid of the pre-alarm / warning already in advance in order to avoid and to shorten the blackout respectively.

Furthermore, this protection is important for rotating machines because the maximum torque of synchronous machines decreases linearly and the breakdown torque of asynchronous machines even shows a square-law decrease as a function of the voltage.

For transformers this protection is not necessarily required but it is, however, advantageous to switch off the circuit-breaker in case of a blackout such that when switching on a generator in case of a blackout an extreme inrush current of all transformers is avoided.

Adjustable Parameters:

Operating value [Par. 15]:	50% ... 100% * U_N
Delay [Par. 16]:	0 s ... 240 s
Function, preset [Par. 108]:	Alarm, circuit-breaker tripping, blocking until acknowledgement, (function code $43)

Pre-alarm, Warning:

Operating value [Par. 17]:	50% ... 100% * U_N
Delay [Par. 18]:	0 s ... 240 s
Function, preset [Par. 109]:	Exclusively alarm (function code $01)

2.1.7 Overvoltage (ANSI 59)

The overvoltage protection protects all generators and consumers. It is essentially used with equipment only which might cause an overvoltage as e.g. generators and possibly capacitor groups and net filters.

It is recommended to additionally de-excite and stop generators in case of the occurrence of overvoltage.

Adjustable Parameters:

Operating value [Par. 19]:	10% ... 200% * U_N
Delay [Par. 20]:	0 s ... 240 s
Function, preset [Par. 110]:	Alarm, circuit-breaker tripping, de-excitation, stop of the diesel-generator set, blocking until acknowledgement (function code $4F)

Pre-alarm, Warning:

Operating value [Par. 21]:	10% ... 200% * U_N
Delay [Par. 22]:	0 s ... 240 s
Function, preset [Par. 111]:	Exclusively alarm (function code $01)

2.1.8 Underfrequency (ANSI 81L)

This protection is almost exclusively used with generators in case of overload or faults of the prime mover.

Due to the fact that switching-off of the DG set should be the protection measure becoming effective last, shedding of load by switching off unimportant consumers should be initiated first in case of an underfrequency. For this purpose, five different groups of unimportant consumers can be switched off due to overcurrent and underfrequency on the basis of their own operating values and delays each (see section 2.1.13).

Adjustable Parameters:

Operating value [Par. 23]:	50% ... 200% * f_N
Delay [Par. 24]:	0 s ... 240 s
Function, preset [Par. 112]:	Alarm, circuit-breaker tripping, blocking until acknowledgement, (function code $43)

Pre-alarm, Warning:

Operating value [Par. 25]:	0% ... 200% * f_N
Delay [Par. 26]:	0 s ... 240 s
Function, preset [Par. 113]:	Exclusively alarm (function code $01)

2.1.9 Overfrequency (ANSI 81H)

This protection is to be used almost exclusively with generators in order to protect from overfrequency and overspeed (e.g. in case of disturbed speed controllers or dynamically also in case of the disconnection of large loads).

Adjustable Parameters:

Operating value [Par. 27]:	0% ... 200% * f_N
Delay [Par. 28]:	0 s ... 240 s
Function, preset [Par. 114]:	Alarm, circuit-breaker tripping, blocking until acknowledgement, (function code $43)

Pre-alarm, Warning:

Operating value [Par. 29]:	0% ... 200% * f_N
Delay [Par. 30]:	0 s ... 240 s
Function, preset [Par. 115]:	Exclusively alarm (function code $01)

2.1.10 Reverse Power (ANSI 32)

This protection protects power sources from an excessive active power being fed back. This way e.g. diesel engines can be protected from an excessive reverse power.

A larger and longer reverse-power output of an equipment is to be limited by the equipment itself (e.g. electrical propulsion system) because reaching of the set reverse-power limit would lead to a successive switching-off of all generators and thus to a blackout.

Adjustable Parameters:

Operating value [Par. 31]:	-200% ... 0% * P_N
Delay [Par. 32]:	0 s ... 240 s
Function, preset [Par. 116]:	Alarm, circuit-breaker tripping, blocking until acknowledgement, (function code $43)

Pre-alarm, Warning:

Operating value [Par. 33]:	-200% ... 0% * P_N
Delay [Par. 34]:	0 s ... 240 s
Function, preset [Par. 117]:	Exclusively alarm (function code $01)

2.1.11 Underload (ANSI 37)

This function protects an engine from falling below a certain minimum load for a longer period of time. This is important especially for DG sets to avoid any unfavourable operating conditions.

The function should, however, be mainly used for the purpose of alarm and only in exceptional cases to switch off consumers.

Adjustable Parameters:

Operating value [Par. 59]:	0% ... 100% * P_N
Delay [Par. 60]:	0 s ... 30000 s
Function, preset [Par. 130]:	Exclusively alarm (function code $01)

Pre-alarm, Warning:

Operating value [Par. 61]:	0% ... 100% * P_N
Delay [Par. 62]:	0 s ... 30000 s
Function, preset [Par. 131]:	Not active (function code $00)

2.1.12 Underexcitation (ANSI 40)

To protect from the faulty excitation of a generator or from the lack of excitation, if the generator does not output a sufficient lagging reactive power.

In case of a faulty excitation a synchronous generator suddenly works as asynchronous generator. In doing so, it continues to supply active power such that the reverse power criterion does not become active.

In case of the parallel operation of several generators the underexcitation protection is implemented via the comparison of the reactive power of the generators by means of the data exchange of the GPM500.

The maximum admissible reactive-current input of a generator can be obtained from the phasor diagram of the generator and from the static stability limit being entered there. From this the maximum admissible reactive power as operating value to be set is obtained.

Details are to be seen from the parameterisation instruction under parameter 55.

Adjustable Parameters:

Operating value [Par. 55]:	-200% ... 0% * S_N
Delay [Par. 56]:	0 s ... 240 s
Function, preset [Par. 128]:	Alarm, circuit-breaker tripping, blocking until acknowledgement, (function code $43)

Pre-alarm, Warning:

Operating value [Par. 57]:	-200% ... 0% * S_N
Delay [Par. 58]:	0 s ... 240 s
Function, preset [Par. 129]:	Exclusively alarm (function code $01)

2.1.13 Load Shedding

In case of overloading of the DG sets due to overcurrent or underfrequency a load shedding, i.e. switching-off of unimportant consumers is possible. Up to 5 levels with one current and one frequency tripping value and one assigned output contact each are available. In the basic configuration 3 levels can be realised and with additional DIO500 modules 5 adjustable levels can be realised at maximum.

Adjustable Parameters:

Current operating value, levels 1...5 [Par. 37,39,41,43,45]:	30% ... 400% * I_N
Frequency operating value, levels 1...5 [Par. 38,40,42,44,46]:	0% ... 100% * f_N
Delay, levels 1...5 [Par. 119,120,121,122,123]:	0 s ... 120 s

2.1.14 Phase Failure/Phase Sequence (ANSI 47)

This protection function is initiated without delay in case of the failure of the voltage of at least one phase and in case of a wrong direction of the rotating field (anti-clockwise rotating field). The effect of the initiation can be parameterised by means of the function code.

Adjustable Parameters:

Function, preset [Par. 146]:	Alarm, circuit-breaker tripping, local acknowledgement required, blocking until acknowledgement (function code $53)

2.2 Optional Protection Functions

2.2.1 Differential Protection (ANSI 87)

The differential protection function compares the currents at the input and output of an equipment. Faults are detected exclusively inside the protection zone being enclosed by transformers. The equipment concerned is always isolated without delay. As a consequence, the differential protection is not to be taken into account with respect to the time selectivity.

In case of a fault in one of several generators without differential protection the short-circuit protection (ANSI 50) of the other generators would be initiated, too, and it would sometimes cause a blackout. But when using the differential protection, the defective generator is disconnected almost immediately and thus prior to the initiation of a short-circuit protection. The generator differential protection (87G) thus also shortens the dead interval for the consumers of the net concerned and thus improves the stability.

The differential protection is not parameterised by means of a trip delay time, but with the aid of several other parameters. The first group characterises the tripping characteristic and the second group characterises the inrush stabilisation.

For the transformer differential protection the transformation ratio and the vector group must be additionally parameterised.

– **Tripping characteristic:** If high fault currents are flowing through an equipment to a place of fault outside the equipment, then the differential protection should not respond at all. The fault of the protective transformers being involved, however, increases absolutely and relatively as a function of the increasing current. Therefore the protection must become less sensitive with high currents. For this reason, the tripping limit is not specified as an absolute value but as a dynamic value depending on the intensity of the current flowing through the equipment.

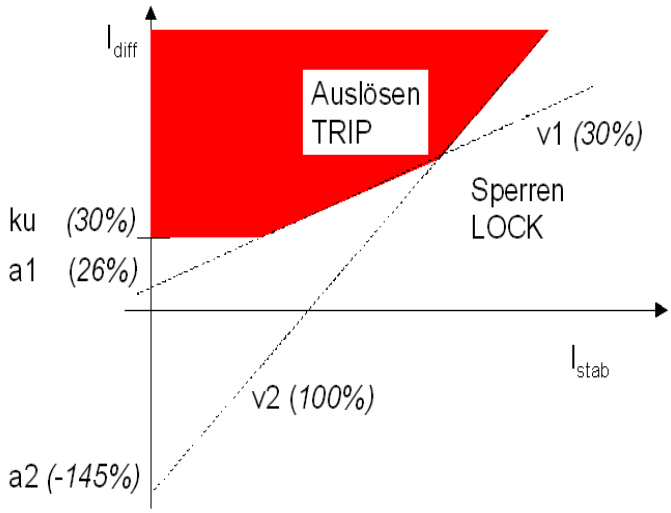


Fig. 2-2 Tripping Characteristic of the Differential Protection

– **Inrush stabilisation:** When switching on transformers they consume very high currents (inrush current) with respect to which there is no corresponding current on the secondary side. In order to avoid any false tripping of the differential protection the protective equipment is equipped with an inrush stabilisation: The protective equipment recognises the typical increased second harmonic in the primary current and, if necessary, blocks the differential protection. The inrush stabilisation is also effective in connection with the generator to avoid tripping of the generator differential protection (87G) when switching on a large transformer.

Adjustable Parameters:

Tripping Characteristic:

ku	Minimum value of the tripping current [Par. 95]:	100% ... 800% * I_N
a1,v1	Start value and increase [Par. 96, 97]:	-800...800
a2,v2	Start value and increase [Par. 98, 99]:	-800...800

Inrush Stabilisation:

Limit value for the second harmonic [Par. 94]: 0...999 * 0.1%* I_N

Function Code

Function, preset [Par. 132]: Alarm, circuit-breaker tripping, de-excitation, stop of the diesel-generator set, local acknowledgement required, blocking until acknowledgement (Function code $5F)



NOTE:
In any case the nominal voltage must be parameterised with the aid of parameter 179, for three-winding transformers additionally that of the secondary winding by means of par. 180.

The default parameters for the differential protection are suitable for most of the applications and don't need any further adaptation!

2.2.2 Earth-fault Protection, General Introduction

Earth faults in insulated and high-resistance grounded nets are acquired with the aid of the GPM500 in two different ways:

– Acquisition of the voltage displacement, i.e. the sum of the phase-to-earth voltages exceeding zero in case of an earth fault;
– Acquisition of the earth-fault current at the fault location against earth and ship's hull respectively flowing back via the (cable) capacitances being distributed in the net.

With the aid of the first acquisition it is possible to make a statement on the existence of an earth fault (voltage displacement ANSI 59N). The second effect enables a statement on the position of the earth fault (ANSI 51N):

This is shown in the following figure with the example of an earth fault with a consumer:

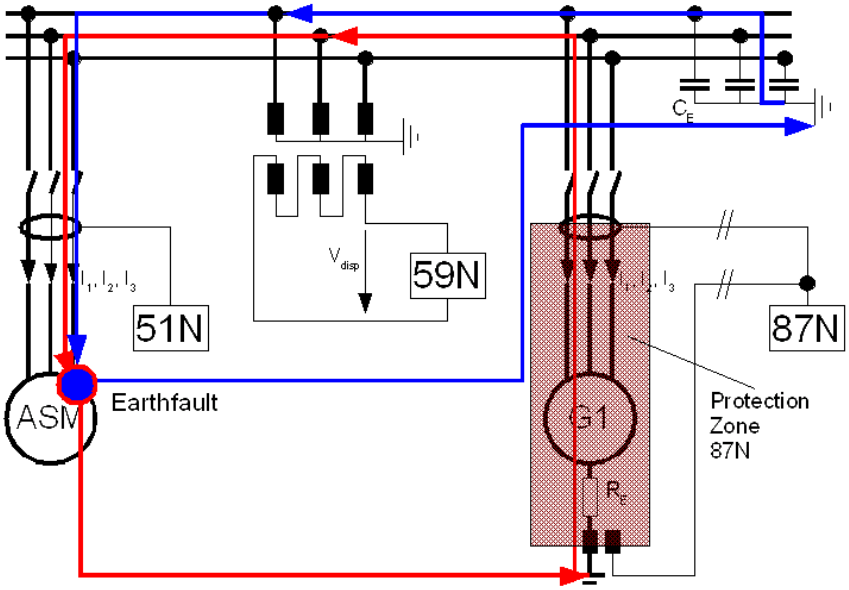


Fig. 2-3 Earth Fault Acquisition

At the fault location the earth-fault current is flowing to earth.

With an isolated net the circuit is closed via the generator and the cable capacitances against earth (darker blue line).

The earth fault in the net can be detected by acquiring the displacement voltage. The earth-fault current at the consumer can be measured by evaluating the left toroidal-core current transformer and the consumer can be switched off selectively after this.

With a high-resistance grounded net the earth-fault current flows e.g. via the earthing resistance and the star point of the generator (lighter red line). By the defined, purely resistive earthing the earth-fault current is increased to a defined value and obtains an additional active component.

To protect the generator from an internal earth fault its earth-fault current must be subjected to a differential evaluation by comparing the currents of toroidal-core current transformer and star-point current transformer (ANSI 87N). This protection is, however, limited to the marked protection zone.

NOTE:
If the earthing resistance and the net respectively are not designed for a continuous earth-faulted operation, then the protection concept must be designed as follows to isolate the fault location in the following three steps:

- **The faulty DG set / item of equipment must be disconnected by means of protection function ANSI 51N or ANSI 87 N within a short period of time;**
- **In case of main switchboards with coupler circuit-breakers the coupler circuit-breaker should be opened by the tripping on faults ANSI 59N in order to restrict the effects of the fault (e.g. also a blackout) to one side;**
- **If the earth fault cannot be localised all generators being switched on must be disconnected by means of protection function ANSI59N to protect the earthing resistances etc.**

2.2.3 Voltage Displacement (59 N)

The displacement voltage as the sum of the three phase-to-earth voltages is used to acquire earth faults. In the undisturbed operation it is equal to zero. For this purpose, voltage transformers in an open delta connection are evaluated.

This, however, does not lead to any indication of the fault location. An earth fault must be located by measuring zero phase-sequence currents.

For the measurement of the displacement voltage a special auxiliary winding of the voltage transformers is used. It is to be dimensioned such that with a nominal voltage on the primary side and with full displacement is supplies a voltage of 100 V.

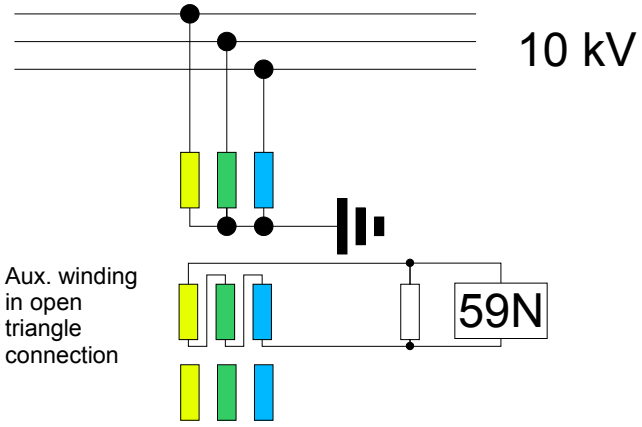


Fig. 2-4 Circuit of the Auxiliary Winding for the Displacement Protection

Adjustable Parameters:

Operating value [Par. 51]:	0% ... 120% * U_N
Delay [Par. 52]:	0 s ... 2400 s
Function, preset [Par. 126]:	Not active (function code $00)

Pre-alarm, Warning:

Operating value [Par. 53]:	0% ... 120% * U_N
Delay [Par. 54]:	0 s ... 2400 s
Function, preset [Par. 127]:	Not active (function code $00)

2.2.4 Earth-fault Current (ANSI 50N, 87N)

The earth-fault current is the sum of the three phase currents and can be determined by means of a toroidal-core current transformer comprising all three conductors.

In most of the systems the earth-fault current is artificially increased by connecting resistors to the generator star points against earth and against the ship's hull respectively or, as an alternative, by connecting an earthing transformer. The otherwise purely capacitive current I_E thus obtains an active component having a positive influence on a possible arc at the fault location. The acquisition is also made easier by increasing the earth-fault current.

Due to the fact that a current is flowing through the toroidal-core current transformer in case of internal faults but also in case of external faults another criterion is to be used to localise the fault location. For this purpose the residual active current flowing through the transformer in any case is evaluated by means of the directional (wattmetric) overcurrent-time protection (57N).

But in many cases the wattmetric evaluation of direction is unprecise such that the application of a differential protection for the zero phase-sequence system (87N) is recommended. In doing so, the residual active current flowing through the generator only is not considered such that exclusively an earth-fault current is determined.

Adjustable Parameters:

Operating value [Par. 47]:	0 ... 5000 * 0,01 A
Delay [Par. 48]:	0 s ... 2400 s
Function, preset [Par. 124]:	Not active (function code $00)

Pre-alarm, Warning:

Operating value [Par. 49]:	0 ... 5000 * 0,01 A
Delay [Par. 50]:	0 s ... 2400 s
Function, preset [Par. 125]:	Not active (function code $00)

2.3 Control and Monitoring Functions

In addition to the protection functions the GPM500 performs control and monitoring functions which are used during operation as automated power supply (APS) and in the automated mode:

2.3.1 Blackout Automatic Feature (Mains Monitor)

In case of a failure of the busbar voltage and closing of the blackout contact the DG set with the highest priority is started by the blackout automatic feature after a parameterisable delay time. The resulting priority is calculated by each generator GPM from the device number (lowest influence), the operating hours and parameter 197 to be manually set, the priority digit (0..12) (highest influence).

When minimum voltage and minimum frequency have been reached, switching-on is released and the circuit-breaker is closed.

The DG sets for which the

– Automatic mode has been selected
– Readiness for start is available (DG set is ready for operation, GPM500 does not have any non-acknowledged faults etc., the detailed conditions are described in the user manual)

are available to the mains monitor.

A start passing-on in case of fault can be parameterised.

NOTE:
In addition to the voltage failure a second criterion must be used for the blackout. For this purpose, a blackout contact being generated from the circuit-breaker positions is to be connected to DI8 of DIO500#2.

Settings:

Delay [Par. 190]:	0 ... 999 * 0.1s
Activation [Par. 189, Bit 0]:	0=not active, 1= active (presetting)

2.3.2 Automatic Synchronising

If there has not occurred any blackout, an automatic synchronising process is initiated for the DG set having been started according to priority prior to switching-on. Actuating signals are transferred to the corresponding speed controller until net voltage and generator voltage are synchronous.

In doing so, the following criteria are checked:

– Voltage difference (r.m.s. values)
– Frequency difference
– Phase angle (distance of the voltage zeroes)
– R.m.s. value of the levitation voltage

The latter representing a redundant but independently computed criterion. It additionally takes into account the deviations of the waveform.

In addition, reaching of minimum voltage and minimum frequency of the generator voltage is checked (switch-on release).

If all above-mentioned criteria are fulfilled, the generator circuit-breaker is automatically switched on.

NOTE:
For consumers the automatic synchronising and blackout start usually are to be switched off by the corresponding parameterisation!

2.3.3 Start Failure

If, after a start command, there is no switch-on release within the parameterised time due to an insufficient voltage or frequency, the starting process is aborted and a start failure alarm is output.

It is recommended to parameterise the start passing-on as a wise reaction to a “Start failure” in order to start another DG set.

Further GPM reactions can be parameterised via the function codes, too.

Adjustable Parameters:

Monitoring time [Par. 83]:	0 s ... 3600 s
Function, preset [Par. 143, lower byte]:	Alarm, circuit-breaker tripping, local acknowledgement required, start passing-on blocking until acknowledgement (function code $63)

2.3.3.1 Start Attempts (ANSI 66)

During the start of a DG set the protective equipment carries out the specified number of start / switch-on attempts within the period of time being defined for the start failure (see section 2.3.3).

If several generators are available, then it is recommended to pass the start command on to another generator already after one unsuccessful start attempt in order to save time

For emergency generators three attempts should be parameterised.

It is also possible to limit the number of starts for each time unit. This is usually done with motors and filter banks to avoid any damage being caused by heating up due to the inrush currents. The number of starts being still possible is displayed on input side 1 below touch button "Start": "< x"! After each start the number of the admissible starts is reduced by 1. After completion of the specified time unit the number of the admissible starts is increased by 1 again.

Adjustable Parameters:

Start attempts [141, upper byte]:	$00 ... $FF Presetting: 5
Time unit [Par. 142, upper byte]:	Hexadecimal in minutes Presetting: $0C (10 min.)

2.3.3.2 Start Passing-on / Relay

In case of critical DG set failures which do not lead to the immediate shutdown, the passing-on of the start command to the next DG set can be parameterised by activating function code SWG. The DG set concerned is stopped following the connection of the started DG set.

2.3.3.3 Protective Start Blocking

Tripping on faults due to an overcurrent can be blocked for a certain time by means of this function. This is relevant especially for asynchronous motors with high starting currents. The current-related protection functions become active only after completion of the set time after closing of the circuit-breaker. The time can be parameterised in steps of 0.1s.

Adjustable Parameters:

Blocking time (=value*0.1s) [Par. 100]:	0*0,1 s ... 300*0,1 s
Preset time [Par. 100]:	0 s

2.3.3.4 Synchronising Failures

If switching-on does not take place within the adjusted time after a start command and synchronisation release due to a lack of synchronisation, then the synchronising process is aborted and a synchronising failure alarm is output. Further GPM reactions can be parameterised.

The synchronisation release / blackout switch-on release require the following:

- The r.m.s value of the phase-to-phase voltage of voltage system 1 to be switched on (e.g. generator) is greater than the release value (parameter 185);
- $f_{gen} > U_{release}/U_{nominal} * f_{nominal;}$
- Start flag (if synchronising mode = 1 "MAN") ;
- Synchronising mode = 1 "MAN" or synchronising mode = 2 "AUT" parameterised;
- The busbar earth electrode is open (DIO500#2:DI7 set);
- There is no tripping on faults.

For a blackout start DIO500#2:DI8 must be additionally set.

As an appropriate reaction to a synchronising failure the start passing-on to another DG set can be parameterised. The output of a stop command is not necessarily wise because the operator might have the intention to manually wind up the circuit-breaker for another attempt. It would then be better to abort the synchronising process only for the time being. The process could then be continued following the acknowledgement of the alarm.

Adjustable Parameters:

Monitoring time [Par. 86]:	0 s ... 240 s
Function, preset [147, lower byte]:	Alarm, circuit-breaker tripping, start passing-on, blocking until acknowledgement (function code $63)
Synchronising mode [147, upper byte]:	Code $01 = manual (display "MAN") Code $02 = automatic (display "AUT")

2.3.3.5 Circuit-breaker Failure

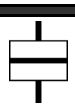
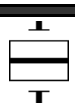
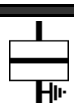
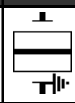
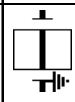
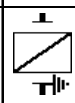
This monitoring unit compares the actual status of the circuit-breaker with the desired status preset by the GPM. If they differ from one another over a fixed short period of time, then the circuit-breaker failure alarm is output.

The following pairs of check-back signals are similarly checked for plausibility (non-equivalence) by means of this protection function if this has been parameterised accordingly:

Message 1	**Input 1**	**Message 2**	**Input 2**	**Message 2 Evaluated, if Register x, Bit y Set**
C.b. closed	DIO500#1:10	C.b. open	DIO500#2:14	Reg.148, bit 10 (”INV”)
C.b. in the disconnected position (withdrawn)	DIO500#2:11	C.b. in the operating position (inserted)	DIO500#2:10	Reg.148, bit 8 (”TRE”)
Earthing disconnector closed	DIO500#2:12	Earthing disconnector open	DIO500#2:13	Reg.148, bit 9 (”ERD”)
Control of the trip coil	SLE500A:7,8	Input, open circuit of the trip coil	SLE500A:14	Reg.148, bit 11 (”COIL”)
Specified position of the c.b.	Internal, as per command	C.b. closed	DIO500#1:10	Always active
Specified position of the c.b. winding-up	Set, always wound up	C.b. ready	DIO500#2:9	Always active

A circuit-breaker failure is initiated, if for one pair either none or both check-back signals are set within a specified period of time (e.g. 120s for disconnected / operating position).

On the display of the protective equipment the conditions are graphically displayed as follows:

NO CONNECTION									
FIXED CONNECTION									X
POSITION FAILURE DISC./EARTH.					X	X	X	X	-
EARTHED			X	X			X	X	-
DISCONNECTED		X		X		X		X	-
OFF									
ON									
UNDEFINED									
TRIPPED									

Moreover, the failure is initiated, if the circuit-breaker signals not wound up / ready in the ON condition. Attention is to be paid to the fact that the GPM500 does not output any special command to wind up a circuit-breaker. It is taken for granted that the circuit-breaker automatically winds up after switching.

NOTE:
There is performed neither a blackout start nor a synchronisation if the circuit-breaker has not been wound up.

The condition is monitored and visualised on the start page.

Condition	Display	Remark
Spring wound, circuit-breaker ready		DIO500#2:9 set
Spring relieved, circuit-breaker not ready	FLASHING 	DIO500#2:9 open

Adjustable Parametersr:

Function, preset [Par. 148]:	Exclusively alarm (function code $01)

2.3.3.6 Stop Failure

If switching-off does not occur within the adjusted time after a stop command or if, with an open circuit-breaker, the voltage value exceeds 10%, then a “stop failure” alarm is output. The GPM reactions must be adapted to the application by parameterisation.

Adjustable Parameters:

Monitoring time	0 s ... 3600 s
Function, preset [Par. 144, lower byte]:	Exclusively alarm (function code $01)

2.3.4 Diesel Failure / Emergency OFF

In case of a diesel failure or in case of emergency OFF switching-off or other reactions being set via the function codes can be initiated by means of this protection. If e.g. switching-off is parameterised, then a second switch-off path for an emergency OFF / emergency stop with subsequent switching-off of the Diesel / auxiliary systems can be realised.

The function is tripped upon activation of input DI8 on module DIO500#1. This input can be monitored for an open circuit by means of DI4 with the corresponding jumpering.

Adjustable Parameters:

Diesel failure / emergency OFF function preset [Par. 158]:	Alarm, circuit-breaker tripping, de-excitation, stop of the diesel-generator set, blocking until acknowledgement (function code $4F)
Open circuit diesel failure / emergency OFF function, preset [Par. 136]:	Exclusively alarm (function code $01)

2.3.5 Frequency Control

The frequency is controlled to the nominal frequency. Like the other nominal data the value of the nominal frequency is entered as parameter in the BAT500.

2.4 Power Management Functions

In addition to the protection functions the GPM500, in its basic configuration, offers some important power management functions which are described in the further course.

For this purpose, first of all some fundamental terms, definitions and structures are explained in the following:

2.4.1 Fundamental Terms

Net:
The power management functions always exclusively refer to the limited range of a net or subnet. A net is a section being limited by opened switching devices. Each net has an unequivocal net number.

Subnet:
A subnet is a net section being limited by opened switching devices.

Busbar:
This term refers to a section between switching devices. In this sense a transformer with primary and secondary circuit-breaker is a ”busbar”, too.

Net Number:
The net number is dynamically determined depending on the positions of the generator circuit-breakers, coupler circuit-breakers and transfer line circuit-breakers. It is permanently shown on page 2 of the BAT500 for checking purposes. To each net / subnet an unequivocal net number is assigned in the power management system (PMS).

The net number is determined according to the following rules:

– The net number is the lowest device number each of the generators which can be connected to the net. Sometimes they are even switched off.
– Each device has got a net number.
– The number is transmitted to the neighbouring busbar by closed coupler circuit-breakers and transfer line circuit-breakers only.
– Open coupler circuit-breakers and transfer line circuit-breakers have got the net number of the side with the three-phase voltage acquisition.
– Closed ring nets are, as standard, excluded but can be realised upon request, if need be.

The following representation shows the formation of the net numbers in a system with three busbars.

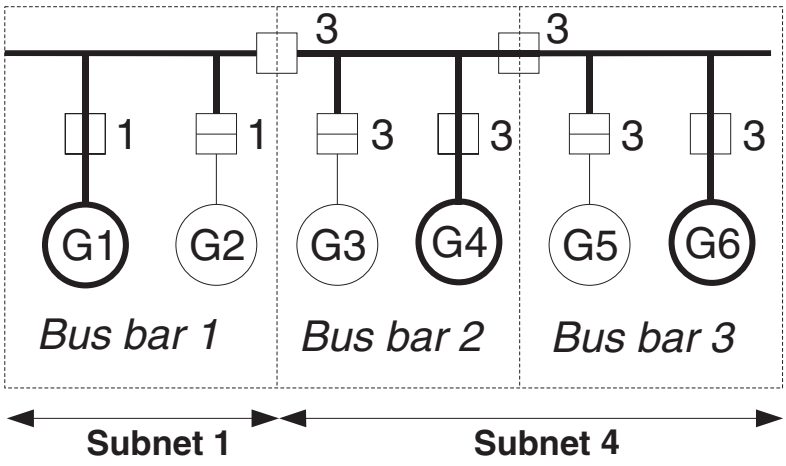


Fig. 2-5 Relation between Generator, Busbar and Net Numbers

The power management functions in detail are:

2.4.2 Power Control

A load sharing takes place between all generators of one net number. Balancing is realised by the GPM500 communication via the redundant CAN bus (GPM bus).

The powercontrol offers the following functions:

– Symmetrical load sharing for diesel generators
– Asymmetrical load sharing for shaft generators and turbine-driven generators (with minimum power for diesel generators)
– Unloading of the generator prior to shutdown plus the additional dieseling.

In the event of an asymmetrical powersharing the following protective restrictions are ensured by the GPM500:

– No underload or reverse power of the other DG sets
– No inadmissible frequency increase in stand-alone operation (e.g. in case of maloperations).

Power can be individually preset for each GPM500. The load sharing is controlled by the GPM500 accordingly.

The presetting can be changed on the BAT500. The power can also be preset by an external system (e.g. automation system, IAMCS) via the Modbus.

For power distribution purposes the GPM500 transfers actuating signals via the GOV500 module to the speed controller of the DG set.

2.4.3 Topload Function

By means of the topload function the DG set can be loaded with a parameterisable percentage of its nominal power, if this is possible by admissibly unloading other DG sets.

This operating mode can be selected by means of button “Topload” on the start page of the BAT and / or via the Modbus from a superior control system.

2.5 Optional Power Management Functions

As an option with additional I/O modules the GPM500 makes available the important function of the load monitor.

2.5.1 Load Monitor Functions

The load monitor has the following main functions:

– Load dependent Diesel start / stop
– Switching-on of big consumers after making available a sufficient power reserve.

The load monitor function is not performed by one device only but it is rather distributed among all GPM500 systems being interconnected via the GPM bus (two redundant CAN busses).

This basic functionality is provided for in each GPM500.

The distributed load monitor additionally has the following subfunctions being available in the different devices several times. They are explained here in their logical order:

– **Calculation of the net number:** Each GPM500 calculates its dynamic net number as described in section 2.4.1. The net number is permanently displayed on the BAT500 for checking purposes.

– **Power reserve demand:** For the consumers being controlled by it each GPM500 signals the required power reserve as the difference between the nominal apparent power (maximum power) and the currently required apparent power. This is independent of whether the consumers are managed in a GPM500 for generator or coupler circuit-breakers or whether the consumer has got its own GPM500. At the same time special operating conditions are preset as e.g. the exclusion of generator stops.

- **Calculation of the power reserve:** On the basis of generator power and nominal power the actual reserve power is calculated and the requested total reserve power is determined by the GPM500 systems.

– **Comparison with power limits:** Each generator GPM500 checks the difference between its actual power reserve and the requested power reserve and checks whether one of its individual start and stop limits has been exceeded. If this is the case, the GPM500 concerned signals the fulfilment of the start and stop criterion respectively to the other generator GPM500 systems.

- **Comparison of the start and stop priorities respectively:** The generator GPM500 systems for which a start or stop criterion is fulfilled, compare the respective priorities. The generator with the highest priority is started or stopped after expiration of the set delay time. Each generator GPM500 computes its resulting individual priority from the device number (lowest influence), the operating hours and the adjustable priority digit (0..12) (highest influence). Attention is to be paid that a low digit leads to a high start priority and to a low stop priority.

The start and stop limits for the individual generators can be differently selected. If generators with different nominal power are available, then the smallest generator each with the aid of which the respective power demand can be covered will be switched on. The start / stop priority determines the order of generators only simultaneously fulfilling the respective criterion. Hence follows that the required reserve power is not given in per cent but always as absolute value in unit kW.

Another consequence is that it cannot be predicted on the basis of the actual start priority which DG set will be really started next. This can be predicted only when the individual fulfilment of the start criterion is signalled by the GPM500 systems concerned. Even in that case it might be possible that another DG set will be started due to another power demand increase.

It is also possible that several generators are started. It is checked whether the apparent power sum of the generators being connected to the net together with the apparent power of the starting generators suffices to fulfil the demands. Generators are started until this condition is fulfilled. Due to the fact that the start delay for all generators takes place in parallel, starting and switching-on might possibly be effected at short intervals.

Switching-on of the consumers will be released only if a sufficient generator power is actually available.

Generators being shut down are not counted any more for the power calculation. Their nominal power is not considered as reserve any more. A DG set is shut down only if the remaining power after the shutdown is sufficient. The relations are shown in the following graph:

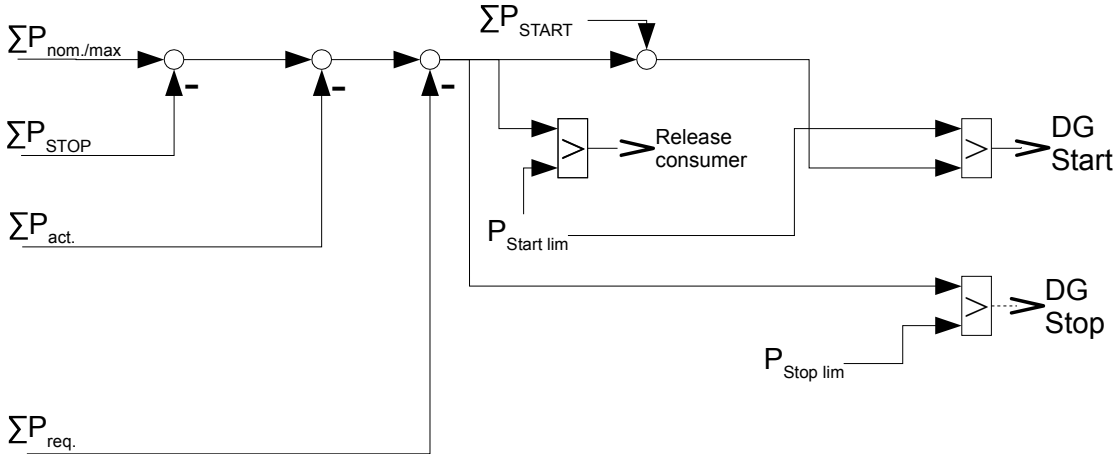


Fig. 2-6 Calculation Scheme of the Load Monitor Functions

Load-dependent Diesel Start

A DG set is started as soon as the sum of the maximum generator power $_P_{nom/max}$ of the generators being connected to the net plus the sum of the maximum power of the generators already starting $_P_{START}$ exceeds the power being currently requested ($_P_{active}$) and the power requested in the future ($_P_{req}$) by less than the minimum reserve $P_{startlim}$. In the GPM500 two different start limits and start delays can be parameterised.

Load-dependent Diesel Stop

In general generators are stopped, if the excess power exceeds a second limit $P_{stoplim}$ following the subtraction of the power of the generator to be shut down.

The detailed sequence for the generator stop is as follows:

1. The GPM500 systems of the generators check whether a stop condition is fulfilled for them after evaluation of power demand and reserve power.
2. From the DG sets with fulfilled stop conditions the one with the lowest start priority (highest priority number) stops.
3. It is checked whether the respective stop condition remains fulfilled when taking into account the nominal power / maximum power of generators being already shut down P_{stop}. If yes, further DG sets are stopped according to their priority.
4. Unloading of the generator and subsequent opening of the circuit-breaker.
5. Running-on phase to cool and to stop the DG set.

2.5.2 Operating Modes

The system knows three operating modes which, if necessary, are to be selected simultaneously:

– “No DG start”: the load monitor does not start any DG sets
(remark: blackout start or start passing on nevertheless take place, if necessary!)
– “No DG stop”: the load monitor does not stop any DG sets
– “Manoeuvre mode”: additional reserve power is made available
(one additional DG set)

These operating modes can, in principle, be selected on every GPM500: This can be effected via the inputs of an optional DIO module or via the Modbus (see section 9.1.3).

The operating mode is applicable to the subnet concerned only.

2.5.3 Selection of the Operating Mode

The operating mode is selected via

1. Digital inputs and outputs or
2. Modbus connection e.g. to an automation system or to a superior PMS system.

The selection of the operating mode need not be possible on every device because the individual inputs are processed in parallel via the GPM bus (OR logic). The selection of e.g. the manoeuvre mode on one device stipulates the manoeuvre mode for all devices of the subnet.

Additional digital inputs and outputs are required for the selection of the operating mode and for each individual big consumer unless the selection is effected via the Modbus.

In total, there are available 4 parameterisable contact assignment variants of the DIO modules for the load monitor. The variant is selected by means of parameter 189, bit 3 and parameter 104, bit 15 (details see section 9.1.3).

2.5.4 Switching-on of Big Consumers

By means of this function it is ensured that a sufficient power is provided when the start of a big consumer has been selected, i.e. DG sets are started, if necessary. It is only when a sufficient reserve power is reached that the start of the selected big consumer is released.

Due to the fact that the load monitor functionality is distributed over several devices, the consumer inputs can be made at several GPM500 systems such that a correct assignment of the consumers to busbar sections can be made.



NOTE:
The load monitor function must have been activated in all GPM500 systems involved. Start and stop commands are generated for the assigned DG set only. Computing is effected in parallel in all devices.

Consumers are switched on according to the following steps:

1. The GPM500 to which the requested switch-on of a big consumer is available, communicates the required power via telegram to the GPM bus. Switching-on is delayed so as to be able to take into account the reactions by the other devices.
2. The total power demand for the subnet is calculated by all GPM500 systems from the power demands in the GPM500 telegrams.
3. In the same way the actual reserve power is calculated by them from the data of the GPM500 telegrams.
4. The GPM500 systems of the generators check whether a start condition is fulfilled for them after evaluation of power demand and reserve power. If this is the case, switching-on of consumers is blocked by them.
5. From the DG sets with fulfilled start conditions the one with the highest priority is started (lowest priority number). (The DG set being shut down is preferred!)
6. It is checked whether the respective start condition remains fulfilled when taking into account the nominal power / maximum power of generators being already started P_{start}. If yes, further DG sets are started according to their priority. The switching-on of consumers remains blocked.
7. If the respective reserve power is sufficient, then there is not fulfilled any start condition in any generator GPM500. In this case the blocking is reset and the switching-on of consumers is released.

2.5.5 Current Acquisition of Big Consumers

There is no current measurement required for consumers requesting the required power reserve directly after switching-on.

In case of consumers, however, making use of a part of the required power only after switching-on, there is caused the problem that the additionally requested reserve is deleted upon switching-on (e.g. with thruster drives). Generators would possibly be shut down again or switching-on of further big consumers would be made possible. If the consumer absorbs even more power then, the net will be overloaded.

To avoid this effect, the actual power consumption can be determined. After switching-on there will be continued to be requested a reserve power amounting to the difference between the maximum and the instantaneous (apparent) power of the consumer. It is only when the maximum power of the consumer is reached that there is not requested any power any more.

The unused current channels each of the DIF500 module are used to acquire the power. A single-phase current measurement each is used. It is thus possible with a GPM500 without differential protection to realise a load monitor with current measurement of up to 6 big consumers. With a GPM500 with differential protection the currents of 3 consumers can be acquired (details see section 9.1.3). The voltage measurement is effected in the generator GPM.

2.5.6 Net Synchronisation

The GPM500 is able to synchronise nets with one another. For this purpose the coupler circuit-breaker GPMs are equipped with synchronising and powercontrollers according to the devices of the generators. For this purpose, the actuating signals are, however, not output at the own device but they are passed on as setpoint frequency by means of a group message, a special CAN telegram, to the two nets involved. All devices involved simultaneously receive the message and generate corresponding actuating signals for the speed controllers of the DG sets. The speed controllers of the DG sets involved should react similarly and the adjusting speed should be adjusted accordingly.

Within the range of a subnet there is possible only one net synchronisation or net separation at the same time because the CAN telegram of high priority being used for this purpose may occur only once.

2.5.7 Net Separation

In case of an intended net separation first of all the net numbers are to be recalculated. The coupling circuit-breaker or transfer line circuit-breaker itself to be switched off assumes net number 249 and thus does no longer play any role in the calculation of the net number. The subnets to the right and to the left of the circuit-breaker automatically receive different net numbers. Consequently, the generators can be supplied with different actuating commands.

A net separation takes place only if there is sufficient power available on one net side.

Within the range of a subnet there is possible only one net synchronisation or net separation at the same time because the CAN telegram of high priority being used for this purpose may occur only once.

2.5.8 Shaft Generator Synchronisation

The GPM500 can also be used for protection and power management purposes for systems with shaft generators (SG). Due to the fact that the frequency of an uncontrolled synchronous shaft generator is determined by the speed of the main engine it cannot be influenced by the assigned GMM500. For this reason, the GPM of the shaft generator must act as master for the frequency control and set the frequency setpoint for the other GPMs of the subnet.



NOTE:
For shaft generators the frequency control is to be de-activated.

2.5.9 Shaft Generator Separation

Switching-off of a shaft generator being ON is controlled by the GPM500 accordingly the other way round. This is carried out by the GPM500, too, if the shaft generator is the sole generator. This takes place as follows:

After the stop command for the shaft generator the GPM500 systems of the DG sets being assigned to the same busbar calculate the remaining reserve power which will be negative. This way the start condition for the DG sets is fulfilled and the DG set with the highest priority is started, synchronised and automatically switched on. Following this, the shaft generator is unloaded and switched off by controlling the DG sets.



NOTE:
With the GPM500 for the shaft generator it is recommended to deactivate the PMS functions because switching on and off should be controlled by the operator.
Attention is to be paid to the fact that in case of an insufficient reserve power further DG sets are started and run in parallel to the shaft generator. To avoid this, a stop signal must be externally output for the shaft generator or for a transfer line circuit-breaker or during operation with shaft generator there must be selected "No DG start" for the PMS.

2.5.10 Shore Connection

For the power management a shore connection is, in principle, treated like a shaft generator.

2.5.11 Connection to a Control System

A superior control system as e.g. a PMS or an automation system can intervene in the load monitor in different ways (register 40029, high byte/ 40050, low byte, see also section 8.1.3):

1. Alteration of the start priority (command $67 "Decrease PRIO", $68 "Increase PRIO",$66 "Set to x"[x in the high byte of the register])
2. Selection of operating mode "No DG stop" (set $70, reset $71)
3. Selection of operating mode "No DG start" (set $70, reset $71)
4. Selection of operating mode "Manoeuvre mode" (set $72, reset $73)
5. Selection of "Topload" (set $6B, reset $6C)
6. Request of additional power reserve ($77, power value in kW).

Contents and function of all registers being available via the Modbus are listed in appendix C.

The selection of the operating mode from the control system is always combined with the hardware contacts via OR function. If "No DG STOP" has been selected via digital input this, however, cannot be cancelled via telegram.

3 Functions of the Individual Modules

GPM500 Power Supply Module NEG500 / Combined Power Supply Module NEG501 + 510 (Identity No.: 271.197 879)

The NEG500 is the standard power supply module for GPM500 systems with fewer extension modules. For higher power demands in case of a larger number of extension modules the combined power supply module NEG501 + 510 and NEG502 respectively is required. The NEG501 module is an NEG500 variant without (5 V) DC/DC converter. The NEG501 module is combined with the NEG510 module being connected in series to make available the 5 V.

The power supply modules perform the following tasks:

– Filtering of the 24 V supply voltage
– Supply of a second (19 V 3-phase) supply voltage
– Monitoring of the 24 V DC and 19 V AC supplies
– Making available of a backed-up 24 V output voltage
– Making available of a regulated 5 V output voltage.

In addition, the NEG module establishes the data connection to the BAT500.

ZKG500 Identity No.: 271.195 020
GPM500 Central Unit

The ZKG500 assembly is the standard microprocessor central unit for GPM500 systems.

With the implemented standard program the ZKG500 performs the following tasks:

– Initialisation of all internal assemblies via the internal system bus
– Acquisition of all data via the internal and external busses
– Evaluation of all data acquired
– Transmission of data and commands to all assemblies being connected.

DIO500 Identity No.: 271.195 021
GPM500 Digital I/O Module

The DIO500 is the standard digital I/O assembly for GPM500 systems.

It consists of the following functional units:

– Two CAN controllers
– 8 digital input channels (isolated)
– 4 digital output channels (relays 250V/8A)
– 3 x 4 light-emitting diodes (LEDs) on the front panel (8 x DI, 4 x DO)

GOV500 Identity No.: 271.195 022
GPM500 Governor Motor Control

The GOV500 is used for the governor motor control and as general I/O module in GPM500 systems.

It consists of the following functional units:

– One CAN bus controller
– 2 digital input channels (isolated)
– 2 digital output channels (relays 250V/8A for the motor control)
– 2 analog outputs (+/-10 V or +/-20 mA)
– 4 light-emitting diodes (LEDs) on the front panel (2 x DI, 2 x DO)

TRV500 Identity No.: 271.195 028
GPM500 Buffer Amplifier for Low-voltage Systems

The purpose of the TRV500 is the isolated voltage acquisition in GPM500 systems for low-voltage systems of up to 450 V.

The TRV500 is equipped with 3 measuring channels which, as standard, are configured as voltage inputs. By using other components (shunt resistors) the TRV500 can also be used for current measuring purposes

or

TRV501 Identity No.: 271.197 911

GPM500 Buffer Amplifier for Medium-voltage Systems

For medium-voltage systems with voltage transformers with an output voltage of 100 V the TRV501 module is to be used. Apart from the voltage adaptation this module corresponds to the TRV500 module

and / or

TRV502 Identity No.: 271.197 912

GPM500 Buffer Amplifier for Earth-fault Detection

The TRV502 module is available to detect displacement voltages and earth-fault currents in medium-voltage systems. If it is installed without TRV501, the jumpering is to be adapted, see section 9.2.5. The module is based on the hardware of the TRV500 module, too.

DCC500 Identity No.: 271.195 029
GPM500 DC/DC Converter

The DCC500 assembly is a DC/DC converter (24 V) for the connection of devices which are to be operated on a floating basis with respect to the 24 V mains.

The DCC500 makes available an isolated 24 V output voltage (relevant when connecting a BAT500).

SLE500A Identity No.: 271.002 439
GPM500 Current and Power Acquisition

The SLE500A assembly is used for the current and power acquisition in GPM500 systems.

This assembly is made up of 2 boards (SLE500A and SLE510) and is accommodated in a Phoenix double housing (ME45).

The SLE500A module converts the analog signals of the analog bus (on the right) into serial data on the internal CAN bus (on the left). The internal CAN bus is used for the purpose of communication between the individual assemblies via CAN and is managed by the ZKG500. The analog bus serves to acquire analog values (currents and voltages) of assemblies TRV500 and DIF500.

The SLE500A can be used for undervoltage tripping and open-circuit tripping. In the latter case the jumpering is to be adapted, see section 9.2.6.

Die SLE500A assembly comprises the following functional units:

– One processor (24 MHz, 512K FLASH, 14K RAM, 1K EEPROM)
– One test and download interface (RS-232 / BGND)
– One isolated CAN bus terminal (internal system bus)
– One isolated CAN bus terminal (external CAN bus)
– One watchdog relay
– 16 internal analog inputs (current and voltage measurement)
– 3 current transformers: 1A nominal current (assigned to 5 of the 16 analog inputs)
– 4 light-emitting diodes (LEDs) on the front panel (Sync, Reserve, Breaker.On, Breaker.Tripped).

The following functional units are arranged on the SLE510A assembly:

– One autonomous overcurrent detection
– One overcurrent relay "Circuit-breaker off"
– One "Circuit-breaker on" relay with separate enable input
– 4 digital inputs (isolated).

The assembly performs the following tasks:

– Acquisition of all analog data (internal and via analog bus)
– Evaluation of all acquired data (current and power calculation)
– Monitoring of the currents and, if necessary, overcurrent shutdown
– Switching on and off of a circuit-breaker via relay
– Communication with the ZKG500 (data exchange).

DIF500 Identity No.: 271.195 032
GPM500 Differential-current Detection

The purpose of the DIF500 assembly is the isolated (differential-) current detection in GPM500 systems.

The DIF500 is equipped with 6 current transformers 1A/20mA. By means of them 6 currents can be measured and two three-phase systems can be compared to one another respectively.

By means of a GPM500 including differential protection a load monitor with the current measurement of up to three big consumers can be realised (without differential protection: up to 6 big consumers).

USS500 Identity No.: 271.195 040
GPM500 Undervoltage Coil Backup

The USS500 module supplies the undervoltage coils of circuit-breakers in case of short voltage dips (e.g. in the event of a short-circuit). The USS500 is designed for the connection of two independent supply voltages (e.g. for the use with coupler circuit-breakers, shore connections etc.).

BAT500 Identity No: 271.188 465
GPM500 Operator Control and Display Panel

The BAT500 is a touch screen panel with a serial data bus according to the CANopen standard.

The BAT500 offers the following information and input possibilities to the operator:

– The overview page with the status indication of the respective circuit-breaker, DG set and generator with the essential measured values as well as the output of commands such as start, stop, selection of the automatic mode etc. including the corresponding check-back signals.
– The measurement pages show the measured values of the respective generator such as currents, voltages and power. In addition, special measured values such as earth-fault currents, displacement voltages and excitation currents are displayed with the aid of additionally involved assemblies.

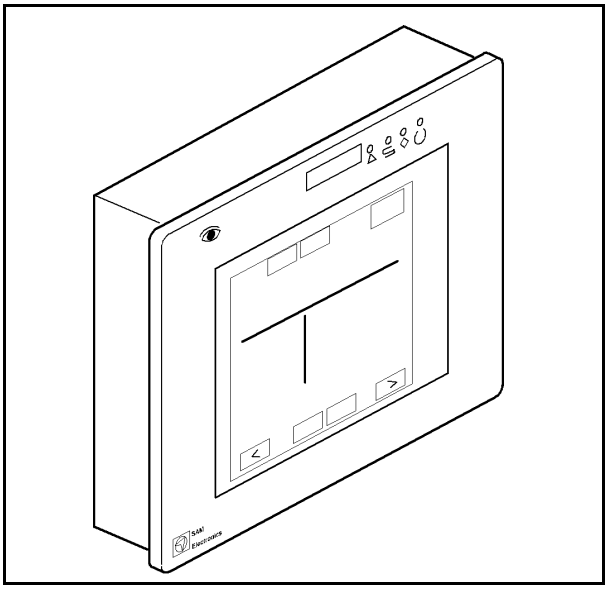


Fig. 3-1 Design of the BAT500

– The adjustment page enables the adjustment of the screen brightness, the selection of the desired operator and display language (English, German, other languages on request) as well as the call of the event list. Moreover, the password is entered here so that parameters can be changed.
– On the parameter pages the parameters of the GPM500 are shown and can be changed (protected by the password). Furthermore, the protection functions can be monitored via the parameter pages.
– On the alarm page faults are displayed in an alarm list. They can be acknowledged there as well as hardwired via contact (push button).

The operator can change between the individual displays by actuating buttons in the (common) lower navigation bar where a group alarm message is displayed, too.

4 Module Selection Table

Function	ANSI Code	DCC500	Komb. NEG501+510	ZKG500	GOV500	DIO500#1	DIO500#2	DIO500#3	DIO500#4	DIO500#5	DIO500#6	DIO500#7	SLE500 A	TRV500 (bis 600V)	bzw. TRV501 (>600V)	TRV502 (>600V)	DIF500	USS500	BAT500	Breadth [mm]	
Basic functions / Standard configuration			1	1	1	1	1						1	1					1	tot.	202,5
incl. following functions:																					
Protection functions, some with pre alarm (*1)																					
Short circuit, Instantaneous over current	50																				
Over current, time delayed (*1)	51																				
Depending over current protection (IDMT) (*1)	51																				
Stator protection	50B																				
Unsymmetrical current/ load (*1)	46																				
Under current/ under load	37																				
Under voltage (*1)	27																				
Over voltage (*1)	59																				
Over frequency (*1)	81H																				
Under frequency (*1)	81L																				
Reverse power protection (*1)	32																				
Excitation supervision, under excitation	40																				
C.b. failure	50BF																				
Trip coil supervision	94																				
Synchronising supervision	25																				
Phase sequence supervision	47																				
Phase failure	47																				
Load shedding 3 steps																					
Blocking after protective trip	86																				
Autom. switch on after protective trip	79																				
Black out start																					
Start failure																					
Stop failure																					
Synchronising failure																					
Watchdog supervision																					
Adaption of trip values for variable frequency		available on request specific to project																			
Consumer protection (contained as standard in standard connection diagram)																					
Inrush current detection	95i																				
Blocked rotor protection	51LR																				
Limitation of start ups per hour	66	available on request specific to project																			
Control and power management functions (contained as standard in standard connection diagram)																					
Automatic Synchronising																					
Load rücknahme vor Absetzen																					
Load sharing																					
Asymmetrical load sharing																					
Internal supervision																					
Software integrity (checksum)																					
Parameter integrity (checksum)																					
Module failure																					
Optional protection functions (contained as option in standard connection diagram)																					
Differential protection	87																1			add.	45
Earthfault protection (HV switchboards)	50N/51N															1				add.	22,5
Directional earthfault protection (HV switchboards	67N/ 87N															1				add.	22,5
Voltage displacement (HV-Switchboards)	59N															1				add.	22,5
Load shedding 5 steps								1													22,5

GPM500 Module Selection Table

Function	ANSI Code	DCC500	Komb. NEG501+510	ZKG500	GOV500	DIO500#1	DIO500#2	DIO500#3	DIO500#4	DIO500#5	DIO500#6	DIO500#7	SLE500 A	TRV500 (bis 600V)	bzw. TRV501 (>600V)	TRV502 (>600V)	DIF500	USS500	BAT500	Breadth [mm]	
Optional Power management functions (included in connection diagram for load monitor)																					
Load monitor depending on connected consumers with following 2 functions and 4 variants:																					
Load dependent diesel start/ stop																					
Load dependent start release for big consumer																					
Load monitor, variant 0 (*2)								1	1	1										add.	67,5
Load monitor, variant 1 (*2)								1	1	1	1									add.	90
Load monitor, variant 2 (*2)								1	1	1	1									add.	90
Load monitor, variant 3 (*2)								1	1	1	1	1								add.	112,5
Load monitor depending on consumer currents with following 2 functions and 4 variants:																					
Load abhängiger Diesel Start/ Stop																					
Load abhängige Startfreigabe für Großverbraucher																					
Load monitor, variant 0 (*2)								1	1	1							1			add.	112,5
Load monitor, variant 1 (*2)								1	1	1	1						1			add.	135
Load monitor, variant 2 (*2)								1	1	1	1						1			add.	135
Load monitor, variant 3 (*2)								1	1	1	1	1					1			add.	157,5
Other options																					
Backup of undervoltage coil																		1		add.	45
Isolated power supply DC24V for BAT500		1																		add.	22,5
(for supply from isolated DC24V nets)																					
Optional with external I/O-moduls																					
Over temperature warning	38/49	available on request specific to project																			
Protection functionen for shore applications																					
Over excitation protection	24	function available on request																			
Vector surge supervision	78	function available on request																			
Undervoltage positive-sequence monitoring		function available on request																			
Mess- und Anzeigewerte auf BAT500, in Basiskonfiguration enthalten																					
Phase currents																					
Phase currents by instrument																					
Phase-to-phase voltage																					
Active and reactive power																					
Active power by instrument																					
Power faktor																					
Frequency																					
Trip activating phase																					
Alarm recording / Event-List																					
Phase angle adjustment acc. vector group																					
Operation hours counter																					
Switching cycle counter		in preparation																			
Trip counter		in preparation																			
Active and reactive energy		function available on request																			
Measuring and indication values (included as option in standard connection diagram)																					
Earth fault current																1				add.	22,5
Measuring and indication values (as additional option)																					
Temperature values		available on request specific to project																			

(*2) variants of load monitor:

variant 0: Selection of operation mode via modbus, 1 add. DIO500-module for start release of 2 big consumers

variant 1: Selection of operation mode by hardware, 1 add. DIO500 module for start release of 2 big consumers

variant 2: Selection of operation mode via modbus, 1 add. DIO500-module for load shedding step 4&5
1 add. DIO500 modul for start release of 2 big consumers

variant 3: Selection of operation mode by hardware, 1 add. DIO500 module for load shedding step 4&5

variant 4: Wahl des Betriebsmodus per Hardware, 1 zus. DIO-Modul für Abwurf unwichtiger Verbraucher 4&5,
1 add. DIO500 modul for start release of 2 big consumers

5 Additional Options

5.1 Central Module ZM 432, Identity No.: 271.182 243

The central module ZM432 is offered as an additional option to realise a redundant Modbus connection. By means of this module it is possible connect either a single GPM500 system or an interconnection of GPM500 systems to one or several external systems (e.g. superior PMS or automation system) in a redundant way. With its 8 RS-485 interfaces it then acts as a Gateway computer (details see section 8.2).

The central module ZM432 is described in a separate documentation which can be obtained on request.

6 Optional Accessories

6.1 Control-power Transformers

6.1.1 Transformer T500, SAM Identity No. 271.197 042

Three-phase Transformer, 400/450 V	
Degree of protection	IP00
Nominal power	65 VA
Frequency	50-60 Hz
Primary voltage	400/450 V
Primary current	0.109-0.096 A
Secondary voltage	150 / 19 V
Secondary current	0.15 / 0.80 A
Vector group	Yyy0
Insulation class	T45/B
Weight	2.0 kg

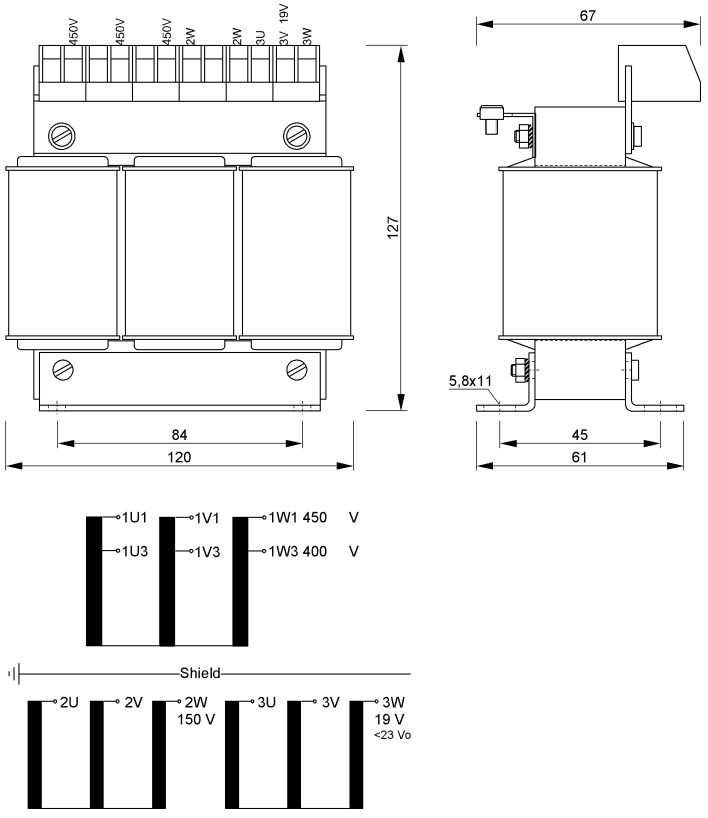


Fig. 6-1 Transformer T500

6.1.2 Transformator T501, SAM-Ident-Nr. 271.197 043

Three-phase Transformer, 690 V	
Degree of protection	IP00
Nominal power	65 VA
Frequency	50-60 Hz
Primary voltage	690 V
Primary current	0.063 A
Secondary voltage	150 / 19 V
Secondary current	0.15 / 0.80 A
Vector group	Yyy0
Insulation class	T45/B
Weight	2.0 kg

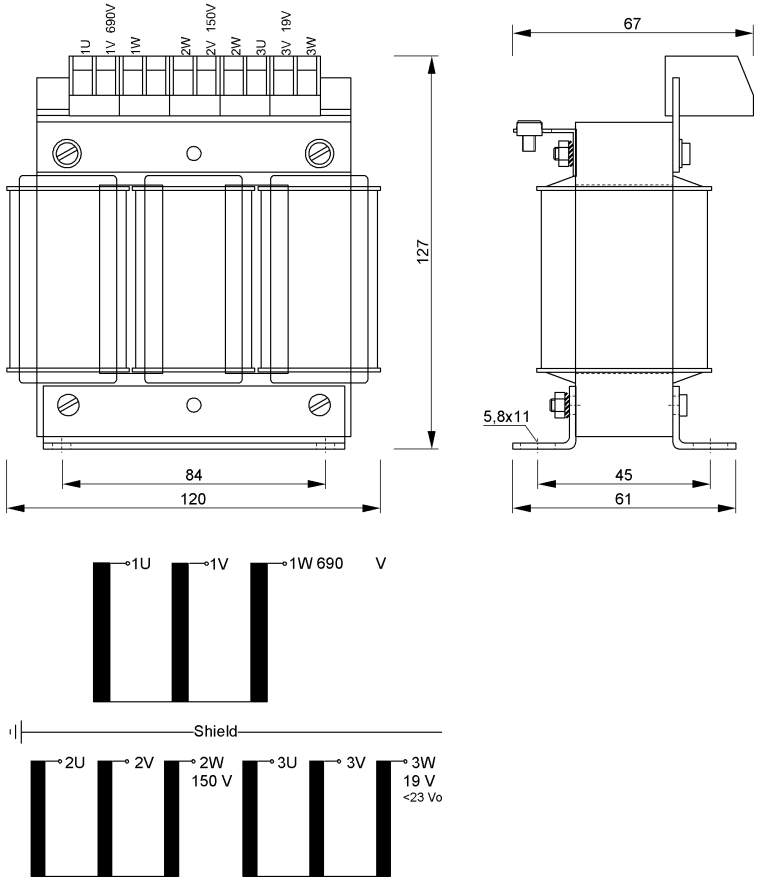


Fig. 6-2 Transformer T501

6.2 CAN Bus Cable for the Connection of the BAT 500, SAM Identity No. 271.188 464

Description	CAN bus cable for the BAT500 including bus termination
Communication	CANopen
Connector BAT-side	9-pole pin-contact strip Sub-D
GPM500-side	Open, no connector
Cable code	CA CANFT
Length	2.5 m

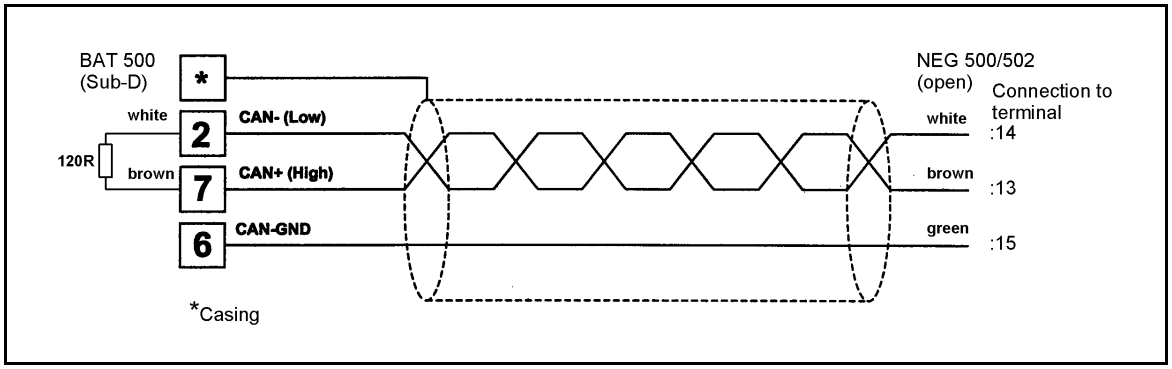


Fig. 6-3 CAN Bus Cable, Connector Pin Assignment

6.3 Adapter for the PC Connection Including Cable, SAM Identity No. 271.188 466

Under this identity No. the adapter for the connection of a PC to the GPM500 including the required cables can be purchased.

The delivery scope comprises the following individual components:

– Converter box USB 2.0 to RS232 TTL 5V, SAM identity No. 271.002 190
– USB cable (A-B), 1.8 m long, standard
– Adapter cable ZKG to USB converter, SAM identity No. 271.002 191

Having established the connection from the USB interface of a PC to the converter box and from there by means of the adapter cable to the 6-pole interface on the module front panel of the ZKG500 module the following functions can be realised with the aid of the software for the GPM:

– Parameterisation
– Programming
– Display of analog and digital data.

The USB multilink BDM adapter (see section 6.4) is required to load the operating system of the ZKG500 module.

6.4 USB Multilink BDM Adapter, SAM Identity No. 271.002 192

The USB multilink BDM adapter is required for the purpose of loading the operating system and for the purpose of real-time debugging via the special BDM interface on the 6-pole interface on the module front panel of the ZKG500 module.

Because of its higher data transmission rate it is also recommended for loading complete projects.

The delivery scope comprises the following individual components:

– USB multilink BDM adapter including cable for the connection to the 6-pole ZKG500 interface
– USB cable (A-B), standard, 1.8 m long
– CD package with the development software.

6.5 Protective Film for the BAT500, SAM Identity No. 271.002 495

This protective film being made of soft PVC can be obtained to protect the BAT500 operator panel from any contamination during operation or commissioning.

During installation the BAT500 is to be inserted through the recess in the protective film first and then into the mounting cutout such that the upper longer part of the film falls down in front of the operator panel.

7 Technical Data

7.1 Mechanical Data / Dimensions

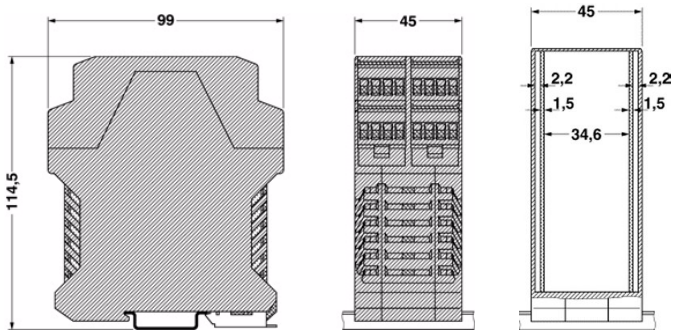
The assemblies are modules which can be mounted on top-hat rails with 16 and 32 terminals respectively (in the form of coded 4-pole plug-in blocks) and a 12-pole plug-in connection to neighbouring modules. The 12-pole plug-in connection comprises the internal CAN bus, the external CAN bus for the connection of the BAT500 and contacts for the control voltages.

There are two module sizes with different casing dimensions:

Casing 45

Dimensions (W x H x D):

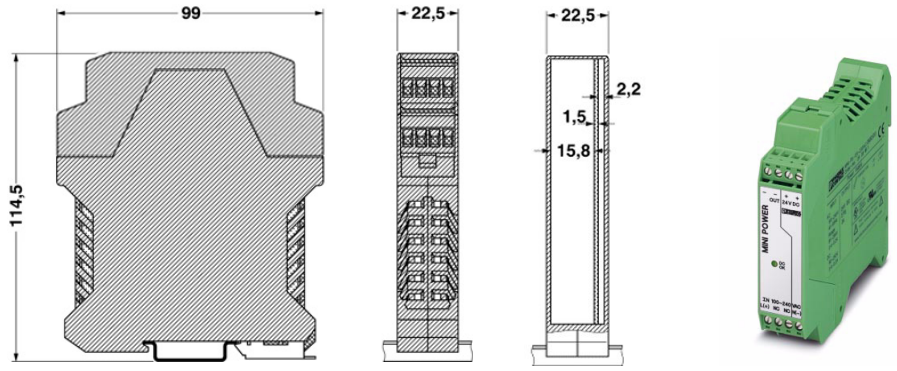
45 x 100 x 115 mm (combined power supply module NEG501+510, SLE500A, DIF500, USS500)



Casing 225

Dimensions (W x H x D):

22.5 x 100 x 115 mm (NEG500, ZKG500, DIO500, DCC500, GOV500, TRV500/501/502)



In the basic configuration for the generator protection there is an overall width of 202.5 mm (combined power supply module NEG501+510, ZKG500, GOV500, DIO500#1, DIO500#2, SLE500A, TRV500).

Due to the fact that modules DCC500 and USS500 are not connected to other modules via plug-in contacts (see survey diagram) they can also be mounted separately. The DCC500 can e.g. be mounted next to the BAT500 on the inside of the door.

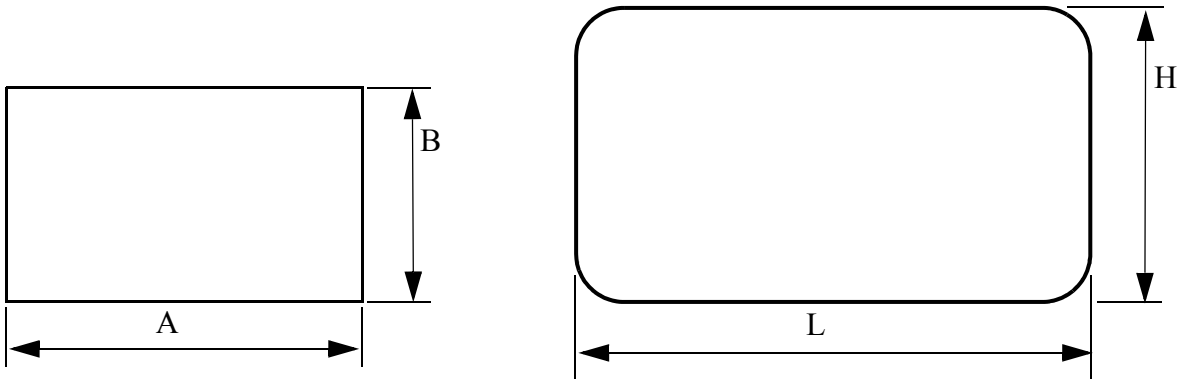
Touch Panel for Door Mounting

BAT500

Monochrome LCD monitor		
Guaranteed minimum service life	50 000 h	
Weight	~ 1,4 kg	
Graphic display	121 x 91 mm	(5.6” diagonal)
Operating temperature	0 bis 50 °C	
Storage temperature	-20 bis +70 °C	
Protection degree IP65	(front panel)	

Frontabmessungen und Ausschnitt:

Screen LxH	187 x 147 mm	7.36 x 5.79“
Cutout AxB	176 x 136 mm	6.93 x 5.35“
Cutout depth	66 mm	2.6”
Max. depth of the mounting plate	5 mm	0.2”



7.2 Electrical Data

7.2.1 Combined Power Supply Module NEG501+510

Input voltage DC:	12-32 V
Input voltage AC:	3AC 19 V
Current input:	12 mA
Output 1:	5 V/1 A (backed-up)
Output 2:	24 V (backed-up)
Output 3:	24 V (not backed-up)

7.2.2 ZKG500

Power supply:	5 V (via internal bus)
Current input:	280 mA
CPU:	24 MHz, 512 Kflash, 14 K RAM, 4K EEPROM
Analog inputs:	3 x 0...10 V
Digital outputs:	1 x optocoupler (24 V/100 mA)

7.2.3 DIO500

Power supply:	5 / 24 V (via internal bus)
Current input (5 V):	40 mA
Digital inputs:	4 / 8 channels with / without wire monitoring Ue=16-32 V; Ie=4-13 mA
Digital outputs:	4 relays (250 V/ 10 A) normally closed contact or normally open contact

7.2.4 GOV500

Power supply:	5 / 24 V (via internal bus)
Current input (5 V):	160 mA
Digital inputs:	2 channels without broken wire monitoring Ue=16-32 V; Ie=4-13 mA
Digital outputs:	2 relays (250 V/ 8 A) "higher/deeper adjustment"
Analog outputs:	2 channels (+/- 10 V or +/- 20 mA) isolated

7.2.5 TRV500

Power supply:	5 V (via internal bus)
Current input:	100 mA
Measuring channels	3 isolated voltage channels
Input voltage range:	600 V r.m.s.
Input resistance:	780 Kohms
Measuring accuracy:	1 %

7.2.6 SLE500A

Power supply:	5 V (via internal bus)
Current input:	150 mA
CPU:	24 MHz, 512 KFlash, 14 K RAM, 4K EEPROM
Analog inputs:	16 internal channels (0...4.75 V)
Current acquisition:	3 internal current transformers, 6 external current transformer connections
Voltage acquisition:	3 connections via analog bus, 2 connections via terminals
Digital inputs:	4 channels isolated (Ue=16-32 V)
Digital outputs:	2 relays for circuit-breaker "ON/OFF"

7.2.7 DIF500

Measuring channels:	6 times current transformer 50:1
Input current range:	1 A (up to 10 A for a short time)

7.2.8 USS500

Input voltage:	2 x 150 V three-phase alternating current
Output voltage:	200 V

7.2.9 BAT500

Power supply:	18 - 30 V DC
Max. energy consumption	600 mA with 24 V DC
Resolution	320 x 240 pixels
Data transfer rate	9600 - 38400 bits
Interface	RS-485
Memory	32 KB

8 Bus Connection to other Systems

8.1 RS-485 Interface with Modbus Protocol

8.1.1 Physical Data

The GPM500 provides an RS485 interface for the purpose of communicating with external systems as e.g. superior power management systems or automation and control systems.

The RS-485 interface is a bidirectional bus system and can serve up to 32 users. The RS-485 interface for the GPM500 is designed as a 2-wire system.

One master and one or several slaves are connected to this serial bus. The communication between master and slave is controlled exclusively by the master. Every GPM500 being connected always acts as slave. The slaves may send only if they have been addressed by the master in advance. Slaves send back to the master only, never to another slave.

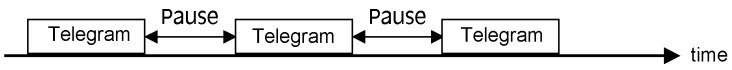
Due to the fact that several transmitters are working on a joint line, it is ensured by means of a protocol that there is only one transmitter active at a time. All other transmitters are in a high-resistance condition at this time.

The RS485 interface of the GPM500 has the following standard settings:

Baud rate	19200 bauds
Bits	8
Parity	None
Stop bits	1

8.1.2 Telegram Timing

The individual telegrams are separated from each other by transmission breaks:



The duration of the transmission breaks for the separation of telegrams depends on the set baud rate and is 3.5 * word transfer time (11 bits). As a consequence, with 9600 bauds at least 4 ms and with 19200 bauds at least 2 ms must go by between two telegrams.

Address	Command	Data	check sum	
1 Byte	1 Byte	0 - 100 byte	CRC Low	CRC High

8.1.3 Interface Protocol Modbus RTU

The protocol used is Modbus RTU in accordance with specifications by Modicon. In general, it is designed for master-slave applications. The master communicates with one or several slaves and the slave becomes active only if it is addressed by the master.

With respect to the Modbus connection of the GPM500 the external system must act as master because for receiving and transmitting data the GPM500 exclusively supports the Modbus slave protocol. The external system must send inquiries to the connected GPM500 systems via the Modbus to receive the actual data (e.g. measured values such as current and voltage).

The GPM500 accepts and replies to external inquiries by means of the following function codes:

– F03: Reading of registers
– F06: Writing of a register
– F16: Pre-assignment / writing of one or several registers.

During planning and design of the system it must be taken into account that the master can overwrite all registers in the allowed area. For this reason the master access is allowed for a mirrored register area only. The original process data are not accessible via Modbus.

The registers in detail are listed in the Modbus register table in the appendix.

Addressing

Digital inputs and outputs can be addressed as bits being packed in registers.

It's only the registers from 40001 to 40300 inclusive which are available to an external system for a read or write access. Most of the write accesses will not have any effect because the register area being enabled is a mirrored area only being overwritten by the GPM500 itself again and again.

Write access is useful for reg. 50 as the command register and for reg. 49 as command extension register. Moreover, parameters can be modified by changing registers 101 to 301.

MODBUS register No. 40001 includes a wildcard. According to the MODBUS conventions it is addressed as follows:

Field name	Datum (hex)
Slave address	xx
Function	03
Start address Hi	00
Start address Lo	00
Number of digits Hi	00
Number of digits Lo	01
Failure check CRC	xxxx

MODBUS register 1 is addressed with the aid of the start address 0000(hex)!

According to the “Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev. J” the registers are addressed starting with zero: Registers 1-16 are thus addressed as 0-15.

Register 40001 is addressed as register 0000 in the data address area of the message. The function code already specifies a register operation. For this reason, reference ‘4XXXX’ is implied.

Operating Data

Operating data are filed in register 40002 to 15. Analog signals are stored in the area from 40002 to 12 and digital information is stored in the area from 40013 to 15.

Alarm Data

Alarm data can be found in reg. 40016 to 23. The following scheme is used:

– Reg. 40016, bit 0: Alarm 1 (short-circuit 1) is ACTIVE
– Reg. 40016, bit 1: Alarm 1 (short-circuit 1) is UNACKNOWLEDGED
– Reg. 40016, bit 2: Alarm 2 (short-circuit 2) is ACTIVE
– Reg. 40016, bit 3: Alarm 2 (short-circuit 2) is UNACKNOWLEDGED
– .....

Command

Commands can be written into register 40029 with the following codes. The command extension should be zero when it is not used.

Command	**Address Hex. (High Byte Reg.40029) / Command Hex. (Low Byte Reg. 40050)**	**Extension (Reg. 40028)**	**Remark**
START	$0069	$0000	Switch-on command for non-starting machines such as transformers or for generator sets being started by external systems.
STOP	$006A	$0000	Switch-off command for non-starting machines such as transformers or for generator sets being started by external systems.
Set PRIO	$xx66	$0000	Sets the priority to xx
Decrease PRIO	$0067	$0000	Decreases the priority by one
Increase PRIO	$0068	$0000	Increases the priority by one
Toggle TOPLOAD	$0074	$0000	Ändert Lastverteilungsmodus
Activate TOPLOAD	$006B	$0000	Activates the TOPLOAD mode
De-activate TOPLOAD	$006C	$0000	De-activates the TOPLOAD mode

Activate NO DG STOP	$0070	$0000	Activates operating mode NO DG STOP for this subnet
De-activate NO DG STOP	$0071		Finishes operating mode NO DG STOP, this mode could, however, remain activated because this is requested by other users.
Activate NO DG START	$006E	$0000	Activates operating mode NO DG START for this subnet
De-activate NO DG START	$006F		Finishes operating mode NO DG START, this mode could, however, remain activated because this is requested by other users.
Set MANOEUVRE MODE	$0072	$0000	Activates the manoeuvre mode for this subnet
DE-ACTIVATE THE MANOEUVRE MODE	$0073	$0000	Finishes the manoeuvre mode, this mode could, however, remain activated because this is requested by other users.
ALARM xx ACKNOWLEDGEMENT	$xx6D	$0000	Acknowledges individual alarm **xx from externally**
PRESETTING OF THE RESERVE POWER	$0077	Leistung in kW	Requests additional reserve power
PRESETTING OF THE MAX POWER	$0078	Leistung in 0.1 %	Limitation to the max. power (chief limitation)
PRESETTING OF THE TOPLOAD POWER	$0079	Leistung in 0.1 %	Sets the power for the topload function

It must be ensured that the ALARM ACKNOWLEDGEMENT is used only if the alarm is displayed on the external system, too.

Parameters

Parameters are stored in EEPROM registers and are not available for the external access via Modbus.

8.2 Redundant Modbus Connection (Optional on Request)

When using the standard solution the GPM500 systems are connected to one external system by one Modbus by means of a point-to-point connection.

On request it is optionally possible to realise a redundant Modbus connection of either a single GPM500 or an interconnection of GPM500 systems to one or several external systems with the aid of two additional Gateway computers. For this purpose, two ZM432 modules with eight RS485 interfaces each are used by preference, to which up to eight external systems can be connected. The interconnection can comprise a maximum of 63 GPM systems which are all interconnected via the GPM bus.

These two ZM432 modules being equipped with the software for the redundant Modbus connection are working as “Gateway computer“ each between the redundant GPM bus system with connected “Target GPM“ and the Modbus to the superior external systems (“Hosts“). In this connection the hosts must work as Modbus master.

The Gateway computer listens on the redundant GPM bus, i.e. CAN bus 1 and 2 respectively and stores the data of up to 63 GPMs in a register field. The host computer accesses these registers via the RS485 Modbus interface.

A command from the host is transmitted to the Gateway computer using an F16 protocol. There it is converted into a CAN telegram and passed on to the target GPM to be addressed. The target GPM sends an acknowledgement on the CAN bus. This acknowledgement is filed in the Gateway computer in a status register (for each system). The host can read out these registers cyclically.

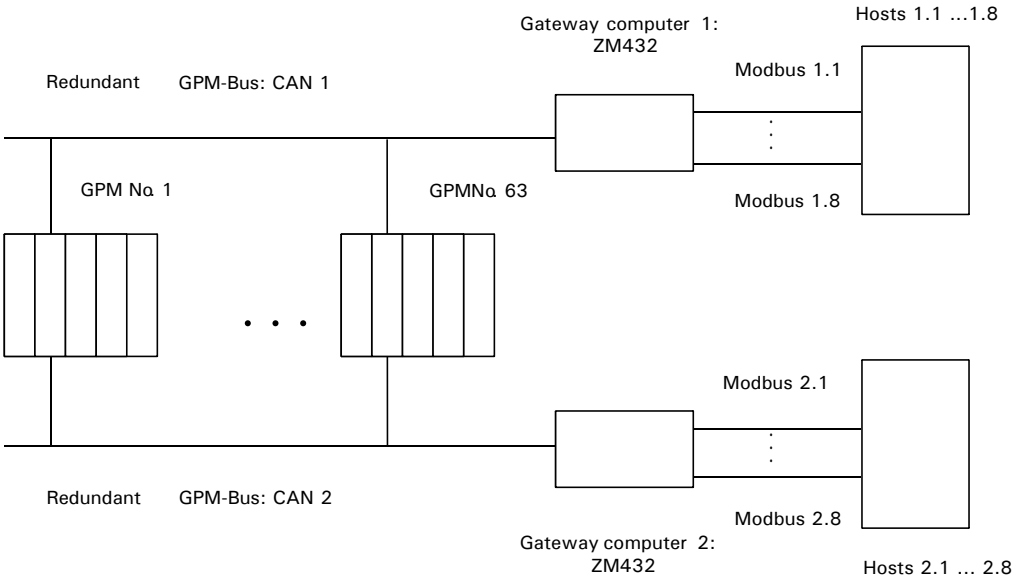


Fig. 8-1 Schematic Sketch of a Redundant Modbus Connection with ZM432

8.3 CANopen Interface

As standard the BAT500 operator control and display panel is connected to the CANopen interface (CAN4). This interface complies with the CANopen standard.

It is definitely possible to connect even further external devices to this interface on request. This, however, requires a detailed coordination with SAM Electronics because the device profiles used are to be agreed upon.

9 Electrical Integration in Switchboards

9.1 Electrical Interfaces and Functions

All interfaces, input and output signals of the generator protection module can be seen from the survey diagrams (Annex A). In the following their functions and special features are explained in detail.

9.1.1 Power Supplies

There are two power supply possibilities for the GPM500: A d.c. power supply DC24 V and a three-phase a.c. power supply 3 AC 19 V. Both are connected to the NEG module. In doing so, the following is to be taken into account:



NOTE:
When using the GPM500 as low-voltage generator protection it is recommended to realise the three-phase device supply and the supply of the undervoltage coil on the switchboard side from the generator voltage via a three-phase transformer with two secondary windings. For the three-phase supply it is urgently recommended to use a transformer T500 or T501 being offered as accessories.

Transformers T500 for generator voltages of 400 and 450 V and T501 for a generator voltage of 690 V have been designed especially for the GPM (see section 6.1).

When using other transformers it is to be made sure that the screen winding is earthed!

THREE-PHASE DEVICE SUPPLY
(NEG500: 5,6,7 and NEG501 Respectively of the Combined Power Supply Module: 5,6,7)

Input voltage: 3 AC 19 V
Current demand:Typically up to 0.8 A, max. 1 A

UNDERVOLTAGE COIL SUPPLY 1
(USS500: 14,15,16) and

UNDERVOLTAGE COIL SUPPLY 2
(USS500: 10,11,12)

Input voltage: 3 AC 150 V
Current demand:Approx. 0.1 A for undervoltage coil 220 V DC, 20 W

When using transformers T500 and T501 respectively the following approximate values are obtained in the three-phase circuit: The primary current demand depends on the number of modules used, too.

Current demand primary:Max. 0.1 A
Recommended back-up fuse: F 2 A

DC DEVICE SUPPLY 24 V
(NEG500: 1/2, 3/4 and NEG501 Respectively of the Combined Power Supply Module: 1/2, 3/4)

With the additional 24 V d.c. supply the device supply can be backed up via a 24 V d.c. supply (e.g. an automation battery). This back-up is recommended and it is absolutely necessary if the blackout start function is to be covered.

An exclusive 24 V supply is possible, too (mainly for medium-voltage systems). In this case, however, in most cases a redundant supply of 24 V d.c. is required.

A redundant d.c. voltage supply is realised by the following connection:

REDUNDANT DC DEVICE SUPPLY +24 V:
NEG500 and NEG501 Respectively of the Combined Power Supply Module: 5&6&7

REDUNDANT DC DEVICE SUPPLY 0 V:
NEG500 and NEG501 Respectively of the Combined Power Supply Module: 3&4

The current demand depends on the extension level, i.e. on the number of modules used.

Current demand: Max. 2 A
Recommended back-up fuse:F 6.3 A

SUPPLY FOR DIGITAL INPUTS +24 V:
NEG500 and NEG501 Respectively of the Combined Power Supply Module: 5&6&7

The supply of the digital inputs of all DIO500 modules should be effected via the above-mentioned terminals, because the voltage output is formed from the two redundant device supplies. This way, the voltage is still active even if the external 24 V d.c. supply fails. Moreover, the above-mentioned supply voltage is protected in a short-circuit proof manner by a varistor.

To supply the BAT500 operator control and display panel with isolated 24 V d.c. supplies the DCC500 is to be used for isolation because in case of the BAT500 there is a low-resistance connection between the casing and 0 V.

Feeding-in from the external 24 V d.c. supply is to be effected as follows:

ISOLATED VOLTAGE SUPPLY OF THE OPERATOR PANEL +24 V:
DCC500 :1/2/5/6 (+24 V)

ISOLATED VOLTAGE SUPPLY OF THE OPERATOR PANEL 0 V:
DCC500 :3/4/7/8 (0 V)

It is advantageous to pick off the external supply voltage from the supply of the power supply unit at terminals NEG501 :2 (+24 V) and :4 (0 V).

The isolated supply voltage for the BAT500 is output in a short-circuit-proof manner via the following terminals:

ISOLATED VOLTAGE SUPPLY FOR OPERATOR PANEL +24 V:
DCC500 :11/12 (+24 V, Isolated, Short-circuit-proof)

ISOLATED VOLTAGE SUPPLY FOR OPERATOR PANEL 0 V:
DCC500 :9/10 (0 V, Isolated)

This module is used exclusively for isolation purposes. In case of earthed power systems the BAT500 can also be normally connected to the 24 V d.c. supply voltage of the GPM500.

9.1.2 Digital Inputs

As standard the GPM500 is controlled via 16 digital inputs of the 2 digital I/O modules DIO 500#1 and DIO500#2. They are described in detail with their function in the following, the abbreviated designation of the signal and function respectively identifying the active condition (high, closed contact):

CIRCUIT BREAKER OFF / DIESEL STOP COMMAND:
DIO500#1 :9 (DI1, Pulse Contact)

By means of this signal the switching-off process of the circuit breaker is initiated in the automatic mode and, following this, the DG set concerned and auxiliaries respectively are stopped by setting output DO2 on the first DIO500.

If it is also possible to manually open the circuit breaker (i.e. hard-wired or at the circuit breaker) without the GPM500, then command "CIRCUIT BREAKER OFF" must be additionally given via a second contact level to the GPM500 such that the circuit breaker failure message is suppressed.

Generator: In the automatic mode the generator is unloaded before opening the circuit breaker. Following this, the generator circuit breaker is opened. After the adjusted running-on time a stop command to the DG set is output by activating output DO2 on the first DIO500 module.

A restart either manually or automatically by the load or mains monitor is possible already directly after switching off the generator being in the running-on phase.

In the automatic mode a stop is not carried out if this is not permitted by the power balance. In this case “BLOCKED” is displayed on the BAT below the stop button.

In the manual mode the generator circuit breaker is opened without delay in the event of a pulse on DE1. Attention is, however, to be paid that after setting the stop input in the manual mode the stop contact (DIO500#1:7, 8 DO2) is not activated, i.e. the DG set is not stopped.



Attention:
In the manual mode switching-off takes place immediately without unloading before, even if a blackout is caused this way!

CIRCUIT BREAKER IS ON:
DIO500#1 :10 (DI2, Permanent Contact)

The check-back signal of the circuit breaker is read in by the GPM for display and protection purposes. It is only after closing of the circuit breaker that the underfrequency and undervoltage monitoring is released by the GPM.

In addition, this signal is compared with the commanded setpoint position of the circuit breaker and in case of a deviation a circuit breaker failure alarm is generated.

CIRCUIT BREAKER ON/ START SYNCHRONISING:
DIO500#1 :11 (DI3, Pulse Contact)

Digital input CIRCUIT BREAKER ON/ START SYNCHRONISING (DE3) has the same function as the start command from the BAT500.

Generator*:*

In automatic mode**:** By activating this input the start process is initiated, i.e. start of the DG set by setting output contact DO1=DIO500#1:5,6, synchronisation (if the synchronisation release is available), switching-on of the circuit breaker (if it is ready for closing) and the subsequent connection of load.

In manual mode: After a pulse on DI3 in manual mode the output contact (DIO500#1:5,6 DO1) only is set for 8 seconds to start the DG set. If the complete independence from the GPM500 is desired, its output contact can be made ineffective by external circuit elements and the start must be realised by external contacts.

For safety reasons, in manual mode the following steps, blocking etc. up to switching-on of the circuit breaker are performed independently of the GPM500 and must therefore be realised externally, e.g. by using a synchroniser for synchronising or by a blackout relay. Another example is the use of a voltage relay being operated by the generator voltage in the manual circuit, if switching-on of a generator should be possible after reaching a certain generator voltage only.

It is to be made sure that the manual switch-on circuit is not blocked by the GPM500. The circuit breaker is blocked only in case of an independent tripping on faults via the memory relay in the SLE500A module causing a permanent OFF command to the circuit breaker.

Consumer:

By activating this input the start process is initiated, i.e. start of the auxiliaries by setting output contact DO1=DIO500#1:5,6 and by subsequently switching on the circuit breaker. The switching-on process is carried out only if a sufficient system voltage is available and if the availability is fulfilled.

INTERNALALLY USED:
DIO500#1 :12 (DI4)

This input is reserved for a open-circuit monitoring of the signal for emergency off and DG set failure respectively (DIO500#1, DI8). If the open-circuit monitoring is not used, there must not be connected anything to this terminal.

Further details see_DG SET FAILURE / EMERGENCY OFF: DIO500#1 :16 (DI8, Permanent Contact).

AUTOMATC MODE:
DIO500#1 :13 (DI5, Permanent Contact)

Depending on the parameter setting for the automatic mode, after the circuit breaker ON command an automatic synchronisation is carried out in case of a synchronisation release and switching-on is performed in case of the availability. Switching-on can be parameterised such that it is performed either

– Automatically or
– Manually after the activation of input "CIRCUIT BREAKER ON / START SYNCHRONISING COMMAND" (see parameter 147).

Generator**:** In case of the parameterisation as generator protection the pre-selection "Automatic mode" additionally causes the activation of the PMS functions such as active-power load control and in case of the corresponding parameterisation of the load monitor.

ALARM ACKNOWLEDGEMENT/ RESET:
DIO500#1 :14 (DI6, Pulse Contact)

This input is designed for the connection of an acknowledgement button. All malfunctions occurring are shown on the display and stored in the device. Alarms being active and unacknowledged are emphasised by a flashing ANSI code text.

All alarms are acknowledged by pressing the button being connected to this input. Following the acknowledgement the status of the alarm is altered to acknowledged and the flashing changes into a continuous display.

Alarms being no longer active can be reset by setting DI6. By the reset the corresponding alarm text is deleted and in case of alarms with re-closing lock-out the memory relay of the SLE500A module for blocking is reset.

START RELEASE:
DIO500#1 :15 (DI7, Permanent Contact)

By setting this input, starting and switching-on are released. It is thus possible to realise a start lock-out by a DG set being not ready or by auxiliary systems, if they are not ready.

Resetting of the release contact after the start does not have any effect.

DG SET FAILURE / EMERGENCY OFF: DIO500#1 :16 (DI8, Permanent Contact)

By means of this input with a corresponding parameterisation of the function code a second switching-off path for emergency off / emergency stop with subsequent shutdown of the DG set and of the auxiliary systems respectively can be realised.

Further reactions can be parameterised by function codes (par. 158).

This input can be monitored for an open circuit. This is effected internally via DI4. For this purpose, on module DIO500 the terminals of jumper J14 must be connected as follows: terminal 1 to terminal 2 as well as terminal 3 to terminal 4 (see also section 9.2.2)

With this jumpering the supply voltage for the contact to be monitored is output via DI4 to terminal :12. A resistor of 10 kohms must be connected directly to its terminals in parallel to this contact.

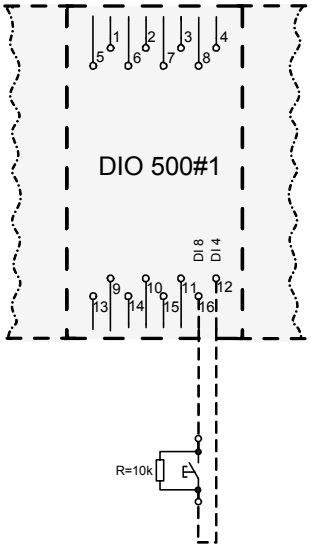


Fig. 9-1 Connection of the Emergency off and Failure Input with Open-circuit Monitoring

CIRCUIT BREAKER IS READY: DIO500#2: 9 (DI1, Permanent Contact)

By setting this input the availability of the circuit breaker (e.g. circuit breaker wound up) is signalled to the GPM.

Setting of the input is a prerequisite for switching-on by the GPM.

CIRCUIT BREAKER IS IN THE SERVICE POSITION: DIO500#2 :10 (DI2, Permanent Contact)

When the circuit breaker has been inserted and, as a consequence, this signal is set and input CIRCUIT BREAKER IS IN THE TEST POSITION is not active, the circuit breaker can be operated in the normal mode including all protection functions.

The service position is displayed on the BAT500 by means of a corresponding symbol.

CIRCUIT BREAKER IS IN THE TEST POSITION:
DIO500#2 :11 (DI3, Permanent Contact)

If, however, this signal is set and input CIRCUIT BREAKER IS IN THE SERVICE POSITION is not active, the circuit breaker can be operated in the testing mode including all protection functions. The test position is displayed on the BAT500 by means of a corresponding symbol.

If none of the above-mentioned signals is set, if e.g. the circuit breaker is being withdrawn or if an open circuit is available, this is displayed by a symbol, too, and a circuit breaker failure alarm is generated in case of the corresponding parameterisation (see par. 148).

EARTHING SWITCH IS CLOSED:
DIO500#2 :12 (DI4, Permanent Contact)

This input exclusively serves to display the position of the earthing switch on the BAT500. Switching-on of the circuit breaker is not additionally blocked by the GPM by this signal because the earthing switch is usually mechanically blocked and can be switched on only if the circuit breaker is switched off and if the disconnector is open.

EARTHING SWITCH IS OPEN:
DIO500#2 :13 (DI5, Permanent Contact)

If, however, with the circuit breaker being switched off this signal is set and input EARTHING SWITCH IS CLOSED is not active, the circuit breaker can be switched on and be normally operated. The position of the earthing switch is displayed on the BAT500 by means of a corresponding symbol.

If none of the above-mentioned signals is set, if e.g. the earthing switch is being closed or if there is an open circuit this is displayed by a symbol, too, and a circuit breaker failure alarm is generated in case of the corresponding parameterisation (see par. 148).

CIRCUIT BREAKER IS OPEN:
DIO500#2 :14 (DI6, Permanent Contact)

This signal is used for the plausibility check of the OFF signal with the ON signal. If the signal does not correspond to the negated ON signal, then it is signalled as being undefined by means of a symbol on the BAT500. Furthermore, this leads to the circuit breaker failure alarm (see par. 148).

BUSBAR EARTHING SWITCH IS OPEN:
DIO500#2 :15 (DI7, Permanent Contact)

This signal is used as closing lock-out with the busbar earthing switch being closed. It must be available with the circuit breaker being switched off such that the circuit breaker can be switched on. This means: If there is no busbar earthing switch available, then the input must be connected to the 24 V potential by means of a fixed jumper.

The earthed position is shown on the BAT500.

BLACKOUT:
DIO500#2 :16 (DI8, Permanent Contact)

Via this input a blackout is additionally signalled to the GPM on a second path.

For a start in case of a blackout this input must be set and there must not be available any busbar voltage.

Tie breaker: For the tie breaker the above-mentioned input must be set, too, such that switching-on of the tie breaker is immediately released by the GPM in case of a missing system voltage.

Consumer: With consumers this input must be connected to the 24 V potential by means of a fixed jumper so as to ensure switching-on.

CURRENT DISPLAY I2/ I3:
GOV500:9,10/ 11,12 (GOV500DI1/ DI2, Permanent Contact)

Herewith the phase current being output via analog output AO2 of the GOV500 module is preselected (for display and for other purposes)

No input set: Display I1

GOV500:DI1 set: Display I2

GOV500:DI2 set: Display I3

BROKEN WIRE MONITORING OF SHUNT TRIP COIL:
SLE500A: 13/14 (SLE500A DI1+24V/ DI Signal)

This input serves the purpose of broken wire monitoring of the entire trip circuit of a shunt trip coil.

For this purpose the 24 V d.c. supply voltage for the trip circuit is applied to terminal :14 and the trip circuit is connected to terminal :13 as follows:

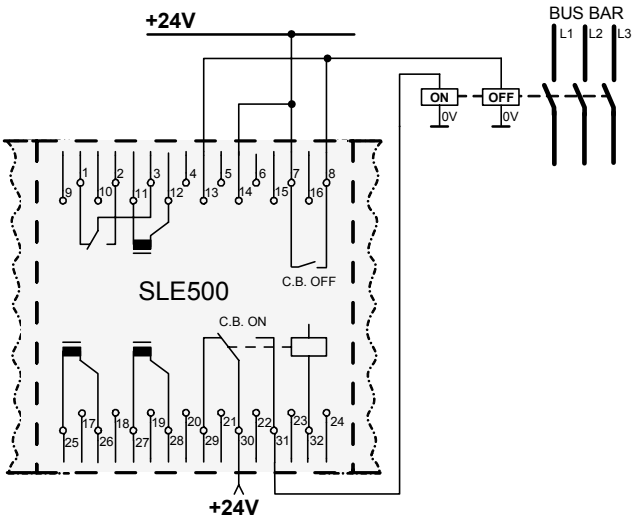


Fig. 9-2 Trip Circuit with Open-circuit Shunt trip coil and Open-circuit Monitoring

The three further digital inputs of the SLE500A module are irrelevant for standard applications.

9.1.3 Optional Digital Inputs for PMS Function “Load Monitor”

For the load monitor function the GPM500 requires digital inputs and outputs for the

– Selection of the operating mode and for
– Individual consumers.

For the inputs permanent contacts are required.

For the selection of the operating mode a separate DIO500 module is used. This module must be made known with the aid of parameter 189, bit 3.

If this bit is set, the contacts of the consumers are displaced to DIO500 of a higher ordinal number. This happens in the same way when using additional modules for load shedding.

In order to achieve a flexible and efficient use of the modules, there are offered 4 different parameterisable variants of the contact assignment of the DIO modules for the load monitor and for the switching-off of further unimportant consumers, too. The operating mode is to be parameterised by means of parameter 189, bit 3 and the mode for unimportant consumers is to be parameterised by par. 104, bit 15.

The four variants are displayed in the following table.

Variant	Unimportant Consumers	Operating Mode	DIO500#3	DIO500#4	DIO500#5	DIO500#6	DIO500#7
0	0	0	Big consumers 1&2	Big consumers 3&4	Big consumers 5&6	----------	----------
1	0	1	Operating mode	Big consumers 1&2	Big consumers 3&4	Big consumers 5&6	----------
2	1	0	Shedding of unimportant consumers of levels 4&5	Big consumers 1&2	Big consumers 3&4	Big consumers 5&6	----------
3	1	1	Shedding of unimportant consumers of levels 4&5	Operating mode	Big consumers 1&2	Big consumers 3&4	Big consumers 5&6

For the DIO500 modules being assigned to the big consumers a specific scheme is to be observed:

– A request contact (pulse contact, DIO500#x:9 DI1 for consumers 1,3 and 5, DIO500#x:11 DI3 for consumers 2,4 and 6) informs the GPM that the apparent power reserve being defined for this consumer is to be requested. By generating this pulse once again the reserve can be released again.

– A check-back contact (Permanent Contact, DIO500#x:10 DI2 for consumers 1,3 and 5, DIO500#x:12 DI4 for consumers 2,4 and 6) informs the GPM that the consumer is switched on.

Shedding of unimportant consumers of levels 4 and 5 is connected to the outputs of DO1 and DO2 of the corresponding DIO module.

The detailed terminal assignment is to be seen from the terminal connection diagrams in Annex A (these additional USP drawings will follow).

9.1.4 Digital Outputs

The GPM500 has digital relay output contacts on modules DIO, GOV and SLE500A.

Suppressor circuits are to be realised by the user. For the damping of a servomotor or of a.c. contactors RC snubber circuits are to be used and for d.c. contactors free-wheeling diodes are to be applied. The damping circuits protect the contacts of the outputs relays and are important to avoid any EMC disturbances.

On central module ZKG500 there is the following digital output:

SWITCH-ON RELEASE INTERNAL:
ZKG500: 16 (Optocoupler, Continuous Signal)

This output is an isolated optocoupler output and its only purpose is to output the switch-on release by the SLE500A module.

It's only when the output at terminal 16 is connected to terminal 32 of the SLE module using an external lead that the relay being described in the following is released and activated to switch the circuit breaker on.

If the jumper is missing, switching-on by the GPM500 is not possible.

CIRCUIT BREAKER ON:
SLE500A: 30,31 (C.B. ON , Pulse Contact 250 V, 12 A)

This pulse contact closes for a minimum of 1 s to activate the closing coil and to switch on the circuit breaker. Following the check-back of signal CIRCUIT BREAKER IS ON (DIO500#1 :10) the contact is reset. If there is no check-back signal then, with the corresponding parameterisation, a circuit breaker failure alarm is generated and the output is reset.

CIRCUIT BREAKER OFF:
SLE500A: 7,8 (C.B. OFF, Pulse Contact 250 V, 8 A)

This contact serves to switch off the circuit breaker. By jumpering the contact can be adapted as closed-circuit contact for an undervoltage release or as open-circuit contact for a shunt trip coil (see section 9.2.6)

If, in the first case, the integrated voltage back-up for undervoltage coils by the USS500 module is omitted, then this contact is directly looped in the undervoltage coil circuit.

When using the USS500 module for the voltage back-up for undervoltage coils terminal 7 of the SLE module is to be connected to terminal 7 of the USS module. In the same way, terminals SLE500A:8 and USS500:6 must be jumpered.

In this case a free-wheeling diode must be used with the undervoltage coil.

The connecting leads should be twisted and be routed separately from the 24 V signal lines.

WATCHDOG/ CYCLE FAILURE:
SLE500A: 1,2 (WDOG, Permanent Contact 24 V, 2 A)

During the normal undisturbed operation the cycle relay (watchdog) has picked up. In the event of a device malfunction or voltage failure this contact drops out.

The two standard DIO500 modules have the following total of 8 relay outputs with a load capability of the contacts of 250 V, 10 A (with a resistive load):

Relays DO1 to DO4 of the first and second DIO500 modules are, as a standard, pre-assigned. All contacts are designed as normally-open contacts.

DIESEL/ AUXILIARY SYSTEM START:
DIO500#1: 5,6 (DO1, Pulse Contact 250 V, 10 A)

Following the start command this output contact is set for 8s to start the corresponding DG set and auxiliary systems respectively (with consumers).

DIESEL/ AUXILIARY SYSTEM STOP:
DIO500#1: 7,8 (DO2, Pulse Contact 250 V, 10 A)

Accordingly, after a stop command this output contact is set for 8s to stop the corresponding DG set and auxiliary systems respectively (with consumers). This, however, is the case in automatic mode only.

In manual mode a stop command does not lead to the actuation of output contact DO2 and thus not to a stop of the DG set / auxiliaries.

CIRCUIT BREAKER TRIPPED:
DIO500#1: 1,2 (D03, Permanent Contact 250 V, 10 A)

An indicator lamp can be connected here to signal tripping on faults. In the undisturbed condition the contact is open.

COMMON ALARM:
DIO500#1 : 3,4 (DO4 , Permanent Contact 250 V, 10 A)

This contact serves to indicate a common alarm, i.e. tripping on faults or device malfunction. It is normally closed and opens in case of an alarm. If another alarm occurs, the contact is closed again for a short period of time of approx. 1s.

DE-EXCITATION:
DIO500#2 : 5,6 (DO1, Permanent Contact 250 V, 10 A)

This contact is used for a high-speed de-excitation of the generator in case of tripping on faults with a correspondingly parameterised function code for de-excitation (e.g. stator protection and differential protection).

SWITCHING-OFF UNIMPORTANT CONSUMERS LEVEL 1:
DIO500#2 :7,8 (DO2, Pulse Contact 250 V, 10 A)

SWITCHING-OFF UNIMPORTANT CONSUMERS LEVEL 2:
DIO500#2 :1,2 (DO3, Pulse Contact 250 V, 10 A)

SWITCHING-OFF UNIMPORTANT CONSUMERS LEVEL 3:
DIO500#2 :3,4 (DO4, Pulse Contact 250 V, 10 A)

These contacts are closed if the respective threshold value for load shedding is exceeded in the event of overcurrent or underfrequency according to the parameterisation.

The GOV500 module makes available the following two output contacts to control a diesel controller (governor):

INCREASE SPEED:
GOV500: 1,8 and 2,7 (Pulse Contact 250 V, 8 A)

DECREASE SPEED:
GOV500: 3,7 and 2,8 (Pulse Contact 250 V, 8 A)

The diesel controller and the servomotor of the diesel engine controller respectively is connected to these contacts. D.c. motors (24 V DC) and capacitor motors (max. 230 V AC) can be connected.

D.c. motors are connected to terminals 1/ 2. In addition, terminals 3, 4 are to be connected to each other.

A.c. motors are connected to terminals 1, 2, 3, where winding “Lower/Slower” is connected to terminal 3, “Higher/Faster” to 2 and the joint connection to 1.

To protect the output contacts, for a.c. servomotors RC snubber circuits are to be used and for d.c. servomotors free-wheeling diodes are to be applied.

MOTOR SUPPLY:
GOV500: 7,8

The d.c. and a.c. supply respectively of the servomotors is connected these contacts (see also the terminal diagrams in Annex A)

9.1.5 Optional Digital Outputs for Load Monitors

The optional load monitor function is available by means of additional optional DIO500 modules. For this purpose the operating mode is to be parameterised for the load monitor. In doing so, the output contacts for messages and control concerning the big consumers are displaced to

DIO500 modules having higher ordinal numbers (this is similar to the inputs) (see section 9.1.3). In addition, there is a displacement of the outputs when using additional levels for load shedding.

For the DIO500 modules being assigned to the big consumers a specific scheme is to be observed as this is the case for the inputs as well:

- Switching-on is released by a release contact when the reserve power has been made available. Depending on the parameterisation this signal can be output as pulse contact or as Permanent Contact (DIO500#x: 5,6 DO 1 for consumers 1,3 and 5, DIO500#x:1,2 DO3 for consumers 2,4 and 6).
- The actual condition is visualised by another output contact: Flashing signalises the existing request whereas a Permanent Contact signalises that switching-on has been carried out (DIO500#x: 5,6 DO 1 for consumers 1,3 and 5, DIO500#x:1,2 DO3 for consumers 2,4 and 6).

The four different paramaterisable variants of the contact assignment of the DIO modules for the load monitor are shown in the table in section 9.1.3.

9.1.6 Voltage / Voltage Transformer Inputs

In the following explanation of the transformer inputs the generator term is used in place of all components to be protected.

Generator voltage and system voltage are acquired by the TRV500 in case of low-voltage systems up to 600 V and by the TRV501 in case of systems with higher system voltages such as medium-voltage systems.

In low-voltage systems up to 600 V the voltages can be directly connected without any matching transformer.

For medium-voltage systems the TRV501 module is to be used. Its voltage inputs are adapted for voltage transformers with a secondary voltage at the rating of 100 V.

The two modules have different high-resistance inputs for the voltage acquisition. The input resistance of the TRV500 module thus is 784 kohms, that of the TRV501 module is 260 kohms.

For the mains voltage the acquisition of a phase-to-phase voltage is sufficient.

MAINS VOLTAGE U12:
TRV500 and TRV501 Respectively: 5, 8 (U3,V3: Max. 600 V and 200 V Respectively)

For the generator voltage the following two phase-to-phase voltages have to be read in:

GENERATOR VOLTAGE U12:
TRV500 and TRV501 Respectively: 13, 16 (U1,V1: Max. 600 V and 200 V Respectively)

GENERATOR VOLTAGE U23:

TRV500 and TRV501 Respectively: 16, 12 (U2,V2: Max. 600 V and 200 V Respectively)

The connection of the voltage transformers for a generator and for a tie breaker with medium-voltage systems is shown in the following two figures.

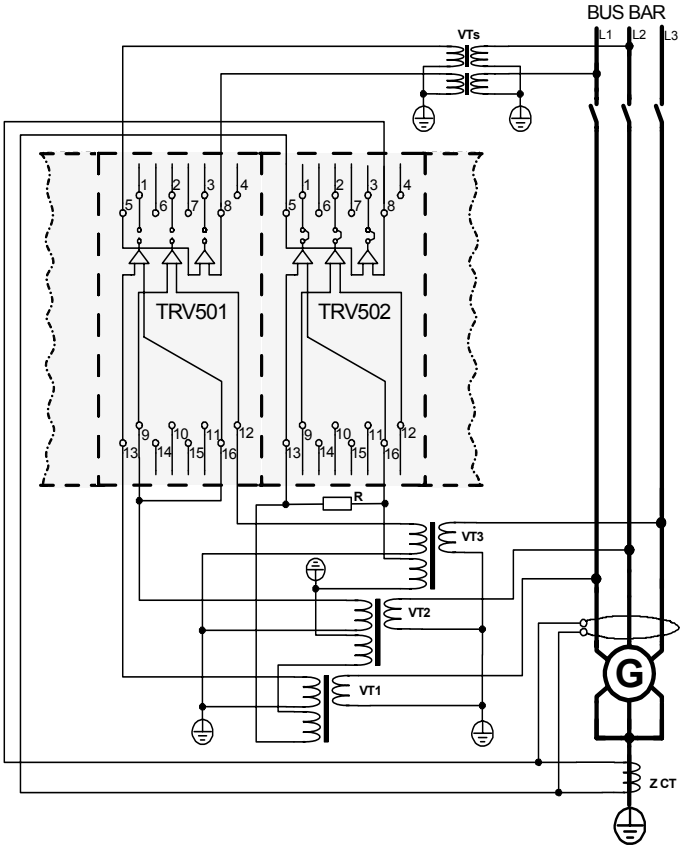


Fig. 9-3 Voltage Transformer Connection for Medium-voltage Generator with Earthfault Detection

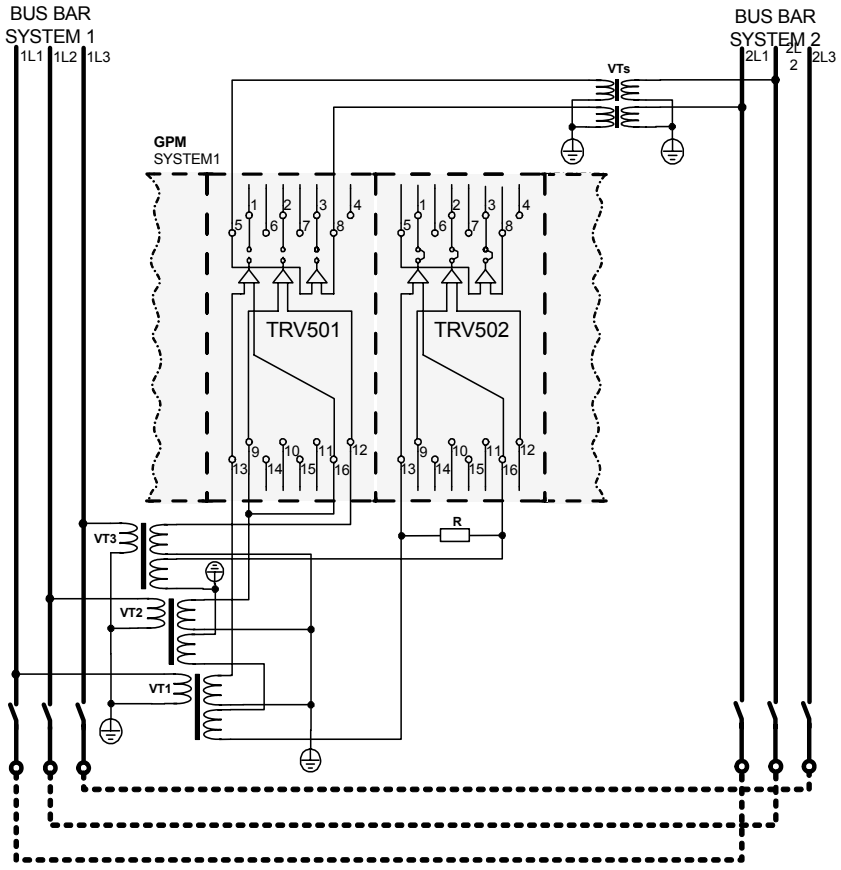


Fig. 9-4 Voltage Transformer Connection for Medium-voltage Tie breaker with Earthfault Detection

In case of an application for a medium-voltage consumer the above-mentioned channels are used in the same way to acquire the busbar voltage. For consumers the TRV502 module can be used, too. It offers the advantage of the additional summation current acquisition being realised via channel 3 for the selective earthfault detection (see further below).

BUSBAR VOLTAGE U12:
TRV501 (and TRV502 Respectively for Consumers) :13, 16 (U1,V1: 100 V)

BUSBAR VOLTAGE U23:
TRV501 (and TRV502 Respectively for Consumers) :16, 12 (U2,V2: 100 V)

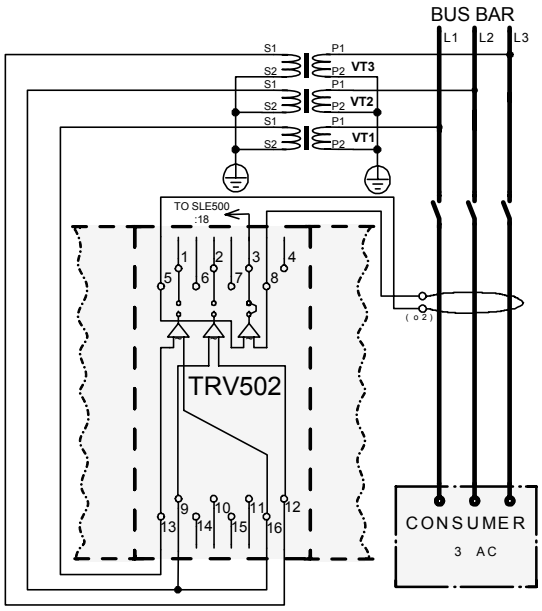


Fig. 9-5 Transformer Connection for a Consumer with Earthfault Detection

For medium-voltage systems the TRV502 module is to be used to detect earth faults by acquiring the voltage displacement and the earthfault current.

It has two 100 V voltage inputs and one current input for the earthfault current acquisition.

DISPLACEMENT VOLTAGE:
TRV502 :13, 16 (U1,V1: Max. 100 V)

An earth fault is determined by acquiring a voltage displacement. For this purpose, the displacement voltage is acquired as the sum of the phase-to-earth voltages by means of additional windings / cores of the voltage transformers in an open delta connection.

These windings are to be designed such that a voltage of 100 V is obtained with a full earth fault and with a max. displacement, i.e. the transformation ratio of the additional winding must $\frac{U_N}{\frac{100V}{\sqrt{3}}}$.

EARTHFAULT CURRENT:
TRV502 :5, 8 (U3,V3: Max. 1 A)

See current transformer inputs, section 9.1.7.

9.1.7 Current Transformer Inputs

For current acquisition purposes current transformers at the star point of the generator are used by preference, if they are available. In doing so, it does not matter whether a differential protection is to be realised or not. It is advantageous that a stator protection can be realised when using the star point transformers. This is not possible when using the outgoing transformers.

The transformers are to be star-connected on the secondary side and the star point is to be connected to terminals 26, 28 and 11 of the SLE500A module. The currents are read in and processed as true r.m.s. values.

GENERATOR CURRENT I1:
SLE500A :25,26 (L1,K1: Max. 1 A)

GENERATOR CURRENT I2:
SLE500A :27,28 (L2,K2: Max. 1 A)

GENERATOR CURRENT I3:
SLE500A :12,11 (L3,K3: Max. 1 A)

Current transformers with a secondary rated current of 1 A are to be used.

The connected load is 1 VA.

EARTHFAULT CURRENT:
TRV502 :5, 8 (U3,V3: Max. 1 A)

This input, as standard, serves the purpose of current acquisition for the earthfault monitoring.

Three different types of the earthfault current acquisition are possible:

1. Star point current of a low-resistance-earthed generator star point
2. Earthfault current of an earthing transformer for earthing a medium-voltage system
3. Summation current e.g. of a consumer outgoing circuit (see fig. consumer medium-voltage)
4. Differential value of star point and summation current for the selective earthfault detection (see fig. generator medium-voltage)

Current transformers with a secondary rated current of 1 A are to be used for this purpose.

The connected load is approx. 0.15 VA only.



ATTENTION:
When using the TRV502 module as the only TRV module, e.g. in connection with a medium-voltage consumer, the correct jumpering is to be ensured by all means.
Instead of using output terminals 1 and 2 acquisition channels 1 and 2 are to be connected to the internal analog bus to the SLE by means of jumpers. The setting of channel 3 for the earthfault detection remains unchanged.
Caution: A module being jumpered this way must not be used together with other TRV modules. The non-compliance can lead to the destruction of the equipment (details see section 9.2.5)

9.1.8 Optional Current Transformer Inputs for the Differential Protection

With generators the outgoing transformers in the switchboard should be used for current acquisition purposes for the differential protection and the transformers in the generator should be used for the other protection functions such that a stator protection can be realised, too.

For consumers with differential protection the outgoing transformers are connected to the SLE500 module and the transformers in the consumer are connected to the DIF500 but with reverse directions of the ampere-turns (see Figure 10 in appendix A).

The transformers for the differential protection are to be star-connected on the secondary side and the star point is to be connected to terminals 2, 4 and 6 of the DIF500 module. The current transformer connection for the stator and differential protection is shown in the figure below.

Current transformers with a secondary rated current of 1 A are to be used. The connected load is 1 VA. The currents are read in and processed as true r.m.s. values.

GENERATOR CURRENT I1 FOR THE DIFFERENTIAL PROTECTION:
DIF500 :1,2 (L1,K1: Max. 1 A)

GENERATOR CURRENT I2 FOR THE DIFFERENTIAL PROTECTION:
DIF500 :3,4 (L2,K2: Max. 1 A)

GENERATOR CURRENT I3 FOR THE DIFFERENTIAL PROTECTION:
DIF500 :5,6 (L3,K3: Max. 1 A)

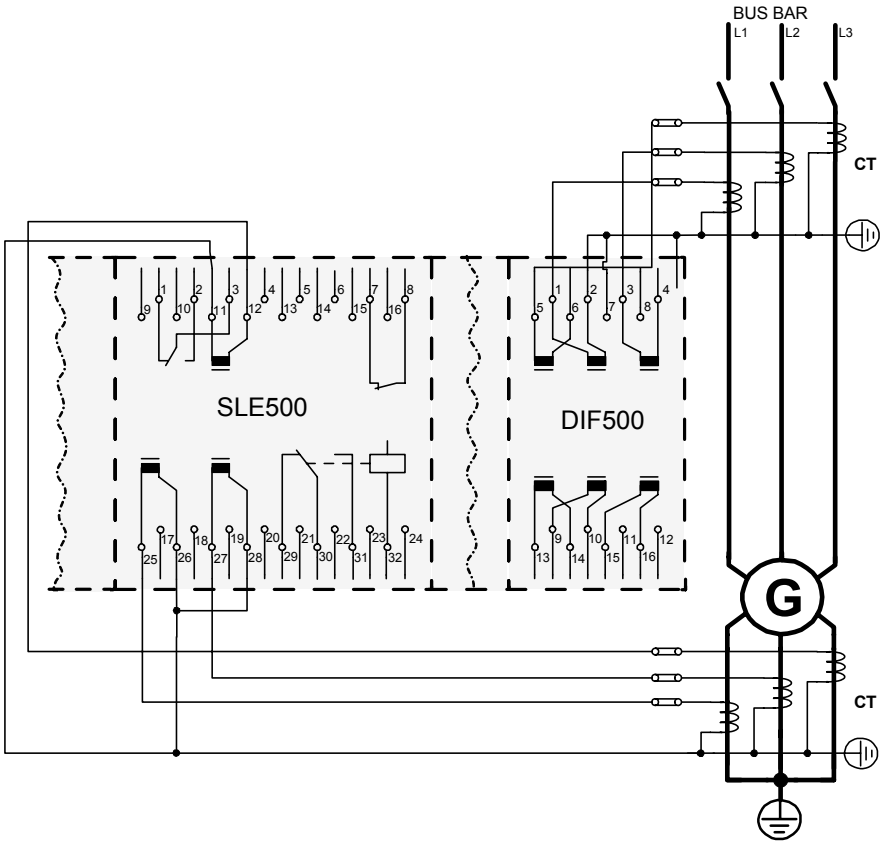


Fig. 9-6 Current Transformer Connection for the Differential Protection

9.1.9 Optional Current Transformer Inputs for Load Monitors

By means of a GPM500 without differential protection a load monitor with the current measurement of up to 6 big consumers can be realised.

In contrast, on a GPM with differential protection the currents of 3 consumers only can be acquired. The currents are read in and processed as true r.m.s. values.

Current transformers with a secondary rated current of 1 A are to be used.

The connected load is 1 VA.

The channel assignment corresponds to the following table (see also terminal diagrams for load monitors in the appendix):

Big consumer No.	Current channel on a GPM incl. differential protection	Current channel on a GPM without differential protection
1	DIF500: 9,10	DIF500: 9,10
2	DIF500: 15,16	DIF500: 15,16
3	DIF500: 13,14	DIF500: 13,14
4	-	DIF500: 5,6
5	-	DIF500: 3,4
6	-	DIF500: 1,2

9.1.10 Analog Outputs

ACTIVE POWER:
GOV500 :13,14 (AO1: -10 V..+10 V)

This analog voltage output –10..+10 V is, as standard, provided on the GOV500 module to indicate the power on a moving-coil instrument.

Zero mark and scaling can be parameterised (see parameters 133 and 186).

Minimum terminating resistance for the voltage output: 500 ohms.

As standard, the output is adjusted to output +/-10 V but a 0..20 mA signal can also be output by changing the jumper settings of the GOV module (see section 9.2.3)

Maximum terminating resistance for the current output: 500 ohms.

CURRENT:
GOV500 :15,16 (AO2: 0..20 mA)

By means of this analog output, as standard, the phase current is output as 0..20 mA signal. The phase being displayed L1, L2 or L3 can be selected (see digital inputs GOV500: DI1 and DI2).

Offset and scale can be parameterised (see parameters 134 and 187).

Maximum terminating resistance for the current output: 500 ohms.

As standard, the output is adjusted to output 0..20 mA but a +/- 10V signal can also be output by changing the jumper settings of the GOV module (see section 9.2.3).

Minimum terminating resistance for the voltage output: 500 ohms.

9.1.11 Module for the Voltage Back-up for Undervoltage Coils

The task of the module for the voltage back-up for undervoltage coils USS500 is to avoid any premature tripping of the generator circuit breaker due to a voltage dip during the delay of the short-circuit tripping.

For this purpose, two parallel capacitors are charged in the USS500 module by two three-phase supplies using a rectifier. These capacitors supply the undervoltage coil and back up the voltage for a few seconds in case of a failure of the three-phase supply such that the circuit breaker does not trip.

With a typical holding power of the undervoltage coil of 5 W the back-up time until dropping down to 70% to 35% of the nominal voltage at minimum is approx. 2 to max. 6s.

This time is calculated on the basis of the total back-up capacitance of 660µF. The two above-mentioned voltage values are voltage values where the undervoltage coil drops out typically.

If the microprocessor-controlled and the autonomous short-circuit tripping of the GPM500 fail, then in case of a short-circuit the generator circuit breaker is opened after expiration of the back-up time of the undervoltage coil.

UNDERVOLTAGE COIL SUPPLY 1:
USS500 :14,15,16 (L1,L2,L3: 3AC 150 V)

UNDERVOLTAGE COIL SUPPLY 2:
USS500 :10,11,12 (L1,L2,L3: 3AC 150 V)

The second three-phase supply system serves to connect a second redundant voltage source like the second voltage system for tie breakers being not their own one. Further details see also 1.8.1.

UNDERVOLTAGE COIL SUPPLY:
USS500 :1/2 (+: DC 220 V)

UNDERVOLTAGE COIL SUPPLY:
USS500 :3/4 (-: DC 220 V)

For the direct connection of the undervoltage coil to the supply by the USS500 module with 220 V DC. The free-wheeling diode being required to protect the undervoltage coil is already included in the USS500 module and does not have to be realised separately.

CONNECTION OF THE SWITCH-OFF CONTACT:
USS500 :5/6 (-DC 220 V, Supply Side)

CONNECTION OF THE SWITCH-OFF CONTACT:
USS500 :7/8 (+DC 220 V, Coil Side)

The switch-off contact C.B. OFF of the SLE500A module (terminals 7,8) is connected to these terminals and looped into the undervoltage coil circuit.

9.1.12 Bus Connections

GPM Bus

The GPM bus, i.e. the two CAN busses CAN1 and CAN2 being redundant with respect to each other, is available for the purpose of communicating with other GPM500 systems, e.g. for load sharing and for the further data exchange.

CAN1: ZKG500: 2,3,4 (CAN1 G,L,H)

CAN2: ZKG500: 6,7,8 (CAN2 G,L,H)

NOTE:
The CAN busses have to be connected through from station to station each. Spur lines are to be avoided!
I.e. the bus connection is to be made such that the cores of the incoming bus section and the cores of the outgoing bus section are connected in parallel at the terminals of the ZKG module and not at a terminal strip from where a spur line leads to the GPM500.

With the last device of a bus section the CAN busses are to be terminated by setting one jumper each (see section 9.2.2)

NOTE:
The external cabling of the CAN busses can be effected using standard cable types taking into account the following points:
A cable being twisted in pairs or even better a cable being shielded in pairs with a total shield and a core cross-section of at least 0.5 mm² is to be used. In doing so, it is to be made sure that signal lines L and H are connected to a twisted core pair.

CANopen Interface

CAN bus interface CAN4 being operated with a CANopen protocol is used to connect the BAT500.

On request this interface can be used to realise the project-specific data exchange with other devices, too.

CAN4: Combined power supply module, NEG501: 13,14,15 (CAN4 H,L,G)

Modbus Interface

For the communication with external systems (e.g. automation system or superior PMS system) there is available a Modbus interface. In terms of hardware, the Modbus is based on an RS-485 interface with two transmission and receiving lines plus GND connection. Modbus RTU is used as protocol.

MODBUS: ZKG500: 13,14,15 (-S/E, +S/E, RGND)

Apart from a simple point-to-point Modbus connection, a redundant connection can be optionally realised on request (see also section 8.2)

9.2 Configuration of the Assemblies by Jumpers

9.2.1 Jumpers on Assembly ZKG500

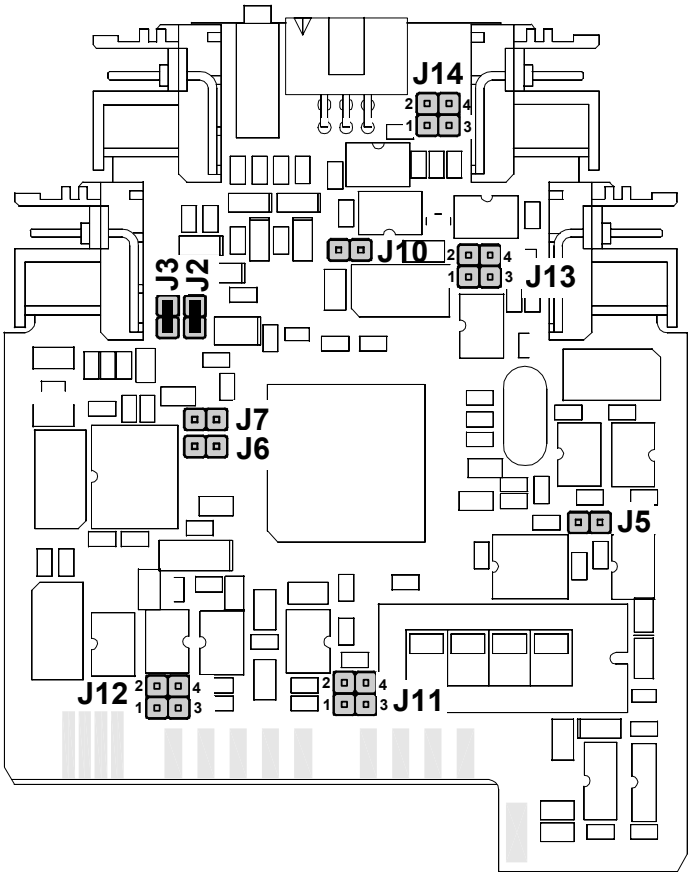


Fig. 9-7 Jumpers on Assembly ZKG500

J2 and J3 are the jumpers to activate the RS-485 bus terminating resistors.
If the RS-485 interface is connected to the end of a bus, then both jumpers must be plugged.

By plugging jumper J5 the monitoring function of the watchdog IC is turned off. This way it is avoided that the CPU permanently receives reset signals from the watchdog IC during the download or testing operation. During normal mode the CPU cyclically generates signal changes for the watchdog IC such that J5 does not have to be plugged.

By means of J6 and J7 the connection of the RS-232 interface to the CPU is established.
During the program test via the RS-232 interface these two jumpers must be plugged.

By means of J10 the connection of the debug/download interface (BGND) to the reset input of the CPU is established. During the program test/download via the BGND interface this jumper must be plugged.

Via pin-contact strips J11, J12, J13 and J14 the CAN busses (0, 4, 1 and 2) are terminated (120 bus terminating resistor). For this purpose, two jumpers each must be plugged on the corresponding pin-contact strip.

9.2.2 Jumpers on Assembly DIO500

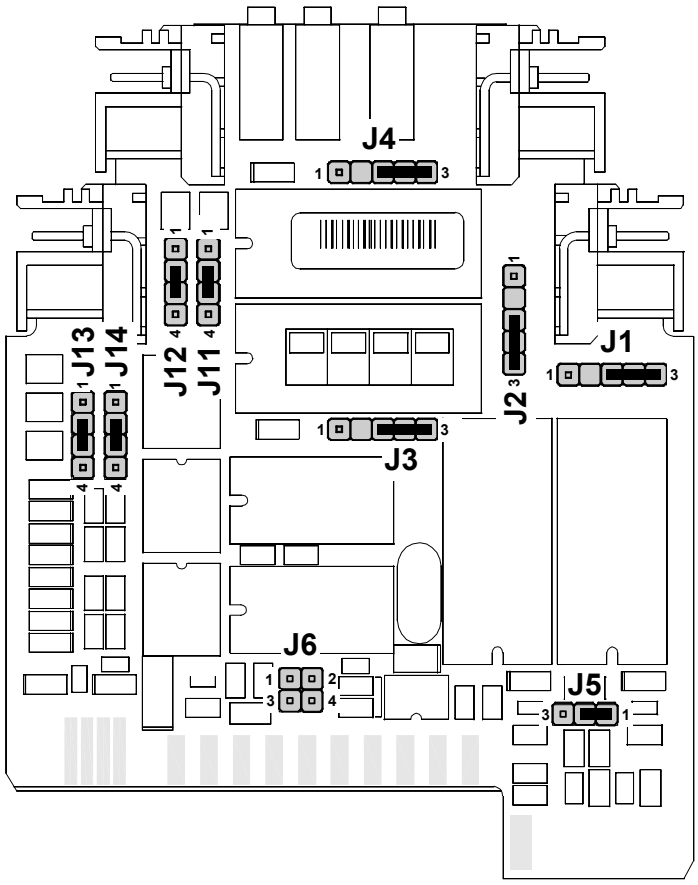


Fig. 9-8 Jumpers on Assembly DIO500

It is defined via pin-contact strip J5 how the digital output relays react if the watchdog relay drops out.
Pins 1-2 short-circuited: All digital output relays are turned off by the watchdog relay (supply of switched 24 V) (standard setting).
Pins 2-3 short-circuited: No effect on the digital output relays (supply of backed-up 24 V).

Via the 3-pole pin-contact strips J1, J2, J3 and J4 it is pre-selected whether a normally closed contact or a normally open contact is brought out to the output terminals for the respective digital output channel.
By short-circuiting pins 1-2 the normally closed contact is brought out and by short-circuiting pins 2-3 the normally open contact is brought out.

By means of the 4-pole pin-contact strips J11, J12, J13 and J14 it is pre-selected whether the digital input channel terminals 1 to 4 are independent or whether they serve the purpose of open-circuit monitoring of their adjacent channel terminals (5-8).

Pins 2-3 short-circuited: The respective digital input channels are independent without open-circuit monitoring.
Pins 1-2 and 3-4 short-circuited: The respective digital input channels are programmed for the open-circuit monitoring.

The CAN bus is terminated via pin-contact strip J6 (120 bus terminating resistor).
For this purpose, 2 jumpers are plugged onto pin-contact strip J6.
This is required only if the assembly is the last assembly on the CAN bus. As standard, these jumpers are not plugged.

9.2.3 Jumpers on Assembly GOV500

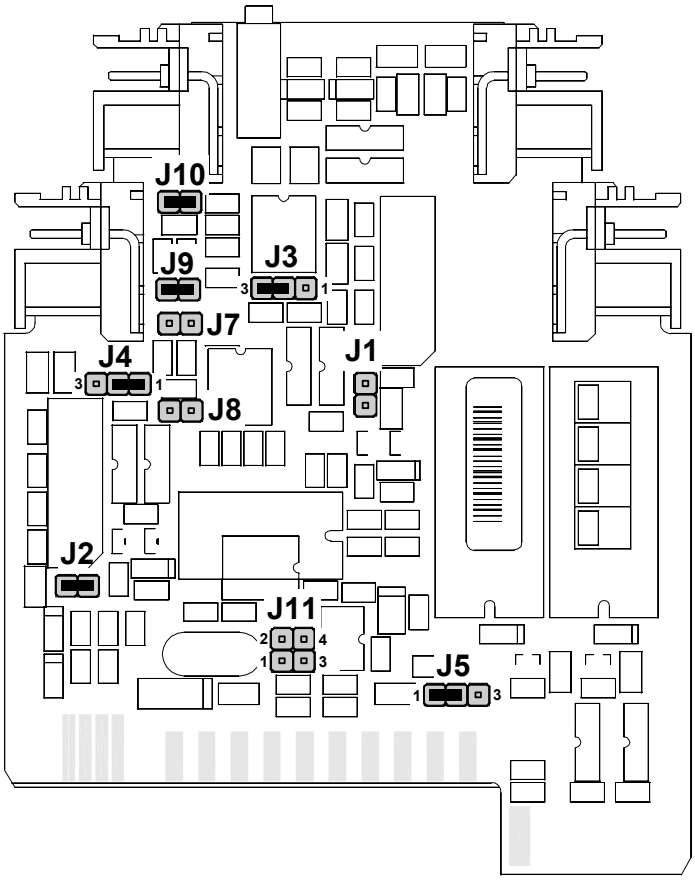


Fig. 9-9 Jumpers on Assembly GOV500

If pins 1-2 of the 3-pole pin-contact strip J5 (presetting) are short-circuited, the „Higher/lower“ relays drop out if the watchdog relay drops out (relay supply by switched 24 V).

If pins 2-3 on J5 are short-circuited, dropping out of the watchdog relay does not have any effect on the „Higher/lower“ relays (relay supply by backed-up 24 V).

Jumpers for the configuration of the analog outputs:

Jumper Name AO1(:13,:14):	J3 (3-pole)	J9 (2-pole)	J10 (2-pole)
Jumper Name AO2(:15,:16):	J4 (3-pole)	J7 (2-pole)	J8 (2-pole)
0 to +10 V Output:	1-2 plugged	1-2 plugged	1-2 plugged
-10 to +10 V Output:	2-3 plugged	1-2 plugged	1-2 plugged
0 to + 20mA Output:	1-2 plugged	Nothing plugged	Nothing plugged
-20 to + 20mA Output:	2-3 plugged	Nothing plugged	Nothing plugged

The internal CAN bus is terminated via pin-contact strip J11 (120 bus terminating resistor). For this purpose, 2 jumpers are plugged onto pin-contact strip J6.

This is required only, if the assembly is the last assembly on the CAN bus.

As standard, these jumpers are not plugged.

9.2.4 Jumpers on Assembly TRV500/501

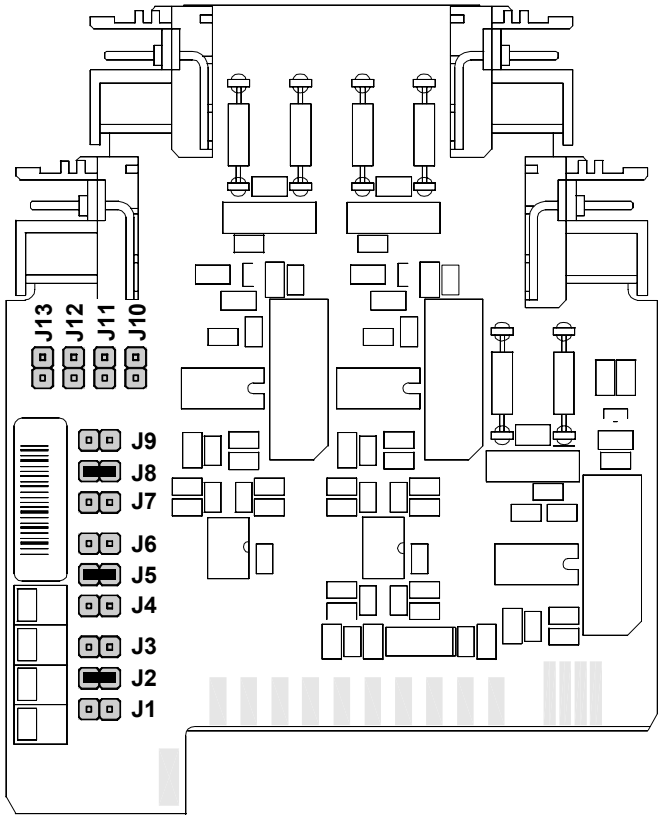


Fig. 9-10 Jumpers on Assembly TRV500/501

The three output signals of the TRV500 are connected to different bus connectors or to external terminals by means of jumpers.

„Changing over“ of the output channels is required always if several TRV500 are jointly operated on one analog bus.

Jumper Name:	Function (if the jumper is plugged):
J1	Connects channel 1 to internal terminal X6.8 (ID3)
J2	Connects channel 1 to internal terminal X7.3/4 (analog bus U3) standard
J3	Connects channel 1 to internal terminal X6.4 (IE3)
J4	Connects channel 2 to internal terminal X6.4 (ID2)
J5	Connects channel 2 to internal terminal X7.1/2 (analog bus U2) standard
J6	Connects channel 2 to internal terminal X6.3 (IE2)
J7	Connects channel 3 to internal terminal X6.6 (ID1)

Jumper Name:	Function (if the jumper is plugged):
J8	Connects channel 3 to internal terminal X6.10 (analog bus U1) standard
J9	Connects channel 3 to internal terminal X6.2 (IE1)
J10	Connects channel 1 to internal terminal X3.2 (external terminal 3)
J11	Connects channel 2 to internal terminal X3.3 (external terminal 2)
J12	Connects channel 3 to internal terminal X3.4 (external terminal 1)
J13	Connects reference voltage (2.5V) to internal terminal X3.1 (terminal 4)

If the output channels are not connected to external terminals (X3), then J13 (2.5V reference voltage) should not be plugged either. This way, X3 remains isolated and it is thus avoided that a high voltage gets onto the analog bus due to “Wrong plugging“.

9.2.5 Jumpers on Assembly TRV502

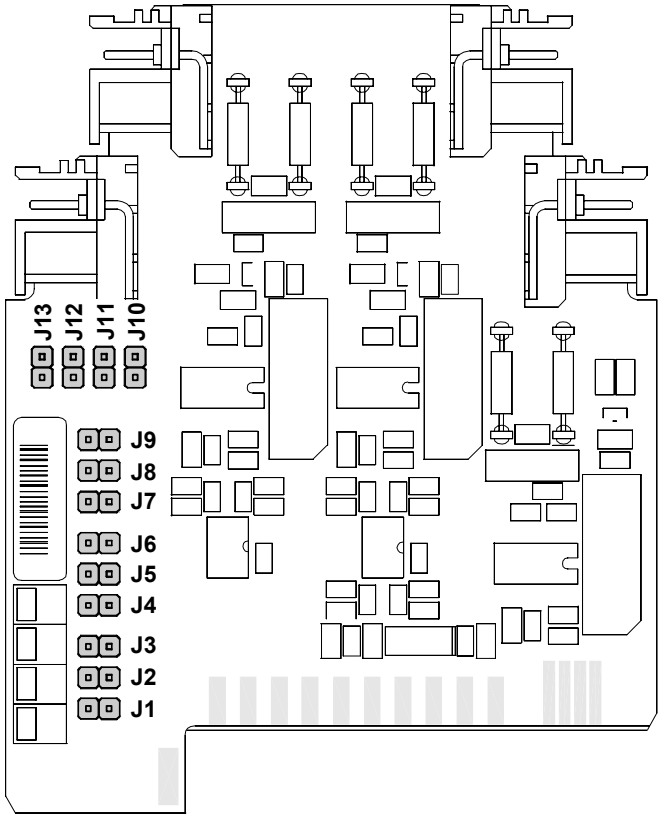


Fig. 9-11 Jumpers on Assembly TRV502

See assembly TRV500/501

9.2.6 Jumpers on Assembly SLE500A

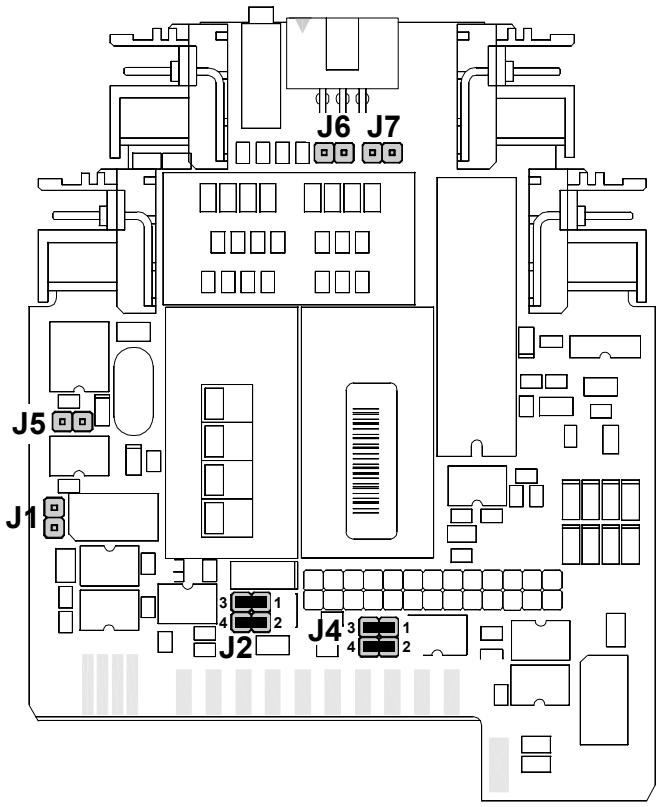


Fig. 9-12 Jumpers on Assembly SLE500A

By plugging jumper J5 the pulses of an oscillator are routed to the watchdog IC. This way the monitoring function of the watchdog IC is turned off. By means of this turning-off it is avoided that the CPU permanently receives reset signals from the watchdog IC during the download or testing operation.
During normal mode the CPU cyclically generates signal changes for the watchdog IC such that J5 does not have to be plugged. As standard, this jumper is not plugged.

By means of J6 and J7 the connection of the RS-232 interface to the CPU is established.
During the program test via the RS-232 interface these two jumpers must be plugged. As standard, these jumpers are not plugged.

By means of J1 the connection of the debug/download interface (BGND) to the reset input of the CPU is established. During the program test/download via the BGND interface this jumper must be plugged. As standard, these jumpers are not plugged.

Via pin-contact strips J4 and J2 the CAN busses (0 and 4) are terminated (120 bus terminating resistor). For this purpose, two jumpers each are to be plugged onto the corresponding pin-contact strip.

9.2.7 Jumpers on Assembly SLE510

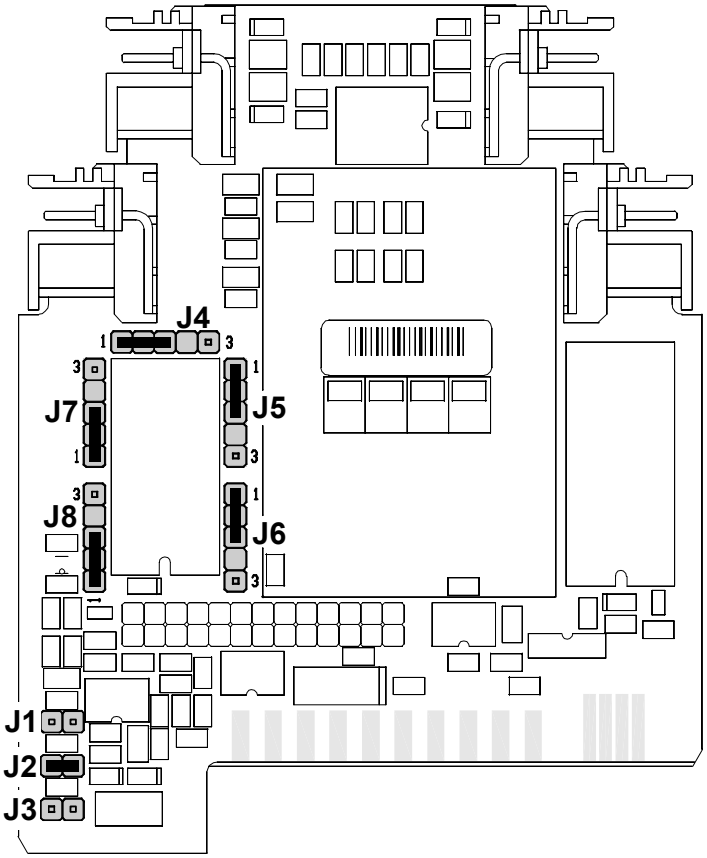


Fig. 9-13 Jumpers on Assembly SLE510

By means of jumpers J4, J5, J6, J7 and J8 it is adjusted whether the output contact of the “Circuit breaker OFF“ relay between terminals :7 and :8 is to be a normally closed or a normally open contact.

All jumpers plugged on 1-2: relay-contact is a normally closed contact.
- All jumpers plugged on 2-3: relay-contact is a normally open contact.

By means of jumpers J1, J2 and J3 the tripping time of the autonomous overcurrent detection is adjusted:

- J1 plugged: tripping time = 200 msec
- J2 plugged: tripping time = 360 msec
- J3 plugged: tripping time = 510 msec

9.2.8 Jumpers on Assembly DCC500

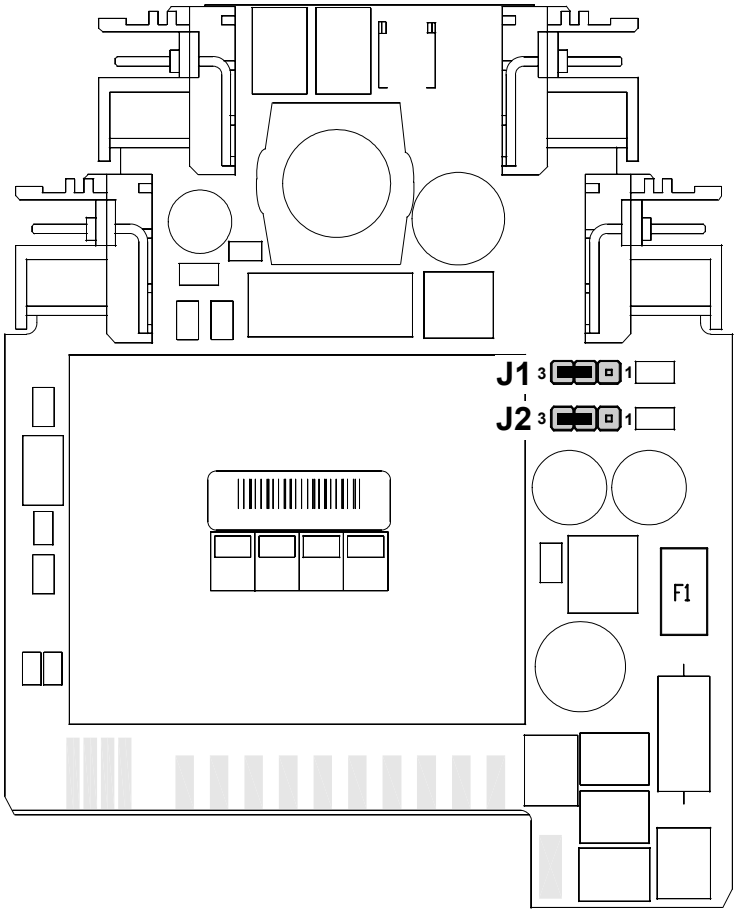


Fig. 9-14 Jumpers on Assembly DCC500

It is defined by jumpers J1 and J2 whether the supply is to be effected from internally or from externally.

Jumpers J1 and J2 plugged on 1-2: The internal 24 V are used as supply.

Jumpers J1 and J2 plugged on 2-3: The voltage at terminals 1/3, 2/4, 5/7 or 6/8 is used as supply.

Survey of Relevant Jumpers

Card	Jumper	Equipped deliverd	Function	Fct. delivered
ZKG500	J2	1-2	Activation of RS-485 bus terminating resistors	ON
	J3	1-2		
	J5	-	Disable Monitoring of watchdog relay	OFF
	J6	-	Connection of RS-232 interface to CPU	OFF
	J7	-		OFF
	J10	-	Connection between debug-/ download interface and CPU	OFF
	J11	-	Termination of internal CAN bus (CAN 0)	OFF
	J12	-	Termination of external CAN bus (CAN 4)	OFF
	J13	-	Termination of GPM bus CAN1	OFF
	J14	-	Termination of GPM bus CAN2	OFF
NEG500/501	J1	1-2 ; 3-4	Termination of internal CAN bus (CAN 0)	ON
	J3	-	Earthing of internal supply voltage 5V	OFF
NEG510	J3	-	Earthing of internal supply voltage 5V	OFF
DIO500	J1	2-3	Preselection if in each case of DA channel a normally closed contact or normally open contact is passed to the output terminals	N.o. contact
	J2	2-3		
	J3	2-3		
	J4	2-3		
	J5	1-2	Determination of DA relay reaction during drop-out of watchdog relay	DO relays get off
	J6	-	Termination of internal CAN bus (CAN 0)	OFF
	J11	2-3	Preselection if DE channel clamps 1-4 are independent or serve as wire control of its neighbouring channels clamps 5-8	Digital inputs
	J12	2-3		
	J13	2-3		
	J14	2-3		
GOV500	J1	-	Release of analog output 1	OFF
	J2	1-2	Release of analog output 2	ON
	J3	2-3	Configuration of analog output 1: unipolar (1-2)/ bipolar (2-3)	Bipolar
	J4	1-2	Configuration of analog output 2: unipolar (1-2)/ bipolar (2-3)	Unipolar
	J5	1-2	Setting if "higher/ lower" relays drop out (1-2) or remain (3-4) when watchdog relay drops out	DA-Relais drops out
	J7	-	Konfiguration of AO2: 10V (1-2) / 20mA (open)	20mA
	J8	-		
	J9	1-2	Konfiguration of AO1: 10V (1-2) / 20mA (open)	10V
	J10	1-2		
	J11	-	Termination of internal CAN bus (CAN 0)	OFF
TRV500/501	J2	1-2	Connects channel 1 with internem analog bus U3 to SLE500	ON
	J5	1-2	Connects channel 2 with internem analog bus U2 to SLE500	ON
	J8	1-2	Connects channel 3 with internem analog bus U1 to SLE500	ON
	J10	-	Connects channel 1 with X3.2 (terminal 3)	OFF
	J11	-	Connects channel 2 with X3.3 (terminal 2)	OFF
	J12	-	Connects channel 3 with X3.4 (terminal 1)	OFF
TRV 502	J2	-	Connects channel 1 with internem analog bus U3 to SLE500	OFF
	J5	-	Connects channel 2 with internem analog bus U2 to SLE500	OFF
	J8	-	Connects channel 3 with internem analog bus U1 to SLE500	OFF
	J10	1-2	Connects channel 1 with X3.2 (terminal 3)	ON
	J11	1-2	Connects channel 2 with X3.3 (terminal 2)	ON
	J12	1-2	Connects channel 3 with X3.4 (terminal 1)	ON
SLE500	J2	1-3 ; 2-4	Termination of CANopen bus to BAT500 (CAN 4)	ON
	J4	1-3 ; 2-4	Termination of internal CAN bus (CAN 0)	ON
SLE510	J1	-	Setting tripping of the independent overcurrent control: J1 = 200ms/ J2 = 360ms/ J3 = 510ms	200ms
	J2	1-2		
	J3	-		
	J4	1-2	Setting if output contact of "power switch-ON"-relay is a normally closed contact (all 1-2) or a normally open contact (all 2-3)	N.o. contact
	J5	1-2		
	J6	1-2		
	J7	1-2		
	J8	1-2		
DCC500	J1	2-3	Utilisation of the internal buffered (1-2) resp. the external supply voltage (2-3) +24V	External supply
	J2	2-3	Utilisation of the internal buffered (1-2) resp. the external supply voltage (2-3) 0V	External supply

10 EMC Notes

Using Screened Cables and Wiring

The following wiring must always be screened:

– Bus cables
– Analog cables

The cable screen must be earthed as closely to the connection as possible.

Producing the Reference Potential Surfaces

Always connect the cable screen to the earth potential at both ends.

Bear in mind that the earth potential can have a different potential at the earthing points.

In this case an additional equipotential bonding conductor with a cross-section of at least 10 mm^2 is to be installed.

Connection of External Screened Cables

Connect the screened cable coming from externally to the local reference potential surface. Establish the connection directly after the entry into the system (switchgear cabinet, rack, mounting plate).

NOTE
The cable screen must not serve as equipotential bonding. The free cable ends are to be kept as short as possible!

Connection of Screened Data and Signal Cables

1. Route the screened data and signal cables to the left or to the right side of the unit the shortest possible way.
1. Establish a low-impedance, large-area connection of the screen braid to the reference potential surface. In this connection the use of spring-loaded screen terminals on a screen bus is recommended.
2. Strip the screen braid end as closely to the signal cable entry of the unit as possible.
3. When using metal plugs the screen braid must be connected to the metal sleeve of the plug.
4. The optimum EMC characteristics are achieved, if the cable screens have a low-impedance connection to the frame potential at both ends.
5. Establish a low-impedance connection of the top-hat rail to the switchgear cabinet / earth potential.
   Because the potentials of the modules refer to the potential of the top-hat rail.

Low-impedance Connection

A low-impedance connection is achieved as follows:

- Large-area, well conducting metal-metal connection;
- Use of flexible grounding strips (RF litz wire);
- Short connection cables with large surface and contact surface;
- In case of varnished, anodised or insulated metal parts the insulating layer is to be removed in the area of the junction.
- Protect the junctions from corrosion (e.g. by greasing).



ATTENTION
Use appropriate grease only.

When connecting the reference surfaces the relevant regulations are to be observed.



NOTE
A usual PE conductor with a small cross-section is insufficient!

Annex A

Example of wiring diagrams

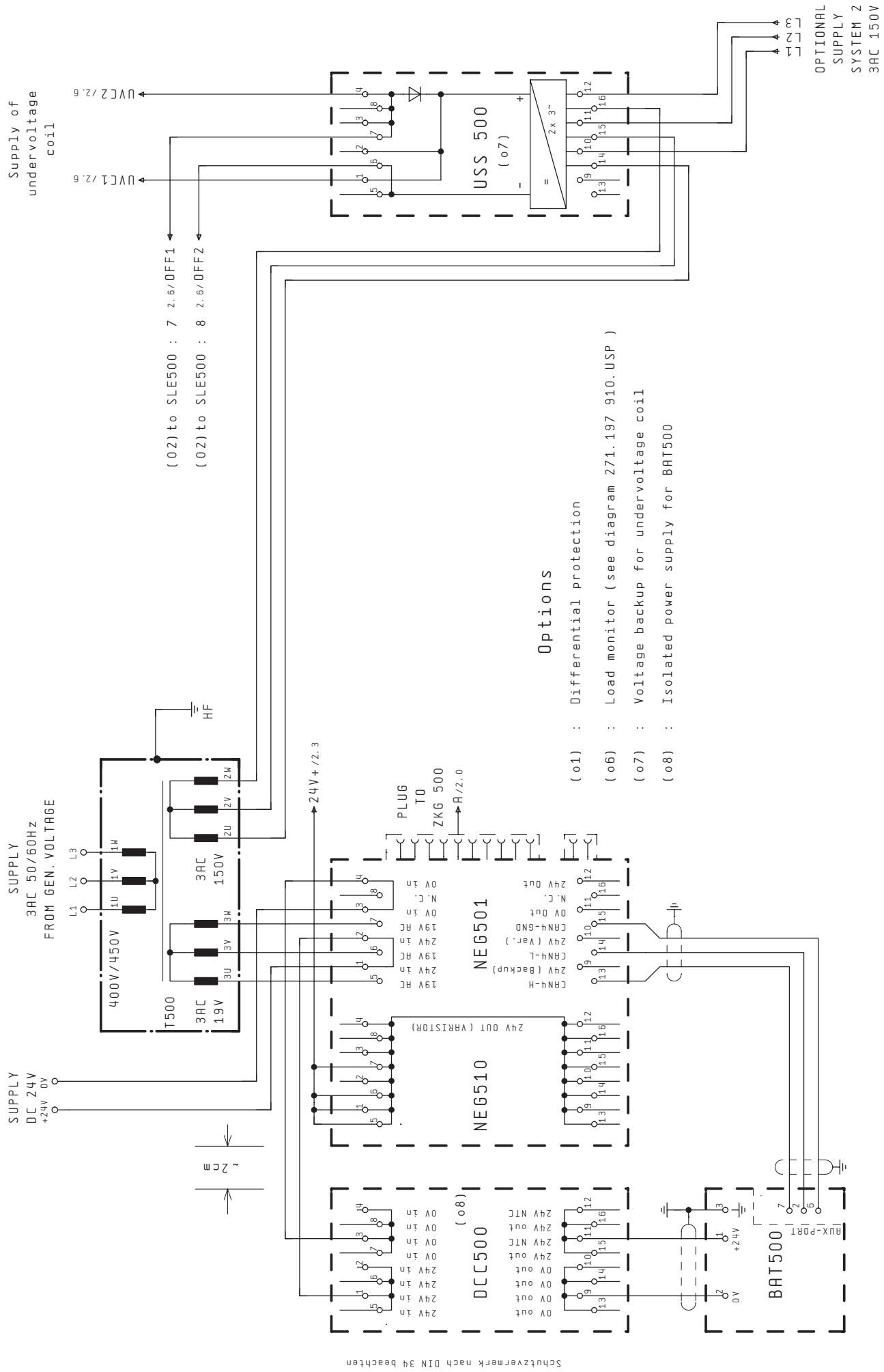


Fig. A-1 LV Generator *(1 of 2)*

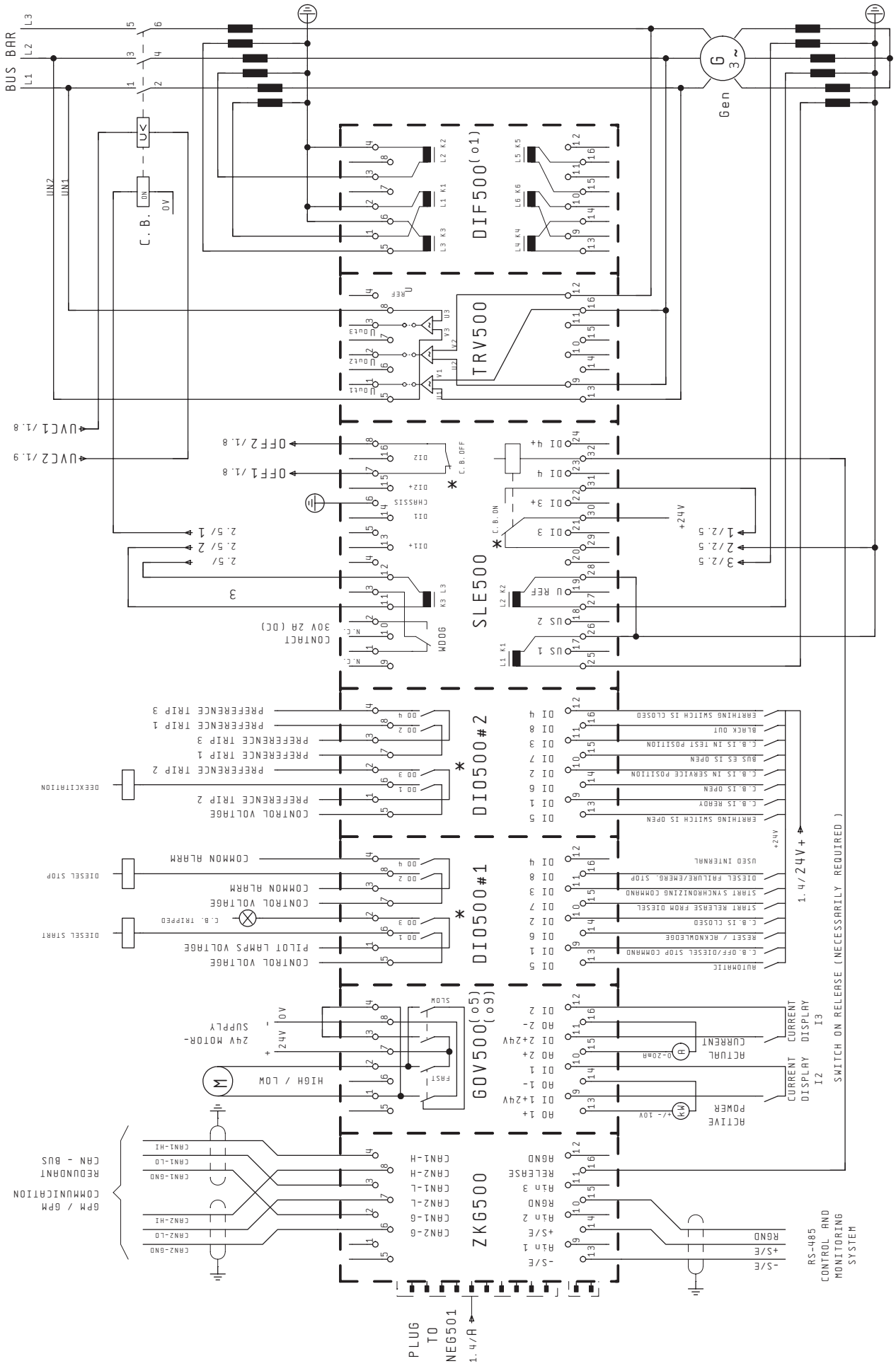


Fig. A-2 LV Generator *(2 of 2)*

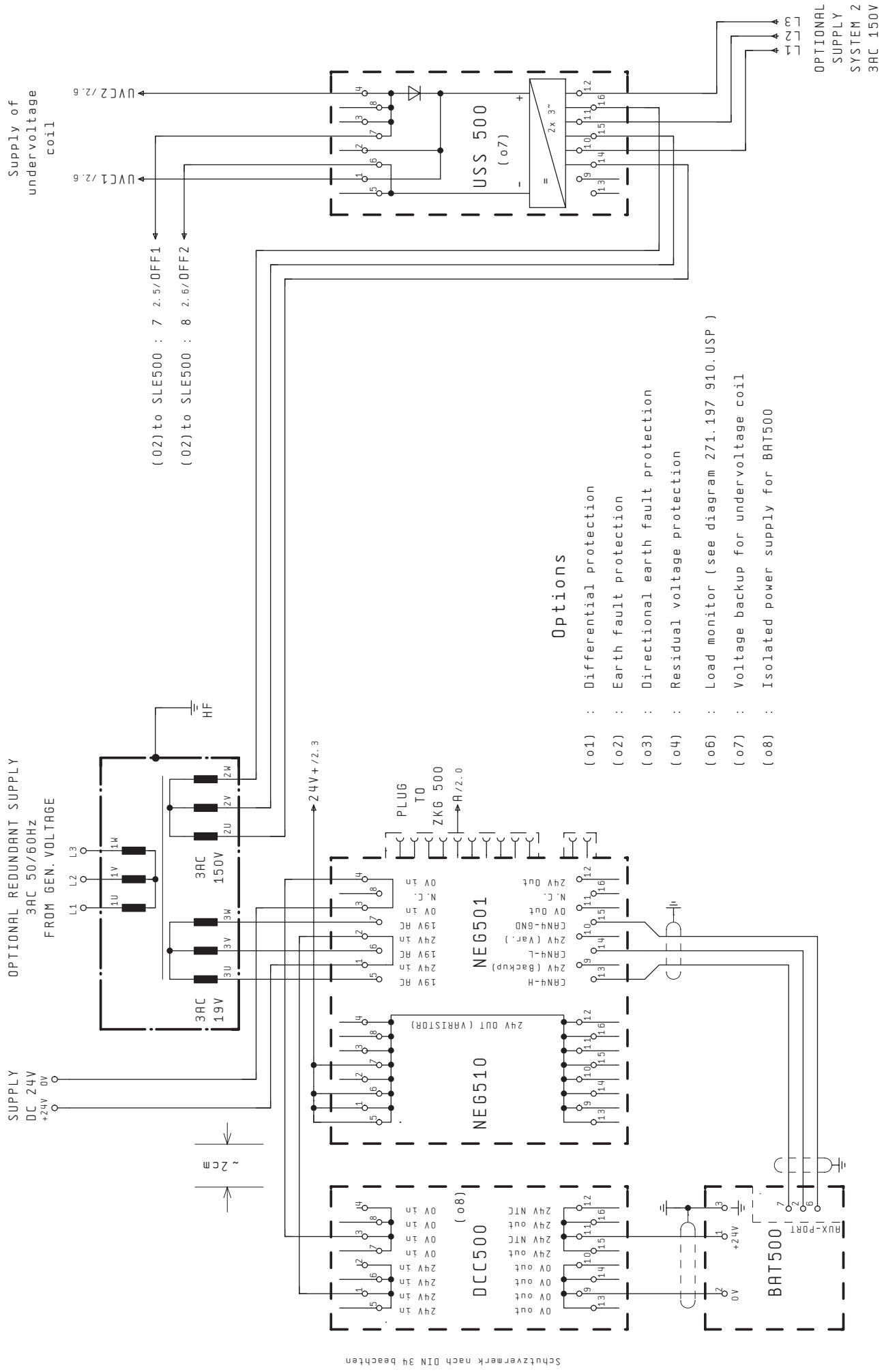


Fig. A-3 MV Generator (1 of 2)

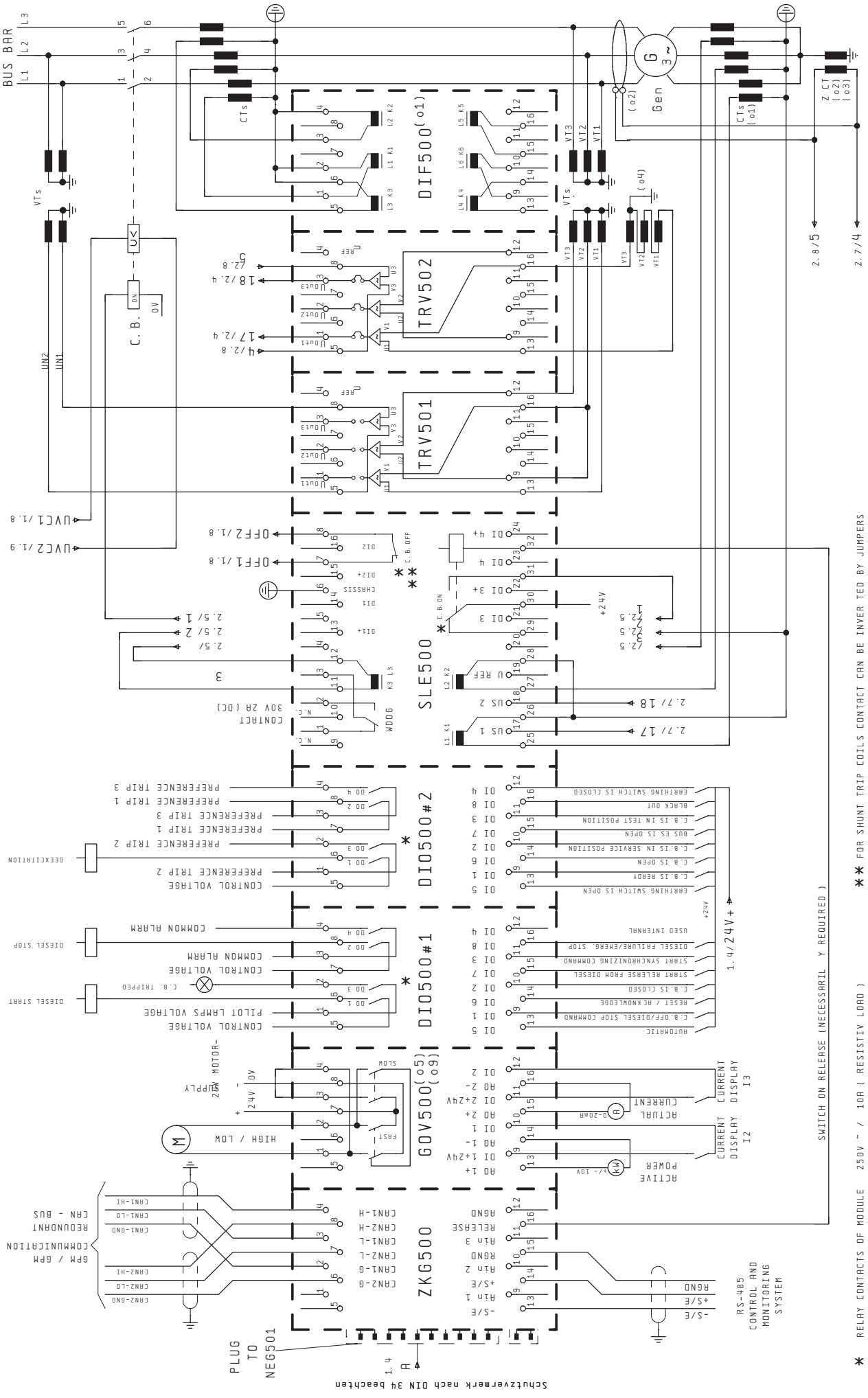


Fig. A-4 MV Generator (2 of 2)

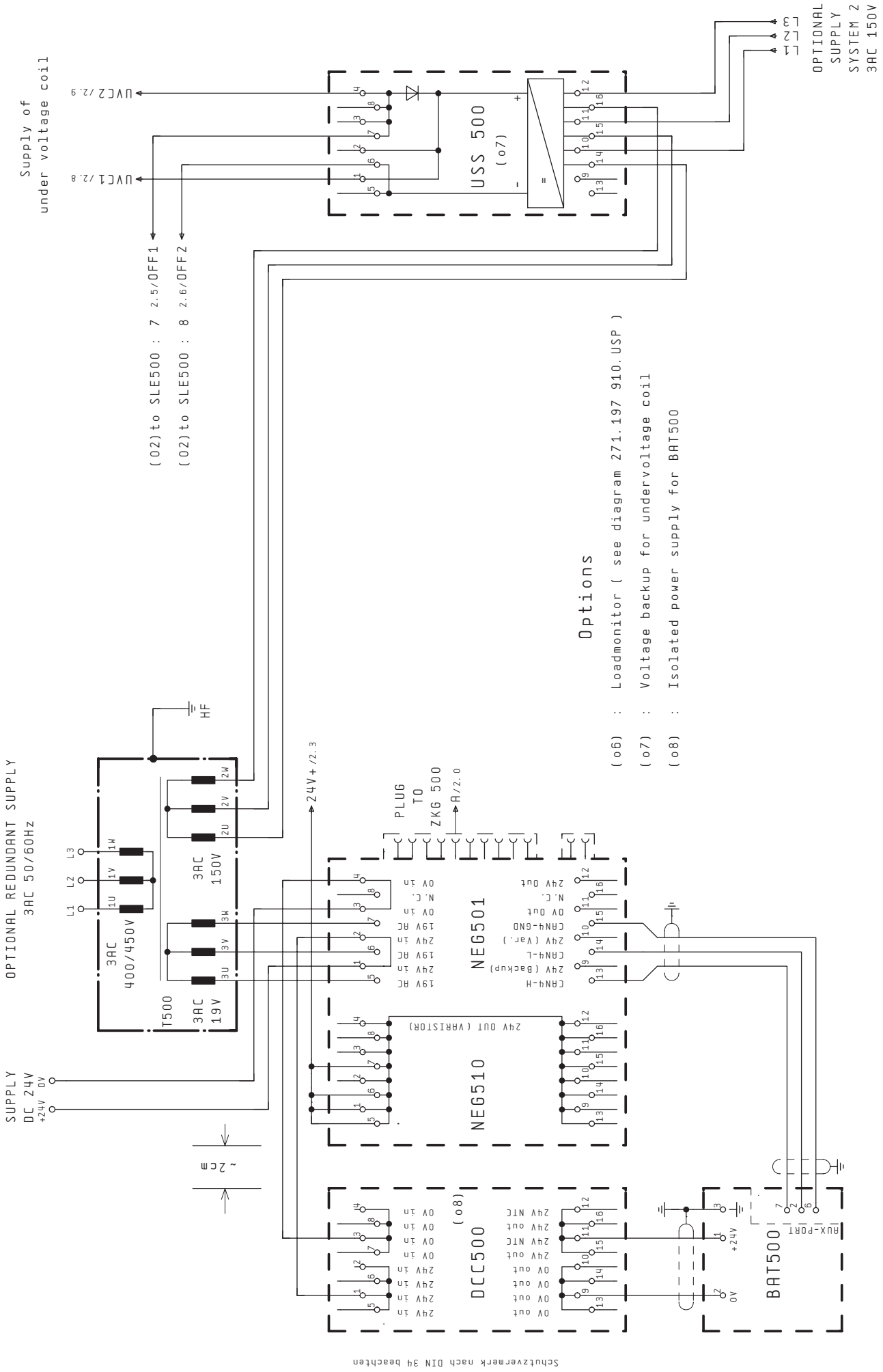


Fig. A-5 LV Bus Tie Breaker (1 of 2)

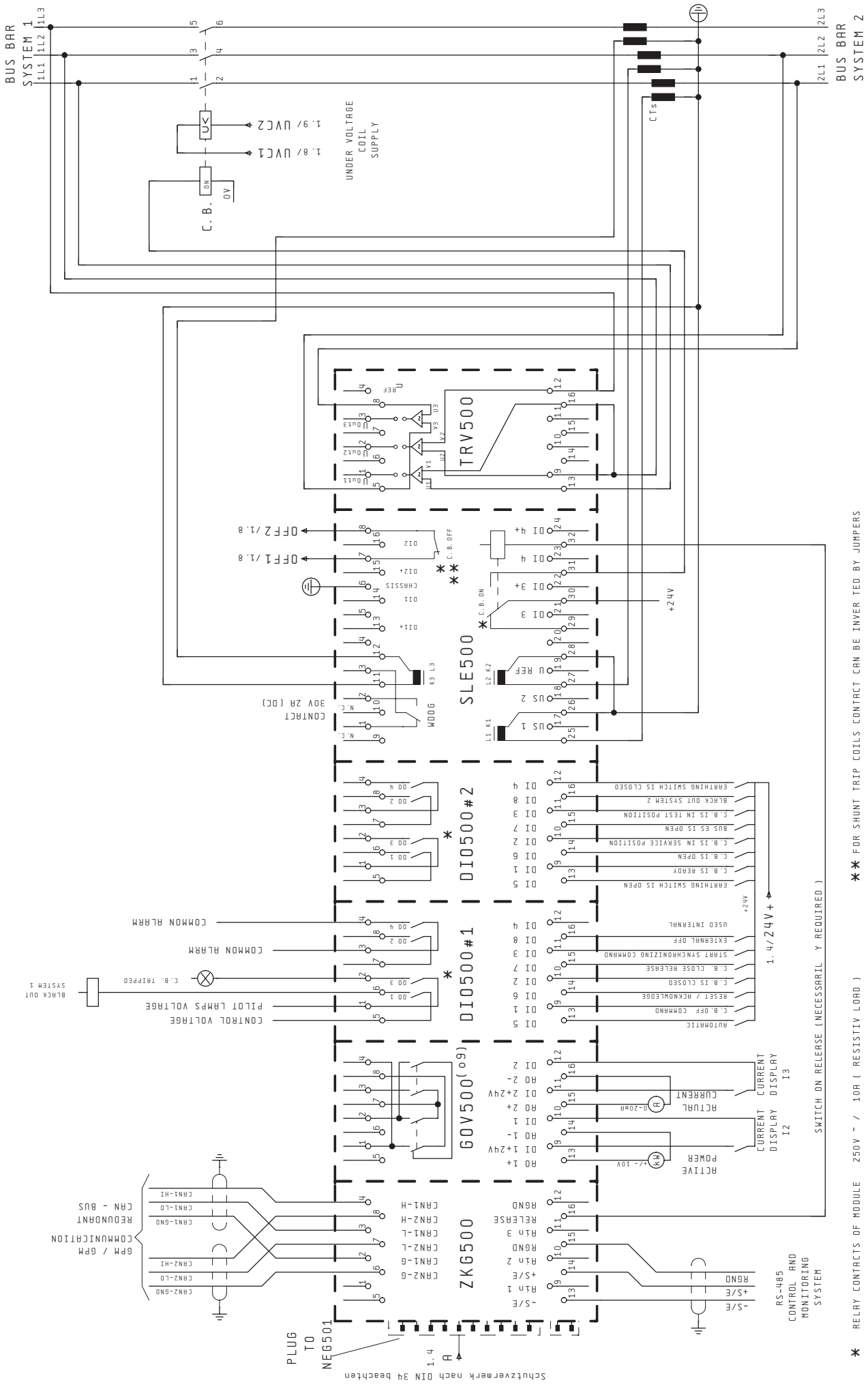


Fig. A-6 LV Bus Tie Breaker (2 of 2)

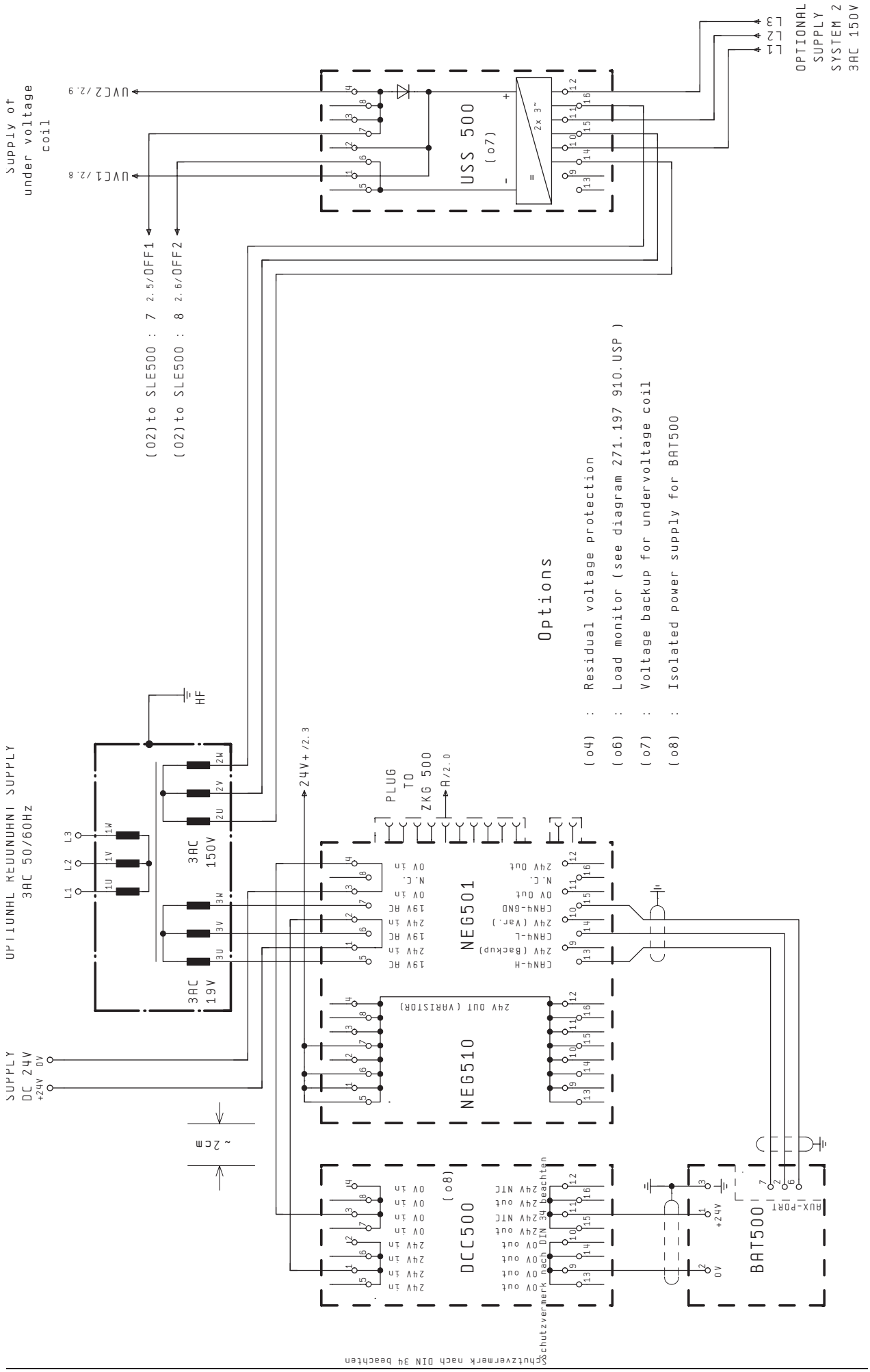


Fig. A-7 MV Bus Tie Breaker (1 of 2)

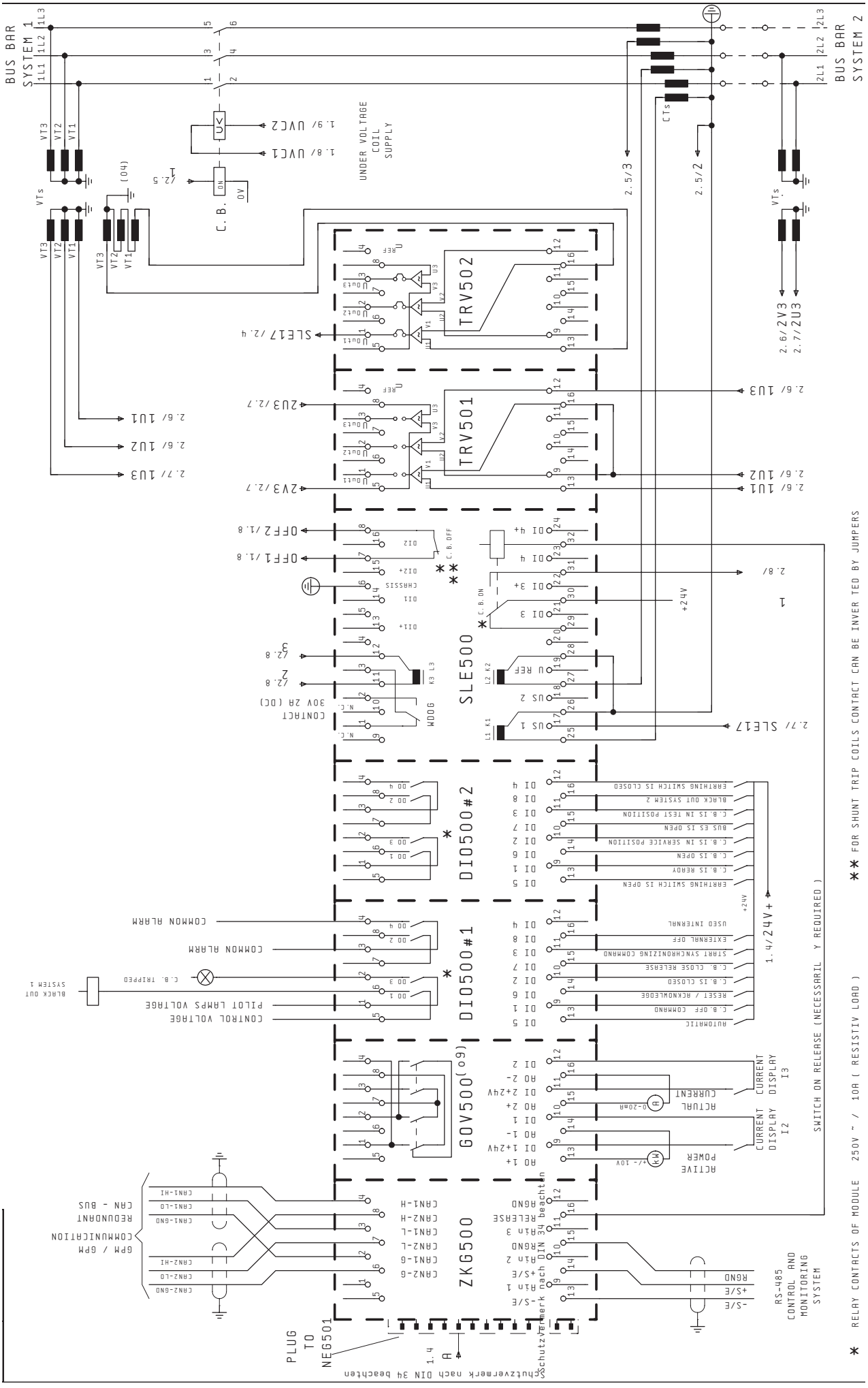


Fig. A-8 MV Bus Tie Breaker (2 of 2)

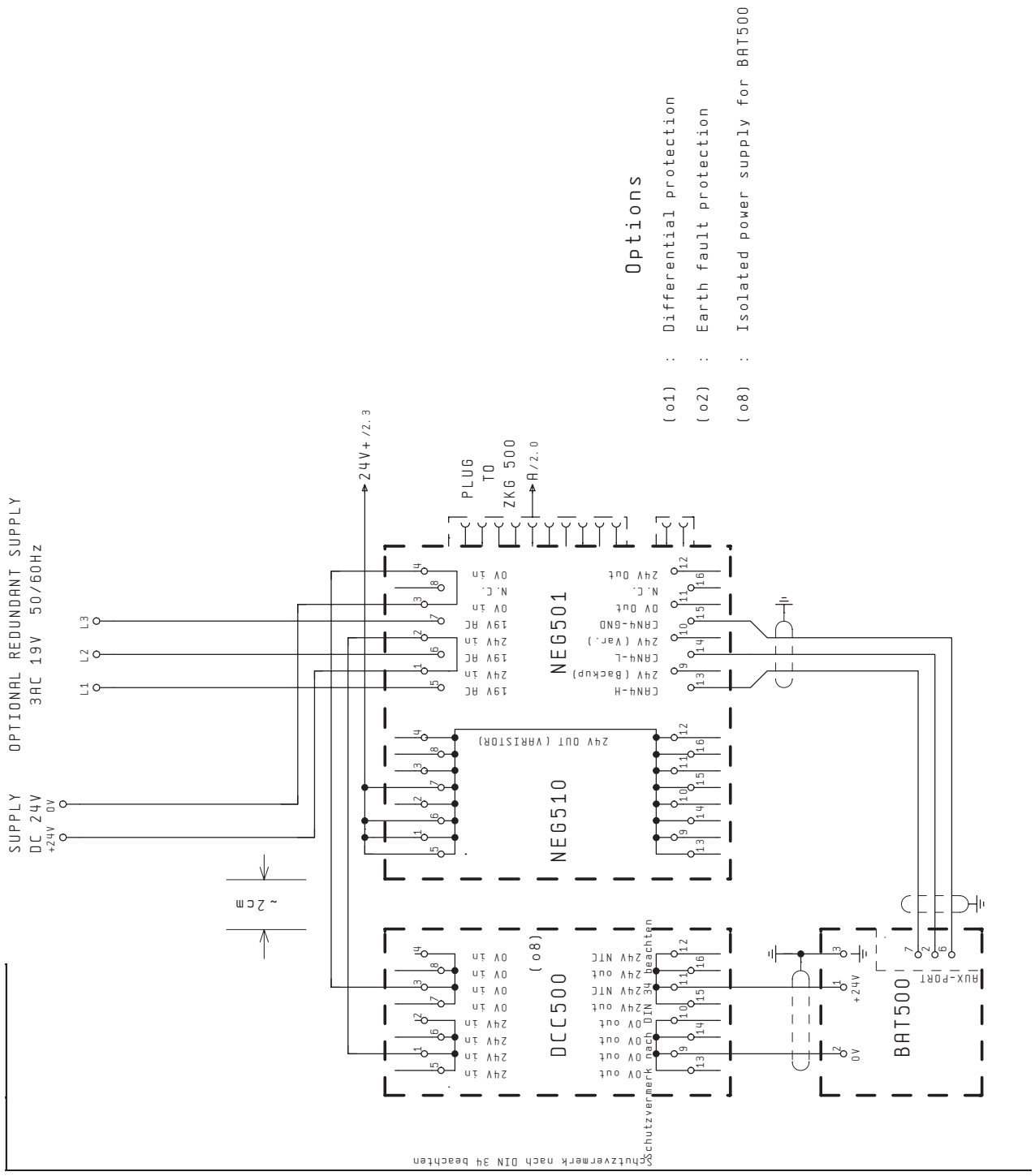


Fig. A-9 MV Consumer (1 of 2)

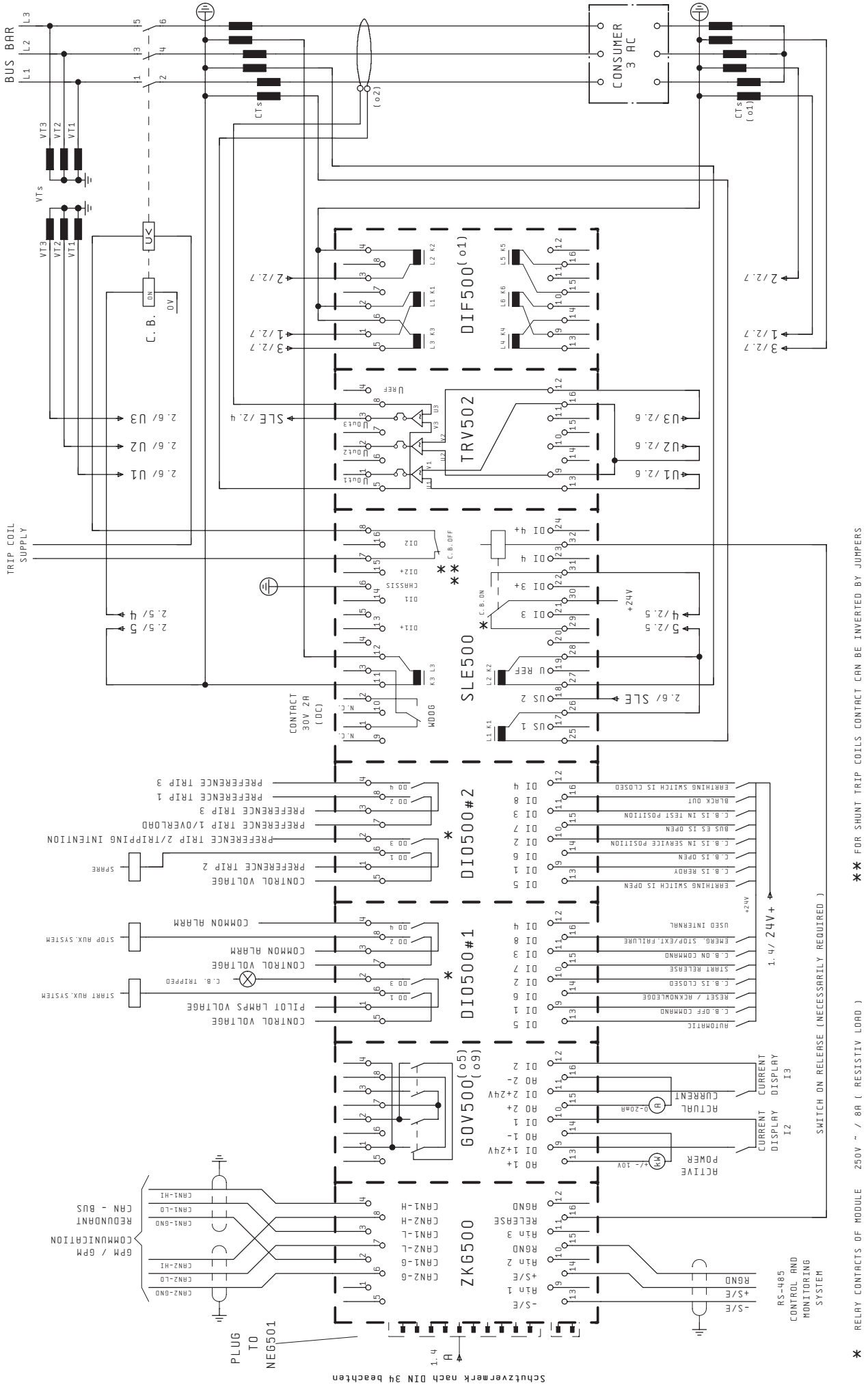


Fig. A-10 MV Consumer (2 of 2)

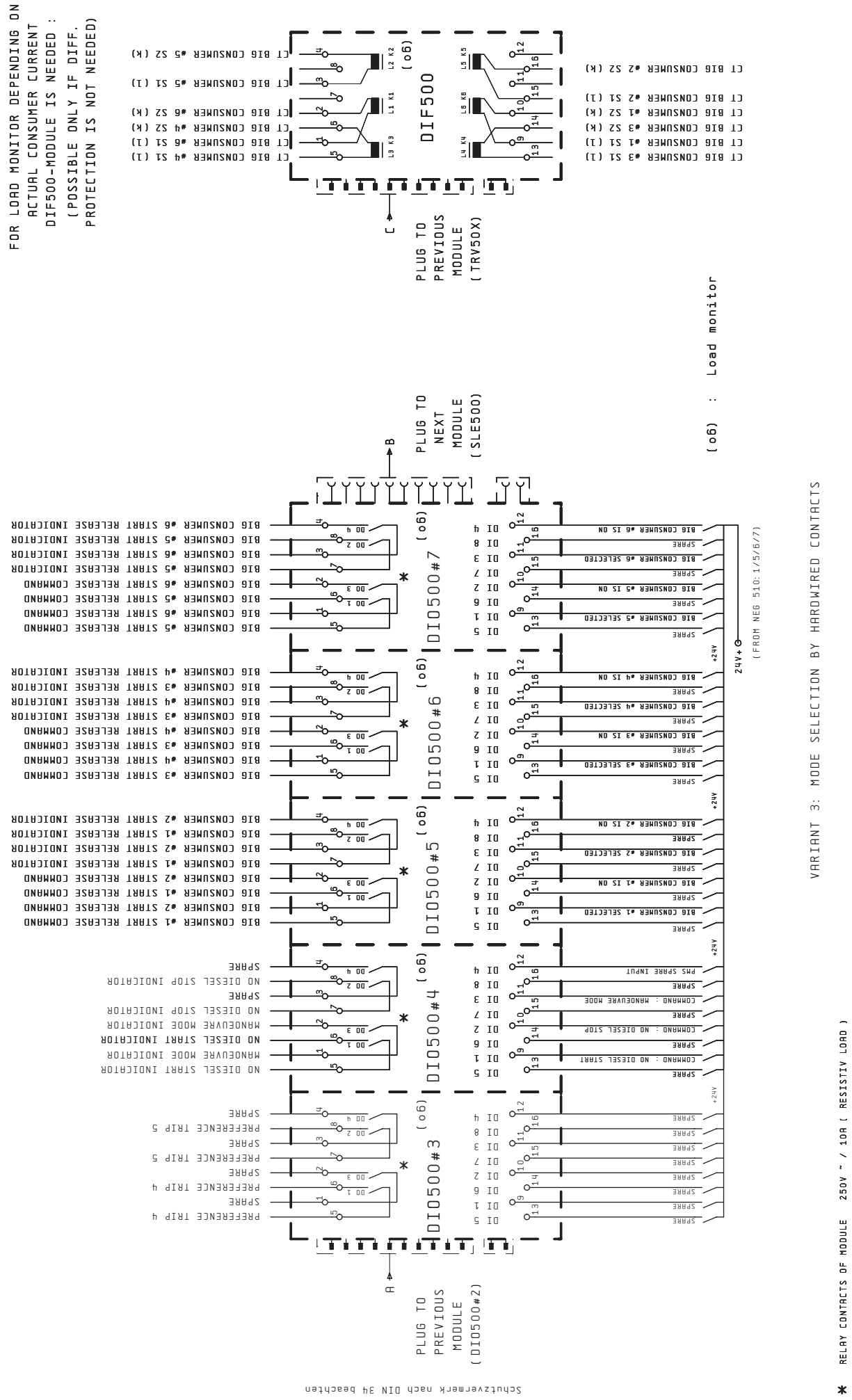


Fig. A-11 Load Monitor (1 of 4)

Fig. A-12 Load Monitor (2 of 4)

Fig. A-13 Load Monitor (3 of 4)

Fig. A-14 Load Monitor (4 of 4)

Annex B

List of Parameters

Param. No.			Grenzwert [%]		Delay time [s]		Funkt.-Code	
Limit / Delay / F.Code	Parameter designation / description	ANSI-Code	Min. Value	Max. Value	Min. Value	Max. Value	Setting (HEX)	Unit / Remarks
1/2/101	Short circuit/ Instant. Overcurrent (Step 1)	50	0	800	0	10		
3/4/102	Short circuit/ Instant. Overcurrent (Step 2)	50	0	800	0	10		
5/6/103	Stator protection	50S	3	100	0	10		
7/8/104	Overcurrent definite time	51	100	400	0	240		
9/10/105	Overcurrent definite time PREALARM	51	100	400	0	240		
11/12/106	Unbalanced Current	46	10	120	0	240		
13/14/107	Unbalanced Current PREALARM	46	10	120	0	240		
15/16/108	Undervoltage	27	50	100	0	240		
17/18/109	Undervoltage PREALARM	27	50	100	0	240		
19/20/110	Overvoltage	59	10	200	0	240		
21/22/111	Overvoltage PREALARM	59	10	200	0	240		
23/24/112	Underfrequency	81L	50	200	0	240		
25/26/113	Underfrequency PREALARM	81L	0	200	0	240		
27/28/114	Overfrequency	81H	0	200	0	240		
29/30/115	Overfrequency PREALARM	81H	0	200	0	240		
31/32/116	Reverse Power	32	-200	0	0	240		
33/34/117	Reverse Power PREALARM	32	-200	0	0	240		
35/36	spare							
37/119	Preferential Trip Step 1 - Current		30	400	0	120		
38/119	Preferential Trip Step 1 - Frequency		0	100	0	120		
39/120	Preferential Trip Step 2 - Current		30	400	0	120		
40/120	Preferential Trip Step 2 - Frequency		0	100	0	120		
41/121	Preferential Trip Step 3 - Current		30	400	0	120		
42/121	Preferential Trip Step 3 - Frequency		0	100	0	120		
43/122	Preferential Trip Step 4 - Current		30	400	0	120		
44/122	Preferential Trip Step 4 - Frequency		0	100	0	120		
45/123	Preferential Trip Step 5 - Current		30	400	0	120		
46/123	Preferential Trip Step 5 - Frequency		0	100	0	120		
47/48/124	Earthfault	51N	0	5000	0	2400		[0,01A] ; [0,1s]
49/50/125	Earthfault PREALARM	51N	0	5000	0	2400		[0,01A] ; [0,1s]
51/52/126	Voltage Displacement	59N	0	120	0	2400		[%] ; [0,1s]
53/54/127	Voltage Displacement PREALARM	59N	0	120	0	2400		[%] ; [0,1s]
55/56/128	Field Failure	40	-200	0	0	240		
57/58/129	Field Failure PREALARM	40	-200	0	0	240		
59/60/130	Underload	37	0	100	0	30000		[%] ; [s]
61/62/131	Underload PREALARM	37	0	100	0	30000		[%] ; [s]
63/64	Start condition 1: Power Limit / Delay	*	0	10000	0	3600		[kW] ; [s]
65/66	Start condition 2: Power Limit / Delay	*	0	0	0	0		[kW] ; [s]
67/68	Stop condition: Power Limit	*	0	30000	0	3600		[kW] ; [s]
69	Consumer 1: Max Power	*	-30000	30000				[kVA
70	Consumer 1: Current Transformer -ratio	*	0	10000				[:1A]
71	Consumer 2: Max Power	*	-30000	30000				[kVA
72	Consumer 2: Current Transformer -ratio	*	0	10000				[:1A]
73	Consumer 3: Max Power	*	-30000	30000				[kVA
74	Consumer 3: Current Transformer -ratio	*	0	10000				[:1A]
75	Consumer 4: Max Power	*	-30000	30000				[kVA
76	Consumer 4: Current Transformer -ratio	*	0	10000				[:1A]
77	Consumer 5: Max Power	*	-30000	30000				[kVA
78	Consumer 5: Current Transformer -ratio	*	0	10000				[:1A]
79	Consumer 6: Max Power	*	-30000	30000				[kVA
80	Consumer 6: Current Transformer -ratio	*	0	10000				[:1A]
81	Overcurrent inverse time	51			0	300		[10ms]
82	Overcurrent inverse time PREALARM	51			0	300		[10ms]

Param. No.			Grenzwert [%]		Delay time [s]		Funkt.-Code	
Limit / Delay / F.Code	Parameter designation / description	ANSI-Code	Min. Value	Max. Value	Min. Value	Max. Value	Setting (HEX)	Unit / Remarks
83	Startfailure				0	3600		
84	Stopfailure				0	3600		
85/86	spare		1	1	1	0,01		
87	Synchronization failure				0	240		[0,01s]
88..92	spare							
93	Load sharing: Ramp		0	1000				[0,1 %/sec]
94//132	Differential Protection (2.Harmonics)	87	0	999				[0,1%]
95//132	Differential Protection ("ku")	87	0	800				
96//132	Differential Protection ("a1")	87	-800	800				
97//132	Differential Protection ("v1")	87	-800	800				
98//132	Differential Protection ("a2")	87	-800	800				
99//132	Differential Protection ("v2")	87	-800	800				
100	Start block	50/51LR	0	300				[0,1s]
133	Analog Output 1 OFFSET		-1000	1000				[0,01V]
134	Analog Output 2 OFFSET		-2000	2000				[0,01mA]
135	Bitmask CAN0		0	$FFFF				
136	Linebreak Engine fail./ Emerg. STOP -Fct.		0	$FFFF				
137	spare		0	0				
138	spare		0	0				
139	spare		0	0				
140	spare		0	0				
141	No. Start Attempts/ Overcurr.IDMT -Funct.	66/ 51	0	$FFFF				
142	Time start att./ Overcurr.IDMT PREALARM -Funct.		0	$FFFF				
143	Starting Attempts / Start failure -Function	66	0	$FFFF				
144	Stop failure -Function		0	$FFFF				
145	spare		0	$FFFF				
146	Phasefailure / Neg. sequence -Function	47	0	$FFFF				
147	Synchr. mode / Synchr. failure -Function		0	$FFFF				
148	Breaker failure -Function		0	$FFFF				
149	Voltage-NEG1 -Function		0	$FFFF				
150	Voltage-NEG2 -Function		0	$FFFF				
151	CAN0 failure -Function		0	$FFFF				
152	CAN1 failure -Function		0	$FFFF				
153	CAN2 failure -Function		0	$FFFF				
154	CAN4 failure -Function		0	$FFFF				
155	FLASH failure -Function		0	$FFFF				
156	EEPROM failure -Function		0	$FFFF				
157	Protection software failure -Function		0	$FFFF				
158	Engine failure / Emergency Stop -Function		0	$FFFF				
159	spare		0	0				
160	Rated Voltage	*	0	15000				[V]
161	Device No. / Device Type	*	0	$FFFF				
162	Up No. / Down No.	*	0	$FFFF				
163	Rated Current	*	0	32767				[A]
164	Rated Power	*	0	32767				[kW]
165	Rated Frequency 0.1 Hz]	*	150	1000				[0,1 Hz]
166	Voltage Transformer - ratio]	*	1	16000				[:100V]
167	Current Transformer -ratio prim.	*	1	30000				[:1A]
168	Current Transformer -ratio sec.1	*	1	30000				[:1A]
169	Current Transformer -ratio sec.2	*	1	30000				[:1A]
170	Load distribution: Amplification Power control		0	1000				
171	Load distribution: Amplification Freq. control		0	1000				
172	Load distribution: Deadband 0.1%]		0	1000				[0,1%]

Param. No.			Grenzwert [%]		Delay time [s]		Funkt.-Code	
Limit / Delay / F.Code	Parameter designation / description	ANSI-Code	Min. Value	Max. Value	Min. Value	Max. Value	Setting (HEX)	Unit / Remarks
173	Load distribution: Pulse length		0	32000				[ms]
174	Load distribution: Pulse interval		0	32000				[ms]
175	Load distribution: Topload		0	0				
176	Engine cool down time		0	32767				[0,1s]
177	Displacement angle Secondary coil 1		0	3599				[0,1°]
178	Displacement angle Secondary coil 2		0	3599				[0,1°]
179	Rated Voltage Secondary coil 1		0	15000				[V]
180	Rated Voltage Secondary coil 2		0	15000				[V]
181	Synchronisation – Phase Angle	25	0	30				[°]
182	Synchronisation – Voltage Difference	25	0	99				[%]
183	Synchronisation – Frequency Difference	25	0	99				[0,01%]
184	Synchronisation – Voltage Levitation	25	0	99				[%]
185	Switch-on release -voltage % Urated]		-200	200				[% Unenn]
186	Analog Output 1 Scale		-9999	9999				nom.=x *0,01V
187	Analog Output 2 Scale		-9999	9999				nom.=x *0,01V
188	TRV-module type		0	$FFFF				
189	Blackout Start / Loadmonitor Start		0	$FFFF				(Bit 0 ... Bit3)
190	Blackout Start 0.1	76	0	999				[0,1s]
191	ZCT (Zero-sequence Current Transf.) ratio		0	10000				[:1A]
192	Amplification SYNC controller		0	100				[%]
193	EEPROM Checksum		0	$FFFF				set via BAT only
194	Display smoothing filter		0	32767				set via BAT only
195	Operation hours equivalent (Byte 2&3)		0	$FFFF				set via BAT only
196	Operation hours equivalent (Byte 0&1)		0	$FFFF				set via BAT only
197	Start priority, digit		0	12				set via BAT only
198	Load limit 0.1%]		0	1000				set via BAT only
199	spare		0	0				set via BAT only
200	spare		0	0				set via BAT only

Annex C

Modbus protocoll

MODBUS Reg. Adr.	MODBUS Reg. No.	Bit	Designation	ANSI-Code	Content
0	40001		Dummy		
1	40002		I L1		Current phase 1
2	40003		I L2		Current phase 2
3	40004		I L3		Current phase 3
4	40005		U12		Gen. Voltage U12
5	40006		U23		Gen. Voltage U23
6	40007		U31		Gen. Voltage U31
7	40008		Umains		MSB-Voltage
8	40009		Pw		Effective power
9	40010		Pa		Apparent power
10	40011		fgen		Gen. Frequency
11	40012		fmains		MSB-Frequency
12	40013	0	Breaker 1 Status		00 = Open
		1	Breaker 1 Status		01 = Closed
		2	- Isolation Contactor OFF (ISOLATED)		10 = Undefined
		3	- Earthing Contactor ON (EARTHED)		11 = Tripped
		4	- Contactors undefined		
		5	x		
		6	x		
		7	x		
		8	*		
		9	*		00 - 10 (decimal) :
		10	*		
		11	*		Numerical status indication
		12	*		
		13	*		
		14	*		
		15			
13	40014	0			
		1			
		2			
		3	Start Passing / Delayed Stop		
		4	Running		
		5	Manuvre mode		
		6	NO DG STOP		
		7	NO DG START		
		8	Breaker 2 Status		00 = Open
		9	Breaker 2 Status		01 = Closed
		10	- Isolation Contactor OFF		10 = Undefined
		11	- Earthing Contactor ON		11 = Tripped
		12	- Contactors undefined		
		13	*		
		14	*		
		15			

MODBUS Reg. Adr.	MODBUS Reg. No.	Bit	Designation	ANSI-Code	Content
14	40015	0 1 2 3 4 5 6 7	Start Priority		Start Priority = Prio.-No
		8 9 10 11 12 13 14 15	Emergency Stop Breaker tripped Collective Alarm Automatic BB Earth Connect. Open Remote Topload activated Spare		EM-Stop from GPM 500 Breaker tripped Collective Alarm Automatic Busbar earth conn. Open Remote Topload activated
15	40016	0 1	Short circuit 1	50	Alarm 1
		2 3	Short circuit 2	50	Alarm 2
		4 5	Stator Protection	50	Alarm 3
		6 7	Over current	51	Alarm 4
		8 9	Over current Warning	51	Alarm 5
		10 11	Unballanced current	46	Alarm 6
		12 13	Unballanced current Warning	46	Alarm 7
		14 15	Under voltage	27	Alarm 8
16	40017	0 1	Under voltage Warning	27	Alarm 9
		2 3	Over voltage	59	Alarm 10
		4 5	Over voltage Warning	59	Alarm 11
		6 7	Under frequency	81L	Alarm 12
		8 9	Under frequency Warning	81L	Alarm 13
		10 11	Over frequency	81H	Alarm 14
		12 13	Over frequency Warning	81H	Alarm 15
		14 15	Reverse power	32	Alarm 16

MODBUS Reg. Adr.	MODBUS Reg. No.	Bit	Designation	ANSI-Code	Content
17	40018	0 1	Reverse power Warning	32	Alarm 17
		2 3	Spare		Alarm 18
		4 5	Preferential trip 1		Alarm 19
		6 7	Preferential trip 2		Alarm 20
		8 9	Preferential trip 3		Alarm 21
		10 11	Preferential trip 4		Alarm 22
		12 13	Preferential trip 5		Alarm 23
		14 15	Earth fault	50N	Alarm 24
18	40019	0 1	Earth fault Warning	50N	Alarm 25
		2 3	Displacement	59N	Alarm 26
		4 5	Displacement Warning	59N	Alarm 27
		6 7	Field failure	40	Alarm 28
		8 9	Field failure Warning	40	Alarm 29
		10 11	Underload	37	Alarm 30
		12 13	Underload Warning	37	Alarm 31
		14 15	Differential protection	87	Alarm 32
19	40020	0 1	Spare		Alarm 33
		2 3	Spare		Alarm 34
		4 5	Spare		Alarm 35
		6 7	Spare		Alarm 36
		8 9	Spare		Alarm 37
		10 11	Spare		Alarm 38
		12 13	Spare		Alarm 39
		14 15	Spare		Alarm 40

MODBUS Reg. Adr.	MODBUS Reg. No.	Bit	Designation	ANSI-Code	Content
20	40021	0 1	Over current 2	51	Alarm 41
		2 3	Over current 2 Warning	51	Alarm 42
		4 5	Start failure		Alarm 43
		6 7	Stop failure		Alarm 44
		8 9	No PMS-Start		Alarm 45
		10 11	Phase failure	47	Alarm 46
		12 13	Synchronising failure	25	Alarm 47
		14 15	Breaker failure	62BF	Alarm 48
21	40022	0 1	Voltage NEG 1		Alarm 49
		2 3	Voltage NEG 2		Alarm 50
		4 5	CAN 0 failure		Alarm 51
		6 7	CAN 1 failure		Alarm 52
		8 9	CAN 2 failure		Alarm 53
		10 11	CAN 4 failure		Alarm 54
		12 13	Checksum FLASH		Alarm 55
		14 15	Checksum EEPROM		Alarm 56
22	40023	0 1	Checksum Protect. SW		Alarm 57
		2 3	Diesel failure		Alarm 58
		4 5	RS485 failure		Alarm 59
		6 7	Spare		Alarm 60
		8 9	Spare		Alarm 61
		10 11	Spare		Alarm 62
		12 13	Spare		Alarm 63
		14 15	Spare		Alarm 64

MODBUS Reg. Adr.	MODBUS Reg. No.	Bit	Designation	ANSI-Code	Content
23	40024		Topload setting [0.1 %]		
24	40025		Maxload setting [0.1 %]		
25	40026		Additional spare power [kW]		
26	40027		Spare		
27	40028		**Command extension**		
28	40029		**Command**		
29	40030		Spare		
…	…		Spare		
99	40100		Spare		
100	40101		Parameter (no access)		
…	…		Parameter (no access)		
299	40300		Parameter (no access)		