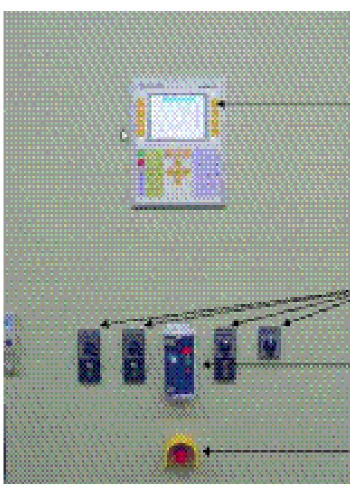
Jenbacher DIA.NE XT Control

Description of Document **Page Number**

CHECK WITH LOCAL UTILITIES FOR RELAY AND SYNCHRONIZER APPROVALS



Up-Dated October 2010

Blank Page for Notes

DIA.NE XT

DIA.NE XT

DIALOG NETWORK NEXT GENERATION

1 Introduction

DIA.NE XT is a new engine management system which GE Jenbacher has introduced for all of its types. The system is based on a powerful central industrial control system which takes on the tasks of the closed-loop module control system, the open-loop module control system and module visualisation. The coupling to the central control system is customer-specific and takes place via standardised industrial bus connections or direct signal lines.

One of the main goals when developing **DIA.NE XT** was the perfect combination of powerful and flexible control electronics on the one hand and a user-friendly operation concept on the other. The innovative hardware concept is made of state-of-the-art components and sets new standards when it comes to power, functionality and reliability of operation. The visualisation unit with colour VDU provides a clear and understandable overview of all information and measured values and is extremely user-friendly.

2 Assembly

DIA.NE XT is composed of the following units (see illustration 1):

A) A central industrial control system for closed-loop and open-loop control and visualisation
B) Decentralised input/output modules in the module control cabinet
C) Connections to intelligent sensors and actuators on a CAN-bus basis
D) Decentralised input/output modules on the engine

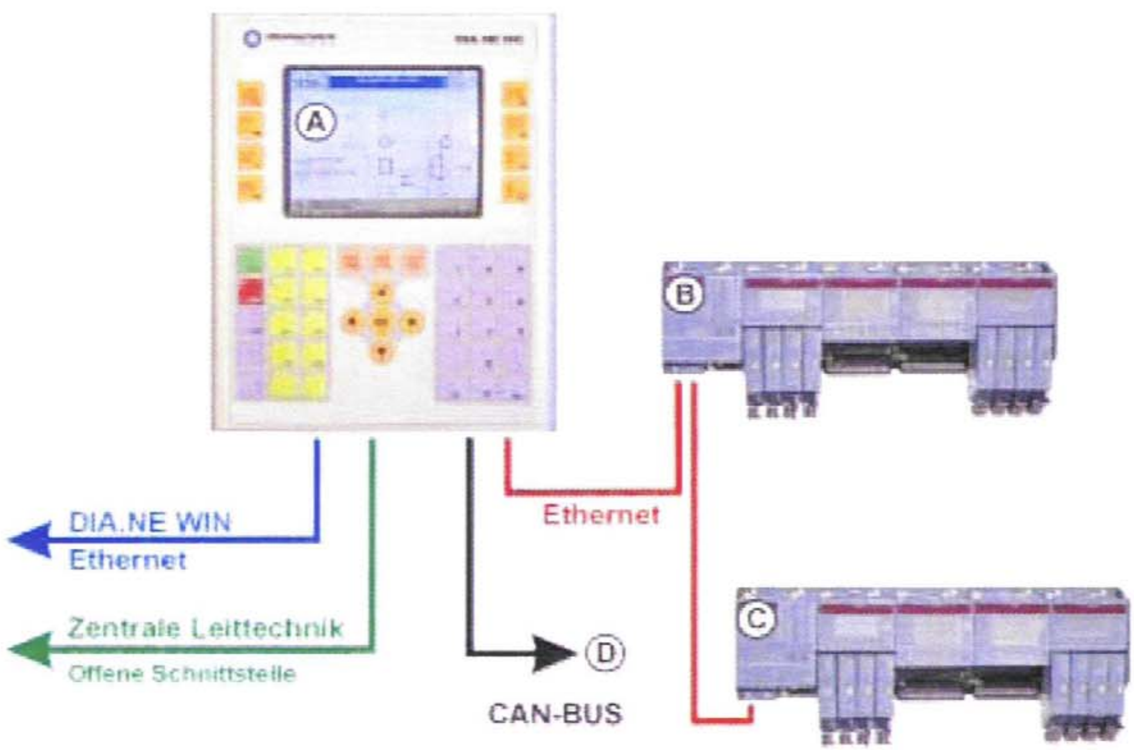


Illustration 1

The various components are connected via Ethernet and CAN BUS-based, interference-free industrial bus media. All measurement data are communicated to the module itself by means of a decentralised I/O concept. The integrated application of state-of-the-art technology therefore reduces the number of electrical connections to the module, thus also reducing possible sources of problems to an absolute minimum.

2.1 Central industrial control system

The central industrial control system, supported by a powerful CPU, performs all module visualisation, closed-loop and open-loop module control functions.
The multi-tasking operating system guarantees the efficient handling of all control and visualisation steps. Multi-tasking assigns the available processor capacity to various programs. Several tasks can therefore be performed within a predefined period of time, a feature guaranteed by the powerful control structures within the operating system. Multi-tasking for DIA.NE XT therefore means that system functions and application programs all run parallel in real time.
The central industrial control system program, the controller parameters and the historical alarm management data are all stored in a flash memory, well protected in case of a power interruption.

The measurement values of the decentralised inputs and outputs are updated through special I/O processors. This ensures that the CPU load is reduced, even in the case of an increased number of I/Os. The Bus medium used is CAN Bus and Ethernet technology.

The most important I/O bus characteristics are:
real-time data transfer,
established protocol,
higher data throughput rate.

The DIA.NE WIN Server and the central control system (optional) are connected directly to the central industrial control system.

2.1.1 Visualisation unit

The visualisation unit increases the operational reliability and provides an ease of use which meets the highest expectations. The visualisation unit comes with a 5.7" QVGA LCD colour VDU and performs all display and control functions. A fully fledged operational control system provides support for the operator, explaining the logical coherence and any operational steps to be taken. A multi-layer user access management system prevents unauthorised user actions. Because (automatic) control and visualisation are handled by the same processor, rapid updating of the information displayed on the VDU is guaranteed.

The VDU contains a clear and functional summary of the measured values. All values are presented graphically. The system is operated using screen selection and function keys. System messages and screen texts are all displayed in the language selected.

In addition to the usual process diagrams, the auxiliary equipment condition, the most important engine measurement values and, in the case of a failure, the engine measurement data recorded before the failure occurred are all arranged in tabulated form.

Illustration 2 contains some DIA.NE XT screen pages. The screens are divided into a status section (screen name / capacity / operational module condition), a measured value section with graphical elements and a function key section (various more detailed subscreens).

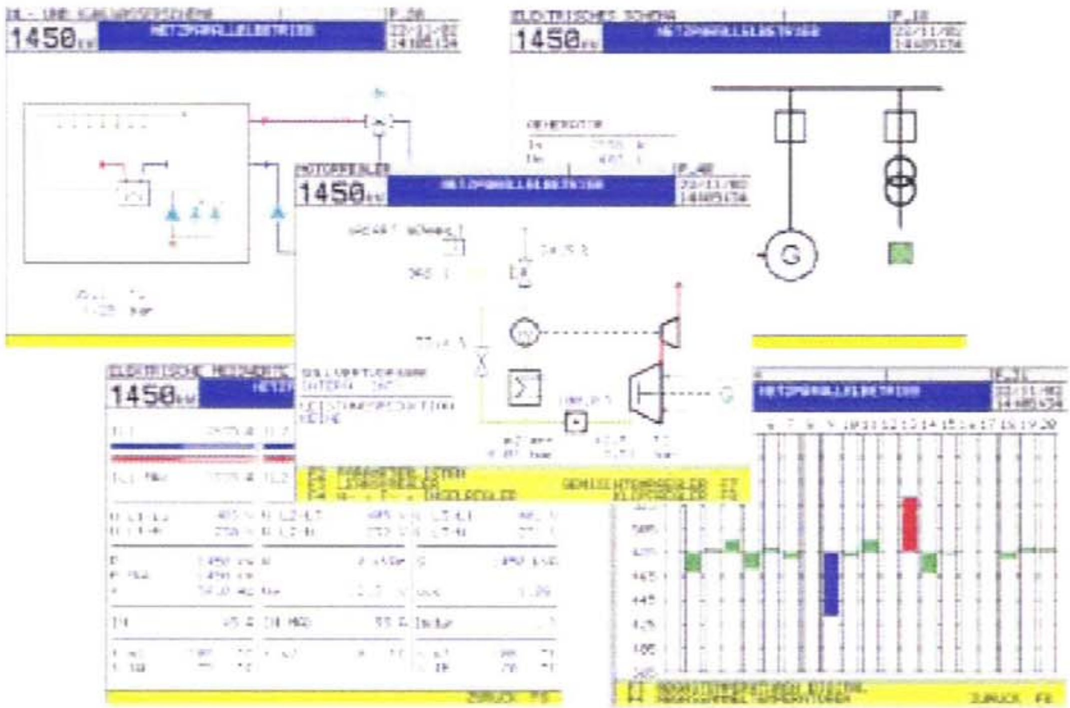


Illustration 2

In addition to the above, DIA.NE XT also performs two special functions:

alarm management and
real-time trend display and failure-trend display.

The **DIA.NE XT** alarm management provides the user with a powerful diagnostic tool. All failure messages are displayed in plain text and are arranged in tabulated form. The sequence of events can be clearly seen from the time indication attached to the failure messages. The historic alarm management records up to 1000 alarm, warning and operational messages.

Illustration 3

For the module and installation controllers, the real-time chronological trends of the relevant measured values (online trends) are displayed in a multi-colour trend overview. To simplify failure analysis, the failure trend is halted 30 seconds after the failure has occurred, thus enabling a detailed representation of relevant measurement values up to shortly before the failure occurred. This enables the user to determine exactly the condition of the machine and the course of the failure.

2.1.2 Closed-loop module control system

Fully fledged control algorithms in combination with digital techniques are applied to enable closed-loop module control. The algorithms implemented for the throttle-valve, turbocharger-bypass, gas-mixer (LEANOX control, see chapter 3 Engine management functions) and ignition-point controllers have proven themselves over long years of practical service. The closed-loop module control system can be extended for special applications based on the specifications of the installation involved.

2.1.3 Open-loop module control system

The central industrial control system is also responsible for performing the open-loop module control functions, i.e. the coordination of all auxiliary plants and installations, and monitoring of the normal operational condition of the module. The open-loop and closed-loop control systems are therefore intertwined.

For various closed-loop tasks to be performed on the installation (cooling water temperature control, ambient air temperature control, etc.), DIA.NE XT can be equipped with up to 8 optional PID controllers with mA output or three-point control.

2.2 Decentralised input/output modules

The inputs/outputs of the central industrial control system are an important part of the process interface. Depending on customer specifications, the control system can be equipped with digital inputs/outputs, PT100 inputs and thermocouple inputs. However, for more specialist applications, inputs for encoders, counters, various DC voltages etc. are also available. To minimise the amount of cabling from the engine to the central industrial control system, the I/O modules are equipped with a so-called PowerLink I/O Bus. PowerLink is based on 100Mbaud Ethernet technology. Using a specially modified transmission protocol, real-time ability and deterministic operation can be guaranteed at 1 ms update rates. In the case of defective I/O modules, the powerful diagnostic capacity of the PowerLink system enables quick detection and remedying of the failure.

2.3 Connections to intelligent sensors and actuators

Depending on their equipment, GE Jenbacher modules are fitted with 1 to 13 intelligent sensors/actuators. These are distributed all over the engine. Parameters, measured values and information on failures are sent via the interference-free and efficient CAN Bus system.

If required, the following equipment is integrated into the CAN Bus system:

Name	Function	
Ignition system	Electronic high-capacity ignition system	
MONIC	Automatic ignition-voltage measurement system	Optional
KLS98	Cylinder-specific misfiring detection system	Type 4, optional
TecJet:	Fuel gas dosing system	Type 4

2.4 Connection to DIA.NE WIN

All modules of the installation are connected to the DIA.NE WIN Server via an Ethernet network. The DIA.NE WIN Server facilitates easy remote maintenance of the module, thus enabling a quick diagnosis and coordinated service planning. DIA.NE WIN comes as an option. The comprehensive functions and options offered by DIA.NE WIN are explained in a set of documents available from GE Jenbacher.

2.5 Connection to the central control system

Standardised industrial bus systems are used to establish the customer-specific connection between the open-loop module control and the central control system.
When connecting the computers, the customer can choose between Modbus, Siemens 3964, Profibus DP and GE Jenbacher specific connections. Digital and analog interfaces are also often used for the connection to a central control system.

3 Engine management functions

The modular structure using a powerful CPU made it possible to create a central control system that can comply with all closed-loop and open-loop control requirements both quickly and reliably.

Illustration 4 contains a diagram of the closed-loop control structure of DIA.NE XT showing the location of all sensors and actuators (Note: this overview was taken from a DIA.NE WIN screen).

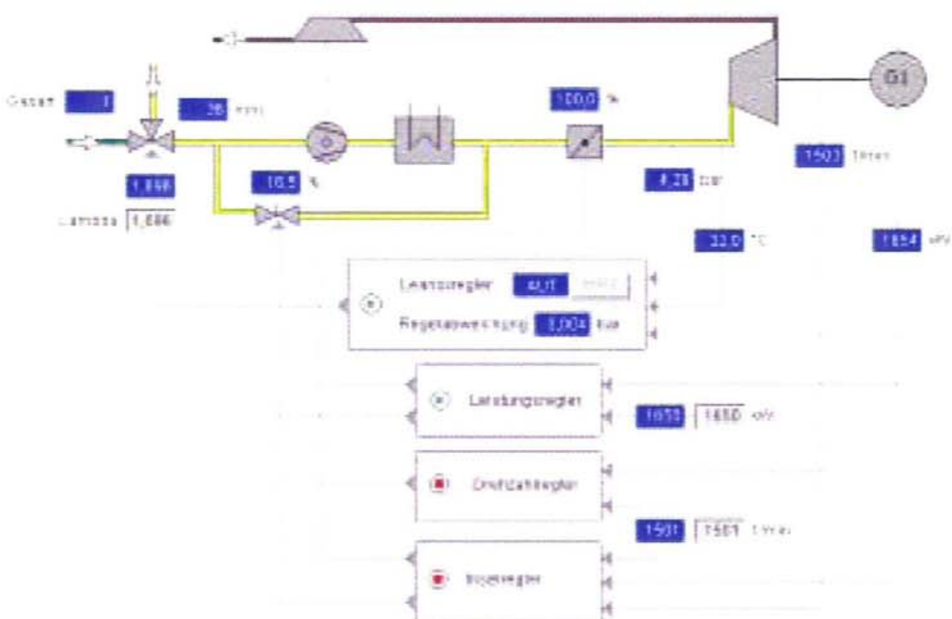


Illustration 4

As the superimposed control system, the engine management guarantees a controlled sequence and coordination of all control functions. The engine is started according to a preset start-up program, for example. This program ensures that the preset values for the speed controller, the gas-mixer settings and the control of the gas valves and the ignition are coordinated. The engine management guarantees that all safety and control functions run in the background at all times. The engine management also controls the auxiliary equipment.

3.1 Speed control

The function of the electronic speed control is to keep the engine speed of a machine to a preset speed setting, even if the load conditions vary. To this end, the actual engine speed is compared to the preset engine speed, and is then matched to it by altering the setting of the throttle valve.

3.2 Idling controller

During module start-up or idling operation, the speed controller has a specific setting in relation to the idling conditions. Depending on the external control settings of the module, an idling lambda controller determines the optimal lambda settings for the idling operation, thus ensuring that any speed deviations are quickly adjusted and that the preset synchronisation speed is quickly achieved.

3.3 Isolated-operation controller

In isolated operation, a constant engine speed is required even when loads are switched on and off. This function is also carried out by the speed controller in a specific setting using a load-dependent parameter diagram. The parameter diagrams are optimised for every engine series. For the transition to isolated operation, special algorithms are implemented to enable quick load shedding or switching loads on.

When several machine groups operate in parallel in an isolated grid (e.g. emergency power operation), there is the risk that when using strict speed control only, the required power output will not be distributed evenly over the modules available. That is the reason for having two types of power distribution:

3.3.1 Power distribution via an equalising line

The average value of the individual engine power outputs is calculated and made available via the equalising line to the controller, which uses it as a target value. When operating via an equalising line the power distribution is accurate and the grid frequency is held exactly.

3.3.2 Power distribution using offset coefficient control

A power distribution system that uses offset coefficient control lowers the desired engine speed as the power output increases. If every engine responds in the same way, then a certain operating point sets in at which all engines deliver the same power.

3.4 Output regulator

In mains parallel operation, the engine is controlled by an output regulator in order to strictly maintain the designated output. In this particular case, the engine speed is preset by the grid frequency. The actual power output of the generator is compared to the designated power output, and is then matched accordingly by adjusting the throttle valve and turbocharger bypass positions.

The customer has numerous ways of entering power setpoint values via the engine management. This makes it also possible to implement automatic power reduction when critical engine conditions arise (e.g. knocking, misfiring).

3.5 LEANOX controller

This optimised exhaust emission can only be achieved by operating lean-mix engines with the correct air excess ratio (Lambda). This principle exploits the direct link between NOx emissions and the air excess ratio to achieve minimum exhaust emissions values. The patented GE Jenbacher LEANOX control system is based on the physical relationship between the air excess ratio Lambda and the parameters power, boost pressure and air-gas mixture temperature. A control system based on these principles has the great advantage that all these quantities can be measured easily and reliably using a cost-efficient measuring process, and that the air ratio Lambda can be calculated exactly. The system eliminates the need for measuring probes in the exhaust system, which can be subject to ageing. This means that the emissions targets can be met reliably.

The task of the LEANOX controller is to calculate and adjust the optimum boost pressure by changing the gas-mixer position, based on the current power output, the current speed and the current air-gas mixture temperature. The linear relationship between the quantities is calculated automatically by DIA.NE XT after two of the operating points have been stored to memory.

The LEANOX controller switches itself on automatically once the actual power output exceeds a predefined threshold value.

The program provides four different sets of parameters for different types of fuel gas. Interpolation between the first two parameter sets based on a gas-quality signal enables emission control for varying gas compositions.

A PI-controller is used for the actual control. In types 2, 3 and 6, the actuator is a stepper motor, which adjusts the gas mixer to change the air ratio. In type 4 engines, the fuel gas is added using a gas-dosing valve. In that case, the LEANOX control influences the preset fuel gas quantity.

3.6 Knock control system

Knocking is uncontrolled ignition caused by the spontaneous ignition of a gas/air mixture in the combustion chamber. This causes superposition of high-frequency gas vibrations with the combustion pressure, and thus high thermal and mechanical component loads. That is why knocking can cause serious damage to the engine within a very short period of time.
However, to enable the primary energy to be used as efficiently as possible (apart from via other engine settings), the pre-ignition must be as close to full as possible, and that requires an engine operating point which is as close to the knock limit as possible.

The knock-resistance of an engine is influenced by various parameters, such as compression ratio, ignition point, combustion chamber temperature, mixture temperature, charge pressure, combustion chamer geometry and spark-plug positioning. A higher power setting will for example result in a higher combustion-chamber temperature, thus increasing the risk of knocking, as would an early ignition point.
One of the important factors for the knock-resistance of the fuel gas is the methane value. This value serves comparison purposes and indicates the mixture ratio of a gas mixture composed of H_2 and CH_4 with an equal knock resistance in precisely defined test conditions. A methane value of 75 means that the knock resistance of the relevant gas is equal to a mixture of 75 % CH_4 and 25 % H_2. Pure methane has a methane value of MV = 100, pure hydrogen a methane value of MV = 0.

Among the factors that have the biggest effect on the methane value are the liquid gas additives added by the gas supply companies at peak hours. Propane/butane with the same calorific value and wobbe index as the fuel gas and air are added. This means that although the customer is supplied with gas with the same calorific value, the methane value of the fuel gas may be reduced dramatically, resulting in knocking if the engine parameter settings were to remain the same.

To prevent damage caused by knocking, a knock control system must be activated under certain operational conditions.

The DIA.NE XT system integrates two different knock control systems for GE Jenbacher engines.

3.6.1 Knock detection using analog knock sensors

In this case, two cylinders are for example monitored by one knock sensor (structure-borne noise pickup) (see ill. 5).

Signal generation for a knock sensor with structure-borne noise pickup:

Illustration 5

If one or both cylinders starts to show knocking behaviour, the ignition point of all cylinders is adjusted towards 'late' and the pre-ignition is reduced accordingly within the preset range. Should this measure not be sufficient, the output is reduced until the knocking behaviour stops. The power is subsequently slowly increased to the preset power setting and/or until knocking starts again, and the ignition point is optimised accordingly.

If the engine still shows knocking behaviour despite the power being reduced and the ignition point being adjusted, the module is switched off after a certain period of time. This switch-off period, the speed at which the power is reduced/increased and the ignition point can be set using the parameters within the DIA.NE XT engine management system.

If hydraulics are integrated into the system, mixture cooling can be changed into water cooling, thus lowering the mixture temperature whenever the knock sensor signal is exceeded and after the ignition point has been adjusted (ill. 6).

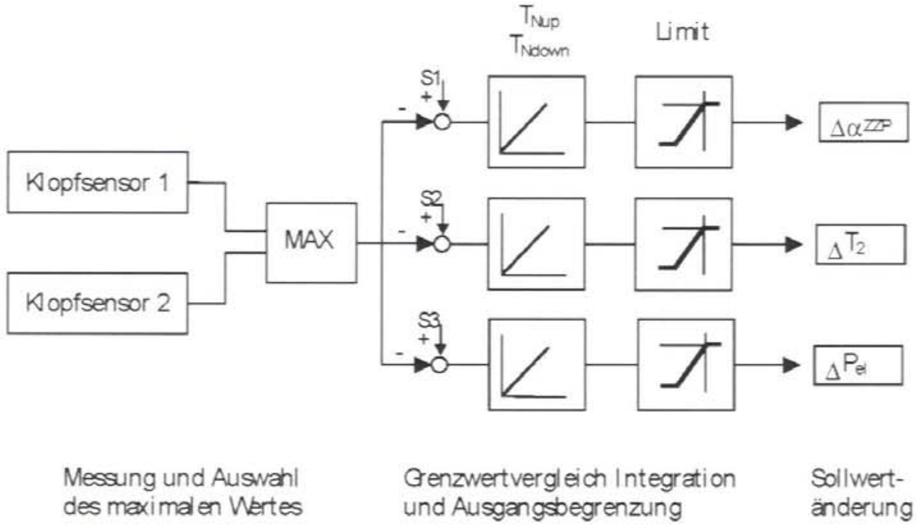


Illustration 6

A combination of these measures will protect the engine from damage caused by knocking in the event of methane value deviations, guaranteeing that the engine is operating at its optimum degree of efficiency and maximum load.

3.6.2 Knock detection using the KLS98 knock detection system

The KLS98 knock detection system detects every cylinder's structure-borne noise signal using its own knock sensor system on the cylinder head. Taking into account the crankshaft-angle dependent timing window, the KLS98 knock detection system is able to distinguish between structure-borne noise as a result of knocking as compared to structure-borne noise caused by mechanical components such as valves, pistons etc.

This enables the system to adjust the ignition point per cylinder if knocking is detected, keeping the engine as close as possible to the optimum degree of efficiency.

If other mechanical noises, mostly resulting from a mechanical failure, exceed a certain threshold value, the module switches off, thus preventing further consequential damage.

To be able to handle the huge data flow, one KLS98 evaluation module is always connected to two cylinders. The KLS98 evaluation module is equipped with a powerful signal processor and provides DIA.NE XT with processed data via the CAN Bus.

The cylinder-specific ignition point is also adjusted via the CAN Bus into which the high-capacity ignition system is integrated.

The KLS98 knock detection system comes standard with type 4 engines and is optional for all other types.

3.7 Ignition voltage measurement

The optional ignition voltage measurement system **MONIC** is also connected to DIA.NE XT via the CAN Bus. MONIC considerably reduces the time required to check the ignition voltage regularly. The most important advantage of the system, however, is the fact that the automatic ignition voltage measurement makes it possible to monitor the ignition voltage via DIA.NE WIN and thus by remote data transfer. If the ignition-voltage threshold values (which can be parameterised) are exceeded or underrun, a corresponding warning will be generated in the alarm management system. This warning, which can be issued on-site or can be automatically transferred by remote data transfer, is channelled through the Hermes auto alarm activation to indicate the necessity of maintenance .

4 Summary

DIA.NE XT is the perfect combination of powerful and flexible control electronics with a user-friendly operation concept.

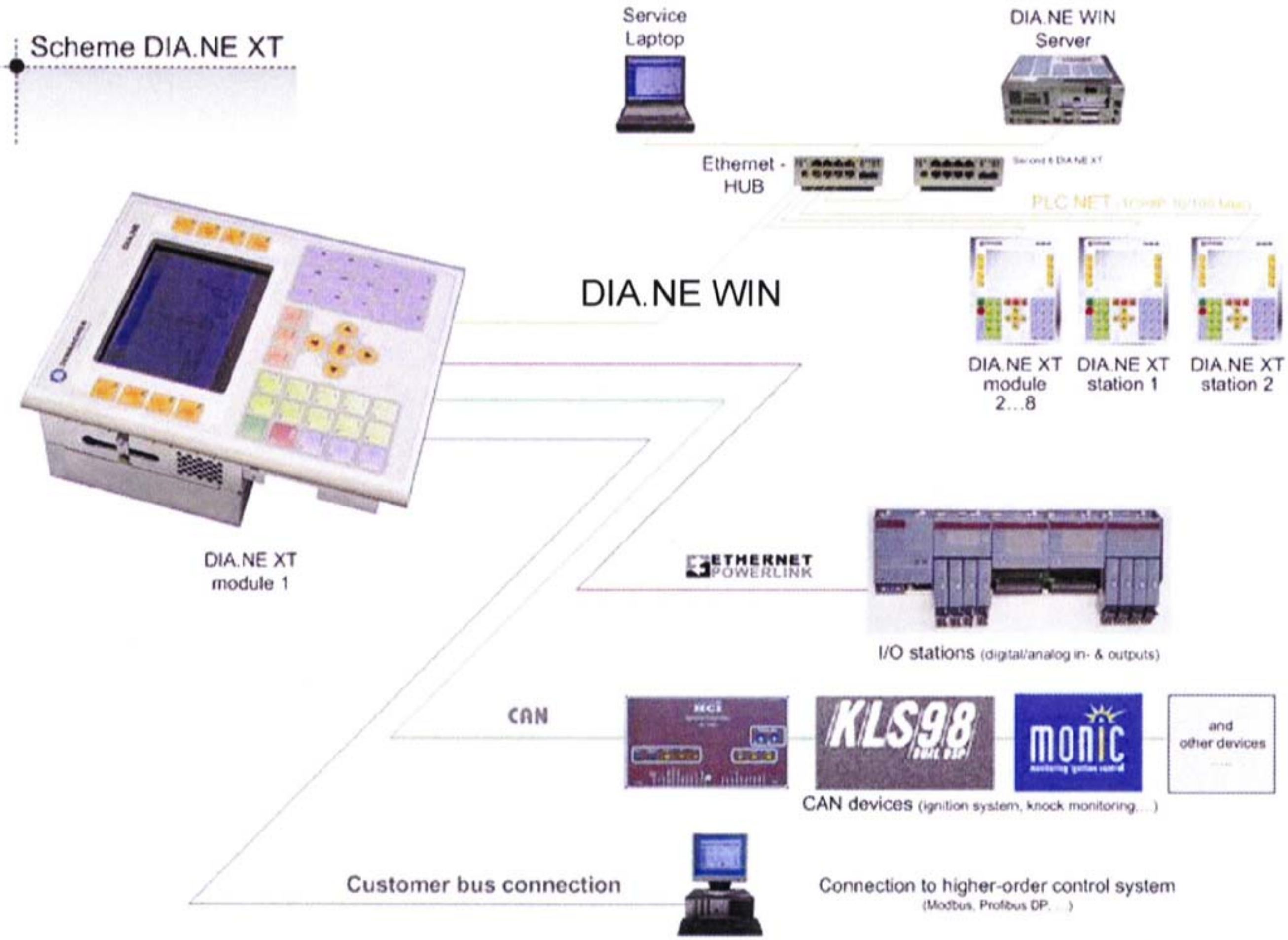
As DIA.NE XT is based on a powerful industrial control system using standardised programming languages in conformity with IEC 61131; it can be customised during the project-preparation phase and if the installation is converted or modified at a later point in time.

The multi-colour and graphic information display makes DIA.NE XT into a particularly user-friendly man/machine interface, thus making the installation easier to operate for the both the operator and the service and maintenance staff.

The numerous ways of connecting DIAN.NE XT to central control systems or to DIA.NE WIN make it easy to integrate into superimposed control systems or to monitor the installation remotely. The optimal compatibility with DIA.NE WIN means that GE Jenbacher are able to offer a state-of-the-art remote maintenance system using DIA.NE XT.

Engine managment concept / structure

Scheme DIA.NE XT

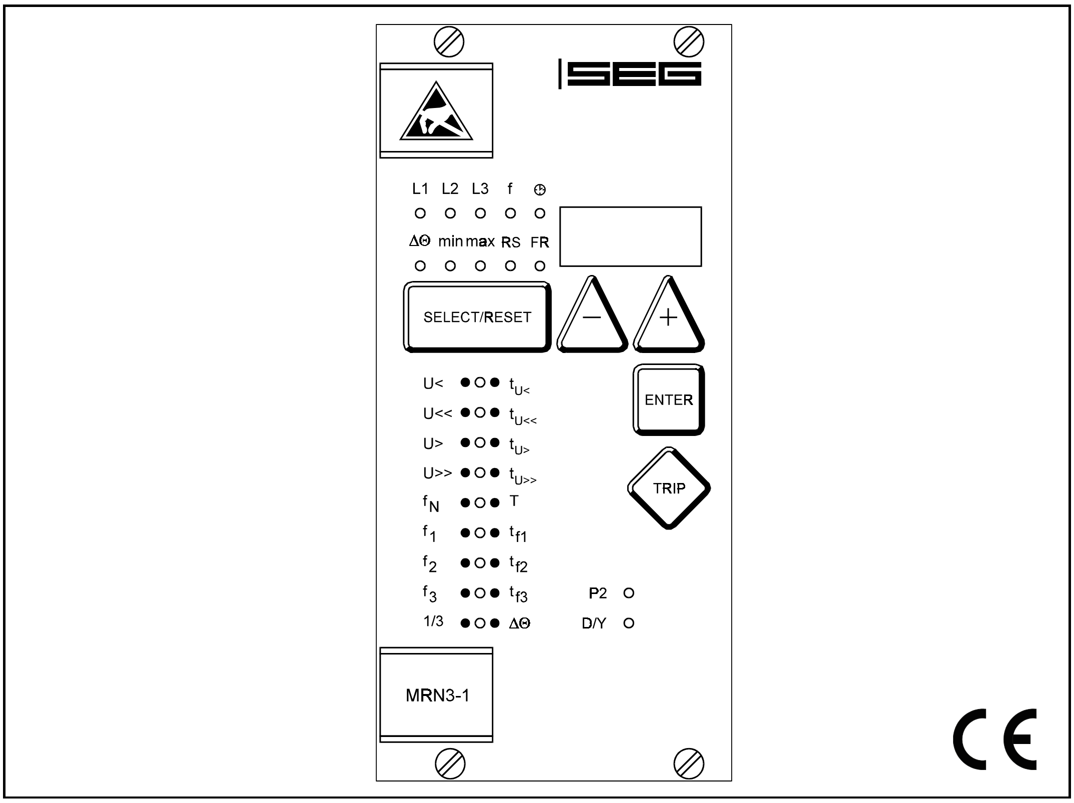


GE Jenbacher
Marketing
March 2004

GE imagination at work

Blank Page for Notes

MRN3 - Mains decoupling relay



Contents

1 Introduction and application

The *MRN3* is a universal mains decoupling device and covers the protection requirements from VDEW and most other utilities for the mains parallel operation of power stations.

- Over/ and undervoltage protection,
- over/ and underfrequency protection,
- extremely fast decoupling of generator in case of mains failure (*MRN3-1*) or
- rate of change of frequency df/dt (*MRN3-2*)

Because of combination of three protectional functions in one device the *MRN3* is a very compact mains decoupling device. Compared to the standardly used single devices it has a very good price/performance ratio.

For applications where the single protection functions are required SEG can offer the single *MR*-relays as follows:

- *MRU3-1* four step independent over-/ and undervoltage protection (also used for generator earth fault protection).
- *MRU3-2* two step independent over-/ and undervoltage protection with evaluation of the symmetrical voltage components.
- *MRF3* four step independent over/ and underfrequency protection and two step frequency gradient supervision df/dt.
- *MRG2* generator mains monitor / vector surge detection.

Important:
For additional common data of all *MR*-relays please refer to technical description "*MR* - Digital Multifunctional Relays".

2 Features and characteristics

- Microprocessor technology with watchdog,
- effective analog low pass filter for suppressing harmonics when measuring frequency and vector surge,
- digital filtering of the measured values by using discrete Fourier analysis to suppress higher harmonics and d.c. components induced by faults or system operations,
- integrated functions for voltage, frequency and vector surge in one device as well as single voltage, frequency and vector surge devices,
- two parameter sets,
- voltage supervision each with two step under-/and overvoltage detection,
- frequency supervision with three step under-/or overfrequency (user setting),
- completely independent time settings for voltage and frequency supervision,
- adjustable voltage threshold value for blocking frequency and vector surge measuring,
- display of all measuring values and setting parameters for normal operation as well as tripping via a alphanumerical display and LEDs,
- display of measuring values as primary quantities
- Storage of trip values and switching-off time (t_{CBFP}) of 5 fault occurences (fail-safe of voltage),
- recording of up to eight fault occurences with time stamp
- for blocking the individual functions by the external blocking input, parameters can be set according to requirement,
- user configurable vector surge measurement 1-of-3 or 3-of-3,
- reliable vector surge measuring by exact calculation algorithm,
- suppression of indication after an activation (LED flash),
- free assignment for output relays,
- display of date and time,
- in complience with VDE 0435, part 303 and IEC 255,
- serial data exchange via RS485 interface possible; alternatively with SEG RS485 Pro-Open Data Protocol or Modbus Protocol.

3 Design

3.1 Connections

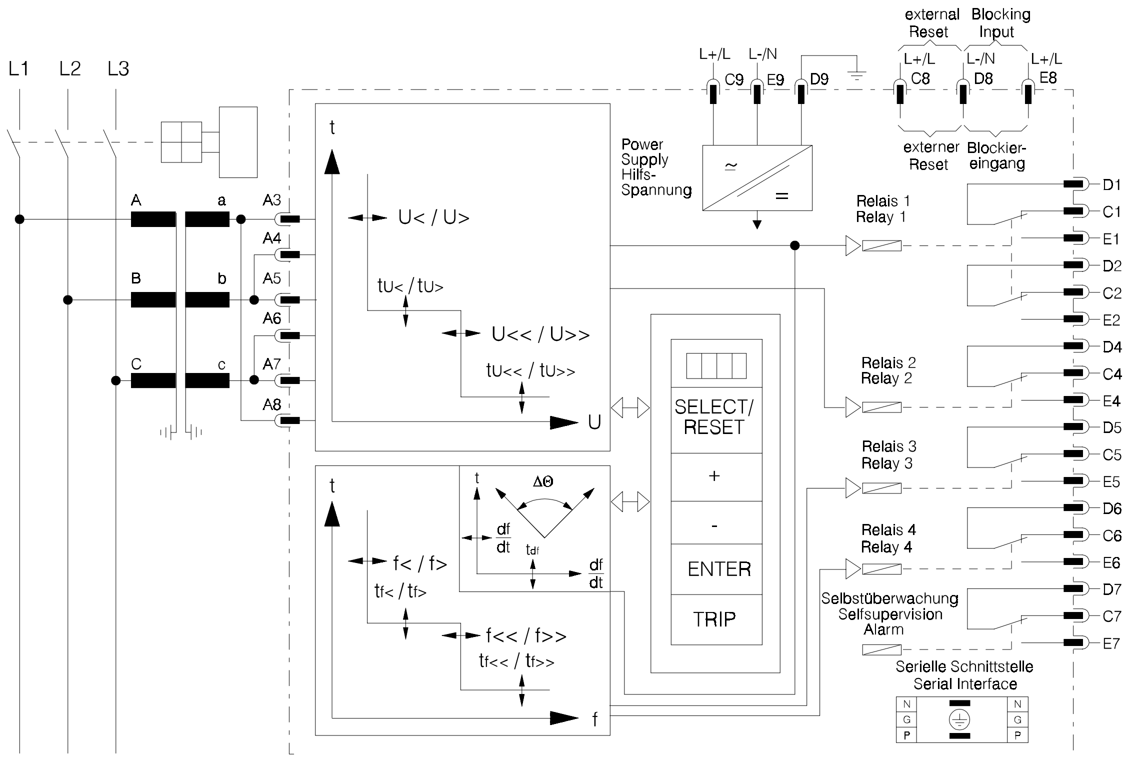


Figure 3.1: Connection diagram MRN3-1 and MRN3-2

3.1.1 Analog input circuits

The analog input voltages are galvanically decoupled by the input transformers of the device, then filtered and finally fed to the analog digital converter. The measuring circuits can be applied in star or delta connection (refer to chapter 4.3.1).

3.1.2 Blocking input

The blocking function can be set according to requirement. By applying the auxiliary voltage to D8/E8, the previously set relay functions are blocked (refer to 4.8 and 5.7.1).

3.1.3 Reset input

Please refer to chapter 5.9.1.

3.1.4 Output relays

The *MRN3* is equipped with 5 output relays. Apart from the relay for self-supervision, all protective functions can be optionally assigned:

- Relay 1: C1, D1, E1 and C2, D2, E2
- Relay 2: C3, D3, E3 and C4, D4, E4
- Relay 3: C5, D5, E5
- Relay 4: C6, D6, E6
- Relay 5: Signal self-supervision (internal failure of the unit) C7, D7, E7

All trip and alarm relays are working current relays, the relay for self supervision is an idle current relay.

3.1.5 Fault recorder

The *MRN3* has a fault value recorder which records the measured analog values as instantaneous values. The instantaneous values

U_{L1}; U_{L2}; U_{L3} for star connection
or U_{12}; U_{23}; U_{21} for delta connection

are scanned at a raster of 1.25 ms (at 50 Hz) and 1.041 ms (at 60 Hz) and saved in a cyclic buffer. It is possible to store 1 - 8 fault occurences with a total recording time of 16 s (with 50 Hz) and 13.33 s (with 60 Hz) per channel.

Storage division

Independent of the recording time, the entire storage capacity can be divided into several cases of disturbance with a shorter recording time each. In addition, the deletion behaviour of the fault recorder can be influenced.

No writing over

If 2, 4 or 8 recordings are chosen, the complete memory is divided into the relevant number of partial segments. If this max. number of fault event has been exceeded, the fault recorder block any further recordings in order to prevent that the stored data are written over. After the data have been read and deleted, the recorder to ready again for further action.

Writing over

If 1, 3 or 7 recordings are chosen, the relevant number of partial segments is reserved in the complete memory. If the memory is full, a new recording will always write over the oldest one.

The memory part of the fault recorder is designed as circulating storage. In this example 7 fault records can be stored (written over).

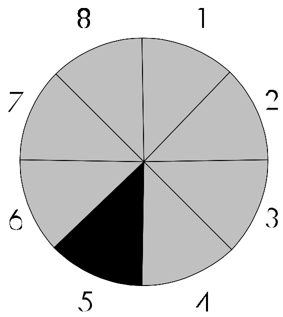


Figure 3.2: Division of the memory into 8 segments, for example

Memory space 6 to 4 is occupied.
Memory space 5 is currently being written in

Since memory spaces 6, 7 and 8 are occupied, this example shows that the memory has been assigned more than eight recordings. This means that No. 6 is the oldest fault recording and No. 4 the most recent one.

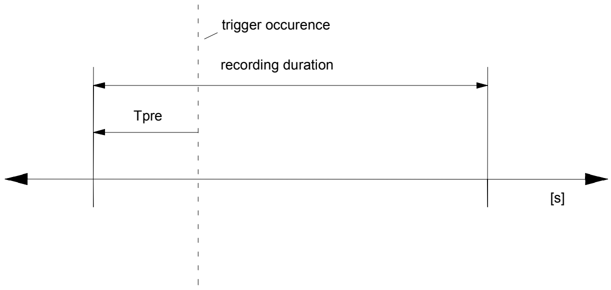


Figure 3.3: Basic set-up of the fault recorder

Each memory segment has a specified storage time which permits setting of a time prior to the trigger event.

Via the interface RS485 the data can be read and processed by means of a PC (HTL/PL-Soft4). The data is graphically edited and displayed. Binary tracks are recorded as well, e.g. activation and trip.

3.2 Parameter settings

System parameters

Parameter settings	MRN3-1	MRN3-2
U_{prim}/U_{sek}	X	X
Δ/Y	X	X
fN	X	X
P2/FR	X	X
LED-Flash	X	X

Table 3.1: System parameters

Protection parameters

Setting parameter	MRN3-1	MRN3-2
U<	X	X
$t_{U<}$	X	X
U<<	X	X
$t_{U<<}$	X	X
U>	X	X
$t_{U>}$	X	X
U>>	X	X
$t_{U>>}$	X	X
T	X	X
f_1	X	X
t_{f1}	X	X
f_2	X	X
t_{f2}	X	X
f_3	X	X
t_{f3}	X	X
df		X
dt		X
1/3	X	
ΔΘ	X	
U_B<	X	X
RS485/Slave	X	X
Baud-Rate*	X	X
Parity-Check*	X	X

Table 3.2: Protection parameters

*only Modbus

Blocking functions

Parameter settings	MRN3-1	MRN3-2
U<	X	X
U<<	X	X
U>	X	X
U>>	X	X
f1	X	X
f2	X	X
f3	X	X
Δθ	X	
df/dt		X

Table 3.3: Blocking functions

Parameters for the fault recorder

Parameter setting	MRN3-1	MRN3-2
Number of fault events	X	X
Trigger events	X	X
Pre-Triggerzeit T_{pre}	X	X

Table 3.4: Parameters for the fault recorder

Additional functions

Parameter settings	MRN3-1	MRN3-2
Ralay assignment	X	X
Fault recorder	X	X

Table 3.5: Additional functions

Date and time

Parameter settings		MRN3-1	MRN3-2
Year	Y = 99	X	X
Month	M = 03	X	X
Day	D = 16	X	X
hour	h = 07	X	X
minute	m = 29	X	X
second	s = 56	X	X

Table 3.6: Date and time

The window for parameter setting is located behind the measured value display. The parameter window can be accessed via the <SELECT/RESET> key.

3.3 LEDs

All LEDs (except LED RS, min. and max.) are two-coloured. The LEDs on the left side, next to the alpha-numerical display light up green during measuring and red after tripping.

The LEDs below the push button <SELECT/RESET> are lit green during setting and inquiry procedure of the setting values which are printed on the left side next to the LEDs. The LEDs will light up red after parameterizing of the setting values next to their right side.

The LED marked with letters RS lights up during setting of the slave address of the device for serial data communication.

The LED marked with the letters FR is alight while the fault recorder is being adjusted.

3.4 Front plate

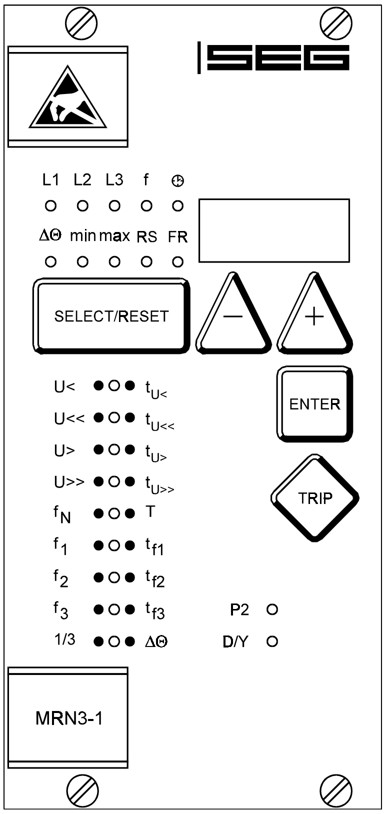


Figure 3.4: Front plate ***MRN3-1***

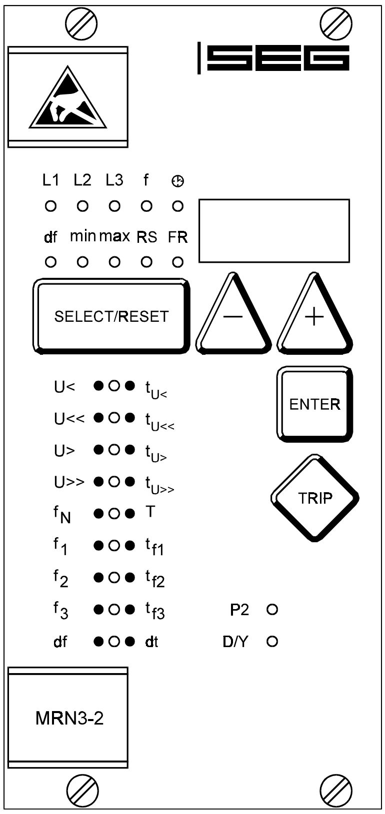


Figure 3.5: Front plate ***MRN3-2***

4 Working principle

4.1 Analog circuits

The input voltages are galvanically insulated by the input transformers. The noise signals caused by inductive and capacitive coupling are supressed by an analog R-C filter circuit.

The analog voltage signals are fed to the A/D-converter of the microprocessor and transformed to digital signals through Sample- and Hold- circuits. The analog signals are sampled with a sampling frequency of 16 x f_N, namely, a sampling rate of 1.25 ms for every measuring quantity, at 50 Hz.

4.2 Digital circuits

The essential part of the *MRN3* relay is a powerful microcontroller. All of the operations, from the analog digital conversion to the relay trip decision, are carried out by the microcontroller digitally. The relay program is located in an EPROM (Electrically-Programmable-Read-Only-Memory). With this program the CPU of the microcontroller calculates the three phase voltage in order to detect a possible fault situation in the protected object.

For the calculation of the voltage value an efficient digital filter based on the Fourier Transformation (DFFT - Discrete Fast Fourier Transformation) is applied to suppress high frequency harmonics and d.c. components caused by fault-induced transients or other system disturbances. The microprocessor continuously compares the measured values with the preset thresholds stored in the parameter memory (EEPROM). If a fault occures an alarm is given and after the set tripping delay has elapsed, the corresponding trip relay is activated.

The relay setting values for all parameters are stored in a parameter memory (EEPROM - Electrically Erasable Programmable Read Only Memory), so that the actual relay settings cannot be lost, even if the power supply is interrupted.
The microprocessor is supervised by a built-in "watchdog" timer. In case of a failure the watchdog timer resets the microprocessor and gives an alarm signal via the output relay "self supervision".

4.3 Voltage supervision

The voltage element of *MRN3* has the application in protection of generators, consumers and other electrical equipment against over-/and undervoltage.
The relay is equipped with a two step independent three-phase overvoltage (U>, U>>) and undervoltage (U<, U<<) function with completely separate time and voltage settings.
In delta connection the phase-to-phase voltages and in star connection the phase-to-neutral voltages are continuously compared with the preset thresholds.

For the overvoltage supervision the highest, for the undervoltage supervision of the lowest voltage of the three phases are decisive for energizing.

4.3.1 Selection of star or delta connection

All connections of the input voltage transformers are led to screw terminals. The nominal voltage of the device is equal to the nominal voltage of the input transformers. Dependent on the application the input transformers can be connected in either delta or star. The connection for the phase-to-phase voltage is the delta connection. In star connection the measuring voltage is reduced by $1/\sqrt{3}$. During parameter setting the connection configuration either Y or Δ has to be adjusted.

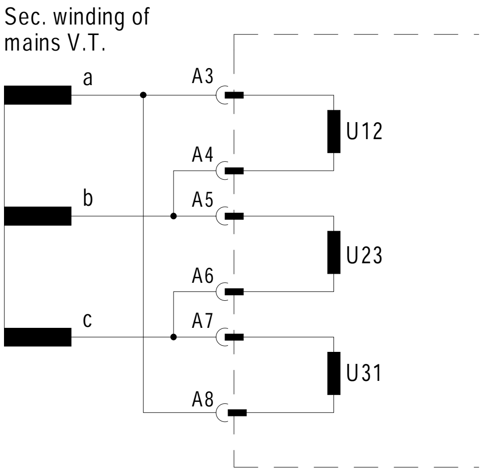


Figure 4.1: Input v.t.s in delta connection (Δ)

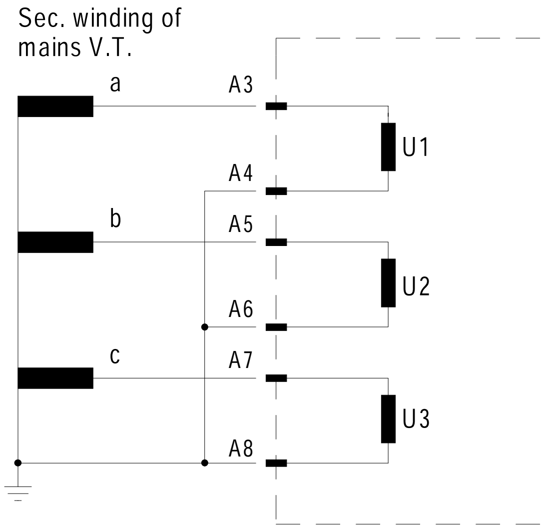


Figure 4.2: Input v.t.s in star connection (Y)

4.4 Principle of frequency supervision

The frequency element of ***MRN3*** protects electrical generators, consumers or electrical operating equipment in general against over- or underfrequency.
The relay has independent three frequency elements f_1 - f_3 with a free choice of parameters, with separate adjustable pickup values and delay times.

The measuring principle of the frequency supervision is based in general on the time measurement of complete cycles, whereby a new measurement is started at each voltage zero passage. The influence of harmonics on the measuring result is thus minimized.

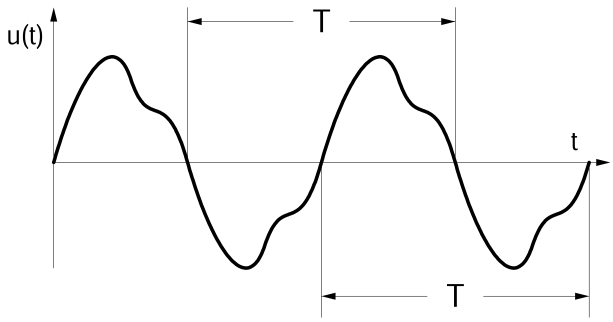


Figure 4.3: Determination of cycle duration by means of zero passages.

In order to avoid false tripping during occurence of interference voltages and phase shifts the relay works with an adjustable measuring repetition. (refer to chapter 5.4.2)

Frequency tripping is sometimes not desired by low measured voltages which for instance occur during alternator acceleration. All frequency supervision functions can be blocked with the aid of an adjustable voltage threshold U_B in case the measured voltages value is below this value.

4.5 Measuring of frequency gradient (***MRN3-2***)

Electrical generators running in parallel with the mains, e.g. industrial internal power supply plants, should be separated from the mains when failure in the intrasystem occurs for the following reasons:

- It must be prevented that the electrical generators are damaged when mains voltage recovering asynchrone, e.g. after a short interruption.
- The industrial internal power supply must be maintained.

A reliable criterion of detecting mains failure is the measurement of the rate of change of frequency df/dt. Precondition for this is a load flow via the mains coupling point. At mains failure the load flow changing then spontaneously leads to an increasing or decreasing frequency. At active power deficit of the internal power station a linear drop of the frequency occurs and a linear increase occurs at power excess. Typical frequency gradients during application of "mains decoupling" are in the range of 0.5 Hz/s up to over 2 Hz/s. The ***MRN3*** detects the instantaneous frequency gradient df/dt of each mains voltage period in an interval of one half period each. Through multiple evaluation of the frequency gradient in sequence the continuity of the directional change (sign of the frequency gradient) is determined. Because of this special measuring procedure a high safety in tripping and thus a high stabilty against transient processes, e.g. switching procedure are reached. The total switching off time at mains failure is between 60 ms and 80 ms depending on the setting.

4.6 Vector surge supervision (*MRN3-1*)

The vector surge supervision protects synchronous generators in mains parallel operation due to very fast decoupling in case of mains failure. Very dangerous are mains auto reclosings for synchronous generators. The mains voltage returning after 300 ms can hit the generator in asynchronous position. A very fast decoupling is also necessary in case of long time mains failures. Generally there are two different applications:

a) Only mains parallel operation no single operation:
In this application the vector surge supervision protects the generator by tripping the generator circuit breaker in case of mains failure.

b) Mains parallel operation and single operation:
For this application the vector surge supervision trips the mains circuit breaker. Here it is insured that the gen.-set is not blocked when it is required as the emergency set.

A very fast decoupling in case of mains failures for synchronous generators is known as very difficult. Voltage supervision units cannot be used because the synchronous alternator as well as the consumer impedance support the decreasing voltage.

For this the mains voltage drops only after some 100 ms below the pickup threshold of voltage supervision relays and therefore a safe detection of mains auto reclosings is not possible with this kind of relay.

Frequency relays are partial unsuitable because only a highly loaded generator decreases its speed within 100 ms. Current relays detect a fault only when short-circuit type currents exist, but cannot avoid their development. Power relays are able to pickup within 200 ms, but they cannot prevent power to rise to short-circuit values too. Since power changes are also caused by sudden loaded alternators, the use of power relays can be problematic.

Whereas the *MRN3-1* detects mains failures within 60 ms without the restrictions described above because they are specially designed for applications where very fast decoupling from the mains is required.

Adding the operating time of a circuit breaker or contactor, the total disconnection time remains below 150 ms. Basic requirement for tripping of the generator/mains monitor is a change in load of more than 15 - 20% of the rated load. Slow changes of the system frequency, for instance at regulating processes (adjustment of speed regulator) do not cause the relay to trip.

Trippings can also be caused by short-circuits within the grid, because a voltage vector surge higher than the preset value can occur. The magnitude of the voltage vector surge depends on the distance between the short-circuit and the generator. This function is also of advantage to the Power Utility Company because the mains short-circuit capacity and consequently the energy feeding the short-circuit is limited.

To prevent a possible false tripping the vector surge measuring can be blocked at a set low input voltage (refer to 5.4.7). The undervoltage lockout acts faster then the vector surge measurement.

Vector surge tripping is blocked by a phase loss so that a VT fault (e.g. faulty VTs fuse) does not cause false tripping.
When switching on the aux. voltage or measuring voltage , the vector surge supervision is blocked for 5 s (refer to chapter 4.8).

Note:
In order to avoid any adverse interference voltage effects, for instance from contactors or relays, which may cause overfunctions, *MRN3-1* should be connected separately to the busbar.

4.6.1 Measuring principle of vector surge supervision

When a synchronous generator is loaded, a rotor displacement angle is build between the terminal voltage (mains voltage $\underline{U}1$) and the synchronous internal voltage ($\underline{U}p$). Therefore a voltage is difference ΔU is built between $\underline{U}p$ and $\underline{U}1$ (Fig. 4.4).

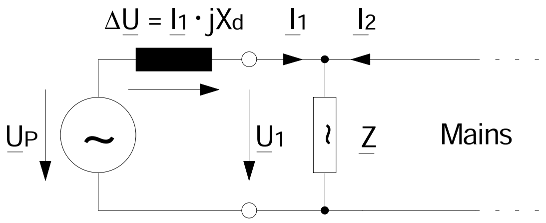


Figure 4.4: Equivalent circuit at synchronous generator in parallel with the mains

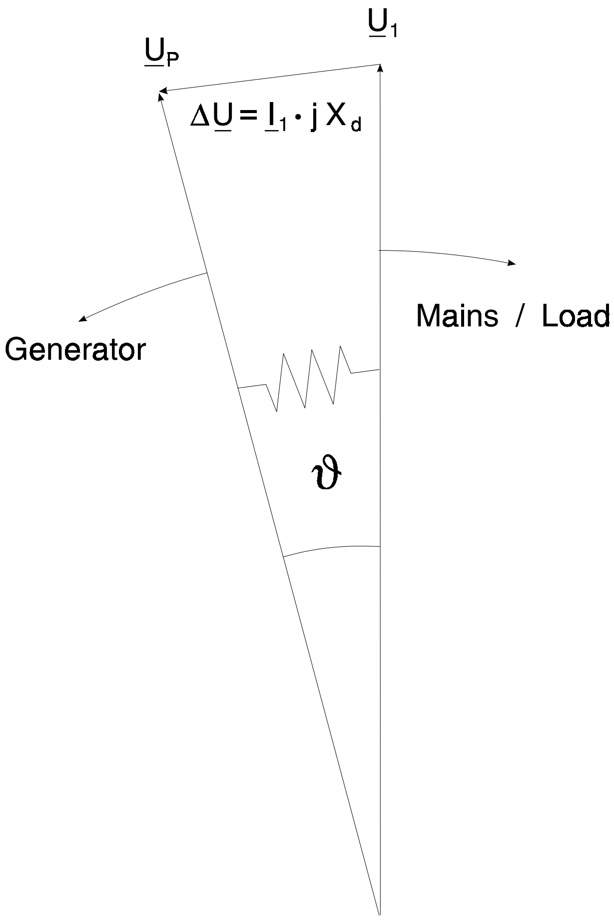


Figure 4.5: Voltage vectors at mains parallel operation

The rotor displacement angle ϑ between stator and rotor is depending of the mechanical moving torque of the generator shaft. The mechanical shaft power is balanced with the electrical feeded mains power, and therefore the synchronous speed keeps constant (Fig. 4.5).

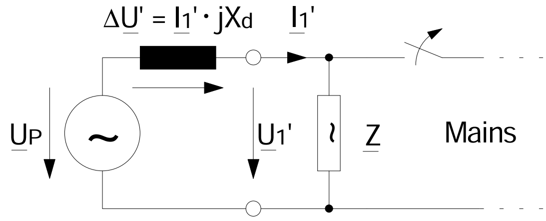


Figure 4.6: Equivalent circuit at mains failure

In case of mains failure or auto reclosing the generator suddenly feeds a very high consumer load. The rotor displacement angle is decreased repeatedly and the voltage vector $\underline{U}_1$ changes its direction ($\underline{U}_1$') (Fig. 4.6 and 4.7).

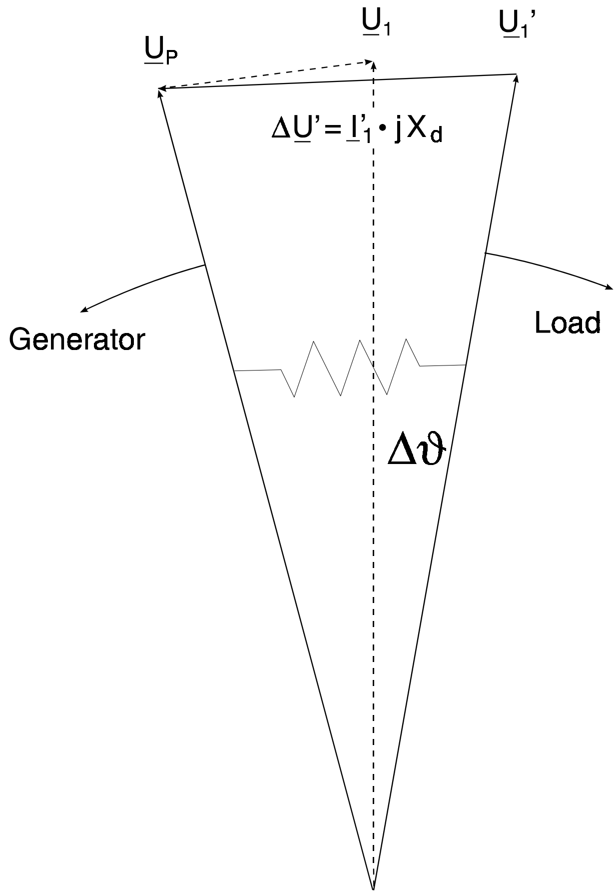


Figure 4.7: Voltage vectors at mains failure

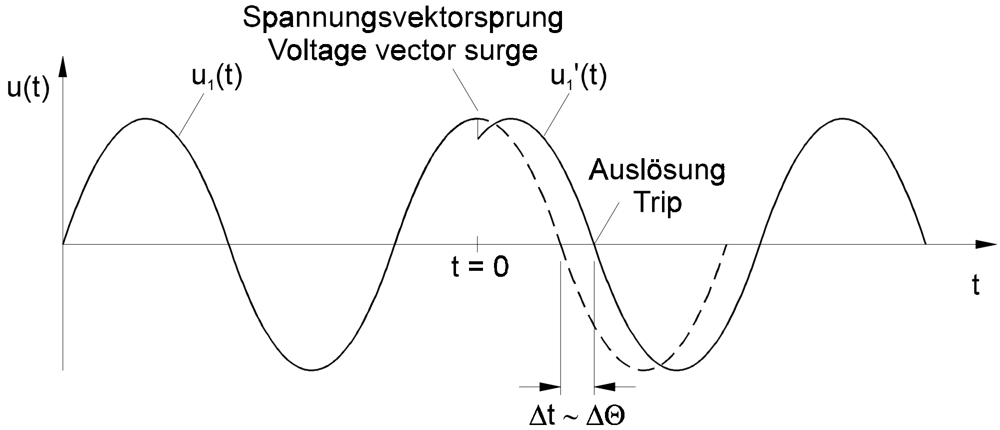


Figure 4.8: Voltage vector surge

As shown in the voltage/time diagram the instantaneous value of the voltage jumps to another value and the phase position changes. This is named phase or vector surge.

The ***MRN3-1*** measures the cycle duration. A new measuring is started at each voltage zero passage. The measured cycle duration is internally compared with a quartz stable reference time and from this the deviation of the cycle duration of the voltage signal is ascertained. In case of a vector surge as shown in fig. 4.8, the zero passage occurs either earlier or later. The established deviation of the cycle duration is in compliance with the vector surge angle.
If the vector surge angle exceeds the set value, the relay trips immediately.

Tripping of the vector surge is blocked in case of loss of one or more phases of the measuring voltage.

Tripping logic for vector surge measurement:

The vector surge function of the ***MRN3-1*** supervises vector surges in all three phases at the same time. Tripping of the relay can be adjusted for an one phase vector surge (more sensitive measurement). For this the parameter 1/3 has to be set to "1Ph". When the parameter 1/3 is set to "3Ph", tripping of the vector surge element occurs only if the vector surge angle exceeds the set value in all three phases at the same time.

Application hint

Although the vector surge relay guarantees very fast and reliable detection of mains failures under nearly all operational conditions of mains parallel running alternators, the following borderline cases have to be considered accordingly:

a) None or only insignificant change of power flow at the utility connection point during mains failures.

This can occure during peak lopping operation or in CHP stations (Combined Heat and Power) where the power flow between power station and the public grid may be very low. For detection of a vector surge at parallel running alternators, the load change must be at least 15 - 20% of the rated power. If the active load at the utility connection point is regulated to a minimal value and a high resistance mains failure occurs, then there are no vector surge nor power and frequency changes and the mains failure is not detected.

This can only happen if the public grid is disconnected near the power station and so the alternators are not additionally loaded by any consumers. At distant mains failures the synchronous alternators are abruptly loaded by remaining consumers which leads directly to a vector surge and so mains failure detection is guaranteed.
If such a situation occurs the following has to be taken into account:

In case of an undetected mains failure, i.e. with the mains coupling C.B. closed, the vector surge relay reacts upon the first load change causing a vector surge and trips the mains C.B.

For detecting high resistance mains failures a minimum current relay with an adjustable trip delay can be used. A trip delay is needed to allow regulating actions where the current may reach "zero" at the utility connection point. At high resistance mains failures, the mains coupling C.B. is tripped by the minimum current relay after the time delay.

To prevent asynchronous switching on, an automatic reclosing of the public grid should be not possible during this time delay.

A further measure could be, that the load regulation at the utility connection point guarantees a minimum power flow of 15 - 20% of rated power.

b) Short circuit type loading of the alternators at distant mains failures

At any distant mains failure, the remaining consumers cause sudden short circuit type loading of the power station generators. The vector surge relay detects the mains failure in about 60 ms and switches off the mains coupling C.B. The total switch off time is about 100 - 150 ms. If the generators are provided with an extremely fast short circuit protection e.g. able to detect di/dt, the alternators might be switched off unselectively by the generator C.B., which is not desireable because the power supply for the station is endangered and later on synchronized changeover to the mains is only possible after manual reset of the overcurrent protection.

To avoid such a situation, the alternator C.B.s must have a delayed short circuit protection. The time delay must be long enough so that mains decoupling by the vector surge relay is guaranteed.

4.7 Voltage threshold value for frequency measuring

At low measuring voltages, e.g. during generator start-up, frequency and vector surge or df/dt-measuring is perhaps not desired.

By means of the adjustable voltage threshold value U_B<, functions f_1 - f_3, df/dt or ΔΘ are blocked if the measured voltage falls below the set value.

4.8 Blocking function

No.	Dynamic Behaviour	U</<<	U>/>>	f_1, f_2, f_3	ΔΘ	df/dt
1	voltage to external blocking input is applied	free programmable	free programmable	free programmable	free programmable	free programmable
2	blocking input is released	released instantaneously	released instantaneously	released after 1 s	released after 5 s	released after 5 s
3	supply voltage is switched on	blocked for 200 ms	blocked for 200 ms	blocked for 1 s	blocked for 1 s	blocked for 1 s
4	3ph measuring volt. is suddenly applied	released	released	blocked for 1 s	blocked for 5 s	blocked for 5 s
5	one or several measuring voltages are switched off suddenly (phase failure)	released	released	blocked	blocked	blocked
6	measuring voltage smaller U_B< (adjustable voltage threshold value)	released	released	blocked	blocked	blocked

Table 4.1: Dynamic behaviour of ***MRN3*** *functions*

Blocking function set in compliance with requirements:

The *MRN3* has an external blocking input. By applying the auxiliary voltage to input D8/E8, the requested protection functions of the relay are blocked (refer to 5.7.1).

5 Operation and setting

5.1 Display

Function	Display shows	Pressed pushbutton	Corresponding LED	Type of relay
Normal operation	SEG			all types
Measured operating values	Actual measured value Min. and max. values of voltage, frequency and vector surge	<SELECT/RESET> one time for each value	L1, L2, L3, f, min, max ΔΘ df	 MRN3-1 MRN3-2
Transformer ratio of the CT's	(SEK) 1.01 – 6500 = prim	<SELECT/RESET><+><->	L1, L2, L3	
Setting values: star/delta connection	Y/DELT	<SELECT/RESET><+><->	Δ/Y	
Parameter switch/ext. Trigger for FR	SET1, SET2, B_S2, R_S2, B_FR, R_FR, S2_FR	<SELECT/RESET><+><->	P2	
Switch-over LED flash No LED flash	FLSH NOFL	<SELECT/RESET><+><->		
undervoltage (low set) tripping delay of low set element	setting value in volt setting value in seconds	<SELECT/RESET><+><-> one time for each value	U< $t_{U<}$	
undervoltage (high set) tripping delay of high set element	setting value in volt setting value in seconds	<SELECT/RESET><+><-> one time for each value	U<< $t_{U<<}$	
overvoltage (low set) tripping delay of low set element	setting value in volt setting value in seconds	<SELECT/RESET><+><-> one time for each value	U> $t_{U>}$	
overvoltage (high set) tripping delay of high set element	setting value in volt setting value in seconds	<SELECT/RESET><+><-> one time for each value	U>> $t_{U>>}$	
rated frequency	setting value in Hz	<SELECT/RESET><+><->	f_N	
frequency measuring repitition	setting value	<SELECT/RESET><+><->	T	
frequency element f_1 tripping delay of frequency element f_1	setting value in Hz setting value in seconds	<SELECT/RESET><+><-> one time for each value	f_1 t_{f1}	
frequency element f_2 tripping delay of frequency element f_2	setting value in Hz setting value in seconds	<SELECT/RESET><+><-> one time for each value	f_2 t_{f2}	
frequency element f_3 tripping delay of frequency element f_3	setting value in Hz setting value in seconds	<SELECT/RESET><+><-> one time for each value	f_3 t_{f3}	
1-of-3/3-of-3 measurement	1Ph/3Ph	<SELECT/RESET><+><->	1/3	MRN3-1
threshold for vector surge	setting value in degree	<SELECT/RESET><+><->	ΔΘ	MRN3-1
setting value df/dt measuring repitition df/dt	setting value in Hz/s setting value in periods	<SELECT/RESET><+><-> one time for each value	df dt	MRN3-2
Blocking	EXIT	<+> until max. setting value	LED of blocked parameter	
Undervoltage blocking of frequency and vector surge measuring (df/dt for ***MRN3-2***)	setting value in Volt	<SELECT/RESET><+><->	f, ΔΘ, df	
Slave address of serial interface	1 - 32	<SELECT/RESET><+><->	RS	
Baud-Rate [1)]	1200-9600	<SELECT/RESET> <+><->	RS	
Parity-Check [1)]	even odd no	<SELECT/RESET> <+><->	RS	
Recorded fault data: star–connection: U1, U2, U3	tripping values in Volt	<SELECT/RESET><+><-> one time for each phase	L1, L2, L3, U<, U<<, U>, U>>	
delta-connection: U12, U23, U31	tripping values in Volt	<SELECT/RESET><+><-> one time for each phase	L1, L2, L3 U<, U<<, U>, U>>	
frequency	tripping values in Hz	<SELECT/RESET><+><-> one time for each phase	f, f1, f2, f3	
rate of change of frequency	tripping value in Hz/s	<SELECT/RESET><+><->	df	MRN3-2
vector surge	tripping value in degree	<SELECT/RESET><+><-> one time for each phase	ΔΘ + L1, L2 or L3	MRN3-1
Delete failure memory	wait	<-> <SELECT/RESET>		

[1)] only Modbus

Function	Display shows	Pressed pushbutton	Corresponding LED	Type of relay
Enquiry failure memory	FLT1; FLT2.....	<-><+>	L1, L2, L3, U<, U<<, U>, U>>, f, Ddf/dt, ΔΘ	
Save parameter?	SAV?	<ENTER>		
Save parameter!	SAV!	<ENTER> for about 3 s		
Trigger signal for the fault recorder	TEST, P_UP, A_PI, TRIP	<SELECT/RESET> <+><->	FR	
Number of fault occurences	S = 2, S = 4, S = 8	<SELECT/RESET> <+><->	FR	
Display of date and time	Y = 99, M = 10, D = 1, h = 12, m = 2, s = 12	<SELECT/RESET> <+><->	🕒	
Software version	First part (e.g. D02-) Sec. part (e.g. 6.01)	<TRIP> one time for each part		
Manual trip	TRI?	<TRIP> three times		
Inquire password	PSW?	<SELECT/RESET>/ <+>/<->/<ENTER>		
Relay tripped	TRIP	<TRIP> or fault tripping		
Secret password input	XXXX	<SELECT/RESET>/ <+>/<->/<ENTER>		
System reset	|SEG	<SELECT/RESET> for about 3 s		

Table 5.1: Possible indication messages on the display

5.2 Setting procedure

In this paragraph the settings for all relay parameters are described in detail. For parameter setting a password has to be entered first (please refer to 4.4 of description "*MR*-Digital Multifunctional Relays").

5.3 Systemparameter

5.3.1 Display of residual voltage U_E as primary quantity (U_{prim}/U_{sec})

The residual voltage can be shown as primary measuring value. For this parameter the transformation ratio of the VT has to be set accordingly. If the parameter is set to "sec", the measuring value is shown as rated secondary voltage.

Example:
The voltage transformer used is of 10 kV/100 V. The transformation ratio is 100 and this value has to be set accordingly. If still the rated secondary voltage should be shown, the parameter is to be set to 1.

5.3.2 Δ/Y – Switch over

Depending on the mains voltage conditions, the input voltage transformers can be operated in delta or Y connection. Change-overs are effected via the <+> and the <-> keys and stored with <ENTER>.

5.3.3 Setting of nominal frequency

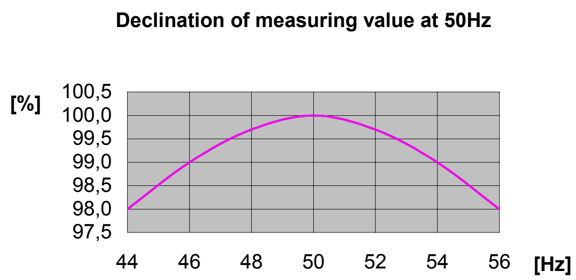
For proper functioning it is necessary to first adjust the rated frequency (50 or 60 Hz).

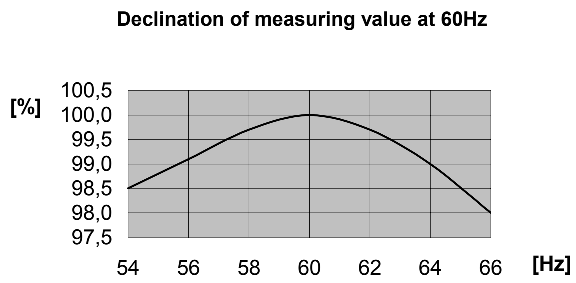
For this a distinction has to be made between the settings v = 50 Hz / f = 50 Hz or v = 60 Hz / f = 60 Hz
The difference lies in the method of voltage measuring. With the setting "v" = 50/60 Hz voltage measuring is independent of the existing frequency. This means, the voltage value can be correctly measured between 30 Hz and 80 Hz without adverse effects from the frequency.

With the setting "f" = 50/60 Hz the measured voltage value is influenced by the frequency. (see Table 5.2)

This difference in settings is required for the fault recorder. If the fault recorder is to be used, the setting must be f = 50 Hz or f = 60 Hz.
The different designations "f" or "v" have no influence on any of the other functions.

All frequency functions are determined by setting the nominal frequency, i.e. whether the set frequency thresholds are evaluated as over- or underfrequency (see also chapter 5.4.4). Also the cycle duration (20 ms at 50 Hz and 16.67 ms at 60 Hz) derives from this setting which determines the minimum tripping delay for frequency elements f_1 - f_3 with an adjustable multiplier (see also chapter 5.4.5).
During setting of the nominal frequency a value in Hz is shown on the display.





Setting	v = 50	f = 50	v = 60	f = 60
Rated frequency	50 Hz	50 Hz	60 Hz	60 Hz
Influence on voltage measurement	none	0.5..1%/Hz (see table 5.2)	none	0.5..1%/Hz (see table 5.2)
Fault recorder	Recording distorted**	Recording correct***	Recording distorted**	Recording correct***
Influence on all other functions	none	none	none	none

Table 5.2: Deviation of measured value at 50 or 60 Hz

* Setting is important for differentiation between over- and underfrequency
** Sample rate is variably adjusted to the momentarily measured frequency. 16 samples are always measured in one period.
*** Sample rate setting is fixed to 50 Hz or 60 Hz. 16 samples per 20 ms or 16.67 ms are always measured.

5.3.4 Display of the activation storage (FLSH/NOFL)

If after an activation the existing current drops again below the pickup value, e.g. U<, without a trip has been initiated, LED U< signals that an activation has occured by flashing fast. The LED keeps flashing until it is reset again (push button <RESET>). Flashing can be suppressed when the parameter is set to NOFL.

5.3.5 Parameterswitch/external trigger for the fault recorder

By means of the parameter-change-over switches it is possible to activate two different parameter sets. Switching over of the parameter sets can either be done by means of software or via the external inputs RESET or blocking input. Alternatively, the external inputs can be used for Reset or blocking and for the triggering of the fault recorder.

Software-parameter	Blocking input used as	RESET input used as
SET1	Blocking input	RESET input
SET2	Blocking input	RESET input
B_S2	Parameter switch	RESET input
R_S2	Blocking input	Parameter switch
B_FR	External triggering of the fault recorder	Reset input
R_FR	Blocking input	External triggerung of the fault recorder
S2_FR	Parameter switch	External triggerung of the fault recorder

With the settings SET1 or SET2 the parameter set is activated by software. Terminals C8/D8 and D8/E8 are then available as external reset input or blocking input.

With the setting B_S2 the blocking input (D8, E8) is used as parameter-set change-over switch. With the setting R_S2 the reset input (D8, E8) is used as parameter-set change-over switch. With the setting B_FR the fault recorder is activated immediately by using the blocking input. On the front plate the LED FR will then light up for the duration of the recording. With the setting R_FR the fault recorder is activated via the reset input. With the setting S2_FR parameter set 2 can be activated via the blocking input and/or the fault recorder via the reset input. The relevant function is then activated by applying the auxiliary voltage to one of the external inputs.

With the setting R_FR the fault recorder is activated via the reset input. With the setting S2_FR parameter set 2 can be activated via the blocking input and/or the fault recorder via the reset input.
The relevant function is then activated by applying the auxiliary voltage to one of the external inputs.

Important note:
When functioning as parameter change over facility, the external input RESET is not available for resetting. When using the external input BLOCKING the protection functions must be deactivated by software blocking separately (refer to chapter 5.7.1).

5.4 Protection parameters

5.4.1 Parameter setting of over- and undervoltage supervision

The setting procedure is guided by two coloured LEDs. During setting of the voltage thresholds the LEDs U<, U<<, U> and U>> are lit green. During setting of the trip delays $t_{U>}$, $t_{U>>}$, $t_{U<}$ and $t_{U<<}$ the according LEDs light up red.

Thresholds of the voltage supervision

During setting of the threshold U>, U>>, U< and U<< the displays shows the voltages directly in volt. The thresholds can be changed by the <+> <-> push buttons and stored with <ENTER>.

The undervoltage supervision (U< and U<<) as well as the overvoltage supervision (U> and U>>) can be deactivated by setting the threshold to "EXIT".

Tripping delay of voltage supervision

During setting of the tripping delays $t_{U<}$, $t_{U<<}$, $t_{U>}$ and $t_{U>>}$ the display shows the value directly in seconds. The tripping delay is changed via the push button <+> and <-> in the range of 0,04 s to 50 s and can be stored with the push button <ENTER>.
When setting the tripping delay to "EXIT" the value is infinit meaning only warning, no tripping.

5.4.2 Number of measuring repetitions (T) for frequency functions

In order to avoid false tripping of the unit at short voltage drops of the system voltage or interference voltages, *MRN3* works with an adjustable measuring repetition. When the instantaneous frequency measuring value exceeds (at overfrequency) or falls below (at underfrequency) the set reference value, the counter is incremented, otherwise the counter is decremented down to the minimum value of 0. Only when the counter exceeds the value adjusted at T, alarm is given and after the tripping delay of the frequency element has elapsed the tripping command is given.
The setting range for T is between 2 - 99.

Recommendation for setting:
For short tripping times, e.g. for machine protection or for mains decoupling T should be set in the range from 2 - 5.
At precision measurements, e.g. exact measurement of the system frequency a setting of T in the range from 5 - 10 is recommended.

5.4.3 Threshold of frequency supervision

The frequency supervision of *MRN3* has three frequency elements independent from each other. Acc. to setting the pickup value above or below the nominal frequency, these elements can be used for over- or under frequency supervision.

Dependent on the preset nominal frequency f_N the pickup values from 30 Hz up to 70 Hz at f_N = 50 Hz and from 40 Hz to 80 Hz at f_N = 60 Hz can be set. During setting of the pickup values f_1 - f_3 the display shows the values in Hz. A value of for instance 49,8 Hz is indicated with "4980".

The function of the individual frequency elements can be deactivated by setting the pickup values to "EXIT". The setting value "EXIT" corresponds to the rated frequency.

5.4.4 Tripping delays for the frequency elements

Tripping delays t_{f1} - t_{f3} of the four frequency elements can be set independently from t_{f1min} - 50 s. The minimum tripping delay t_{f1min} of the relay depends upon the number of set measuring repetitions T (periods) and amounts to:

T	$t_{f,min}$
2....49	(T+1)· 20 ms
50....69	(T - 49)· 50 ms + 1 s
70....99	(T - 69)· 100 ms + 2 s

When setting the tripping delay to "EXIT" by pressing push button <+> up to the maximum setting value, the corresponding tripping relay is blocked. Pickup of the frequency element is however displayed on the front plate by the corresponding LED, an assigned alarm relay is also activated. This setting applies to 50 Hz and 60 Hz.

5.4.5 Parameter setting of vector surge supervision (*MRN3-1*)

Both the vector surge angle ΔΘ as well as the tripping logic concerning the vector surge have to be adjusted for a vector surge supervision.
If the tripping logic is set to 1-of-3 (= "1Ph" on the display), the relay trips as soon as the measured vector surge angle has exceeded the set value ΔΘ in one of the three phases. This is the more sensitive adjustment when compared with the three phase tripping logic 3-of-3 (= "3Ph" on the display), where tripping occurs only if the vector surge angle exceeds the set value in all three phases.

We recommend to choose the one phase tripping logic "1Ph". Only if this adjustment is too sensitive, adjustment "3Ph" should be used.

The recommended setting of the vector surge angle ΔΘ in a low impedance mains is 4 - 6 degrees. This setting is sufficient in most cases, because low impedance mains do not have a vector surge greater than this value. In case of an auto reclosing, this value is exceeded. In high impedance mains the setting should be 10° to 12° to avoid failure tripping when switching on or switching off big consumer loads.

The vector surge function of this device can be checked as follows:

a) Generator in isolated operation: Switching off and on of loads (approx. 20% of the nominal generator capacity) must trip the relay. Later in normal isolated operation the tripping of the relay is inhibited.

b) In mains parallel operation switching on and switching off of consumer loads and controlling the governor of the prime mover should not trip the relay.

If possible the test described under a) and b) should be double checked by a real auto reclosing.

Threshold for the vector surge supervision

When the pickup value of the vector surge supervision is set, a value in angular degree is indicated at the display. The pickup value requested can be adjusted by pushbuttons <+> and <-> in the range of 2° to 22°. LED ΔΘ lights up red during this procedure.

5.4.6 Parameter setting of frequency gradient (*MRN3-2*)

The pickup value of frequency gradient (parameter df) can be set between 0.2 to 10 Hz/s. The number of measuring repetitions (parameter dt) can be set between 2 - 64 cycles. This parameter defines the number of df/dt measurements, which have to exceed the set value, before tripping.

Setting information:
The power difference after mains failure causes a change in frequency, which can approximately be calculated as follows:

$$\frac{df}{dt} = -\frac{f_N}{T_A} \cdot \Delta P$$

with
f_N = rated frequency in Hz
T_A = starting time at rated torque
ΔP = per unit power deficit with reference to the rated active power of the generator

If the inertia time constant is known and a power difference given, the frequency gradient can be estimated by the a.m. equation. At a supposed power difference of 20% and an inertia time constant of 10 s, the frequency gradient is 1 Hz/s.

To prevent false trippings at loading, deloading or failure signals, we would recommend a setting value for dt of minimum 4 cycles.

5.4.7 Voltage threshold value for frequency and vector surge measuring (df/dt at *MRN3-2*)

Correct frequency measuring or vector surge measuring cannot be obtained if the system voltage is very low, for instance during generator start up or voltage failure. False tripping of the *MRN3* in such cases is prevented by an adjustable voltage threshold U_B. If the system voltage is below this threshold, these functions of the relay are blocked.
During adjustment of U_B< LEDs f and ΔΘ or df light up in the upper display part.

5.4.8 Adjustment of the slave address

By pressing push buttons <+> and <-> the slave address can be set in the range of 1 - 32. During this adjustment the LED RS lights up.

5.4.9 Setting of Baud-rate (applies for Modbus Protocol only)

Different transmission rates (Baud rate) can be set for data transmission via Modbus Protocol.
The rate can be changed by push buttons <+> and <-> and saved by pressing <ENTER>.

5.4.10 Setting of parity (applies for Modbus Protocol only)

The following three parity settings are possible :

- "even" = even
- "odd" = odd
- "no" = no parity check

The setting can be changed by push buttons <+> and <-> and saved by pressing <ENTER>.

5.5 Adjustment of the fault recorder

The *MRI3* is equipped with a fault recorder (see chapter 3.7). Three parameters can be determined.

5.5.1 Number of the fault recordings

The max. recording time is 16 s at 50 Hz or 13.33 s at 60 Hz.
The number of max. recordings requested has to be determined in advance. There is a choice of (1)* 2, (3)* 4 or (7)* 8 recordings and dependent on this the duration of the individual fault recordings is defined, i.e.

(1)* 2 recordings for a duration of 8 s (with 50 Hz) (6.66 s with 60 Hz)
(3)* 4 recordings for a duration of 4 s (with 50 Hz) (3.33 s with 60 Hz)
(7)* 8 recordings for a duration of 2 s (with 50 Hz) (1,66 s with 60 Hz)
* is written over when a new trigger signal arrives

Caution:
If the fault recorder is used, the frequency should be set to f = 50 Hz or f = 60 Hz (see chapter 5.3.3).

5.5.2 Adjustment of trigger occurences

There is a choice between four different occurences:

P_UP (PickUP)	Storage is initiated after recognition of a general activation.
TRIP	Storage is initiated after a trip has occured.
A_PI (After Pickup)	Storage is initiated after the last activation threshold was fallen short of.
TEST	Storing is activated by simultaneous actuation of the keys <+> and <->. During the recording time the display shows "Test".

5.5.3 Pre-trigger time (T_{pre})

By the time T_{pre} it is determined which period of time prior to the trigger occurence should be stored as well. It is possible to adjust a time between 0.05s and the max. recording interval (2, 4 and 8s). With keys <+> and <-> the values can be changed and with <ENTER> be saved.

5.6 Adjustment of the clock

When adjusting the date and time, LED ◷ lights up. The adjustment method is as follows:

Date :	Year	Y=00
	Month	M=00
	Day	D=00
Time :	Hour	h=00
	Minute	m=00
	Second	s=00

The clock starts with the set date and time as soon as the supply voltage is switched on. The time is safeguarded against short-term voltage failures (min. 6 minutes).

Note:
The window for parameter setting is located behind the measured value display. The parameter window can be accessed via the <SELECT/RESET> key.

5.7 Additional functions

5.7.1 Setting procedure for blocking the protection functions

The blocking function of the *MRN3* can be set according to requirement. By applying the aux. voltage to D8/E8, the functions chosen by the user are blocked. Setting of the parameter should be done as follows:

- When pressing push buttons <ENTER> and <TRIP> at the same time, message "BLOC" is displayed (i.e. the respective function is blocked) or "NO_B" (i.e. the respective function is not blocked). The LED allocated to the first protection function U< lights red.
- By pressing push buttons <+> <-> the value displayed can be changed.
- The changed value is stored by pressing <ENTER> and entering the password.
- By pressing the <SELECT/RESET> push button, any further protection function which can be blocked is displayed.
- Thereafter the menu is left by pressing <SELECT/RESET> again.
- If the <SELECT/RESET> key is actuated again, the blocking menu is left and the assignment mode is accessed^.

Function	Description	Display	LED
U<	Undervoltage step 1	BLOC	red
U<<	Undervoltage step 2	BLOC	red
U>	Overvoltage step 1	NO_B	red
U>>	Overvoltage step 2	NO_B	red
f1	Frequency step 1	BLOC	red
f2	Frequency step 2	BLOC	rec
f3	Frequenzstufe 3	NO_B	red
$\Delta\Theta$	Vector surge	BLOC	red
df/dt	Frequency changing rate	BLOC	red

Table 5.3: Blockadefunktion für twei Parametersätze

Assignment of the output relays:
Unit *MRN3* has five output relays. The fifth output relay is provided as permanent alarm relay for self supervision is normally on. Output relays 1 - 4 are normally off and can be assigned as alarm or tripping relays to the voltage functions which can either be done by using the push buttons on the front plate or via serial interface RS485. The assignment of the output relays is similar to the setting of parameters, however, only in the assignment mode. The assignment mode can be reached only via the blocking mode.
By pressing push button <SELECT/RESET> in blocking mode again, the assignment mode is selected.

The relays are assigned as follows: LEDs U<, U<<, U> and U>>, f1, f2, f3 are two-coloured and light up green when the output relays are assigned as alarm relays and $t_{U<}$, $t_{U<<}$, $t_{U<}$, $t_{U<<}$, tf1, tf2, tf3 df/dt and $\Delta\Theta$ red as tripping relays.

Definition:
Alarm relays are activated at pickup.
Tripping relays are only activated after elapse of the tripping delay.

After the assignment mode has been activated, first LED U< lights up green. Now one or several of the four output relays can be assigned to under voltage element U< as alarm relays. At the same time the selected alarm relays for under voltage element 1 are indicated on the display. Indication "1_ _ _" means that output relay 1 is assigned to this under voltage element. When the display shows "_ _ _ _", no alarm relay is assigned to this under voltage element. The assignment of output relays 1 - 4 to the current elements can be changed by pressing <+> and <-> push buttons. The selected assignment can be stored by pressing push button <ENTER> and subsequent input of the password. By pressing push button <SELECT/RESET>, LED U< lights up red. The output relays can now be assigned to this voltage element as tripping relays.

Relays 1 - 4 are selected in the same way as described before. By repeatedly pressing of the <SELECT/RESET> push button and assignment of the relays all elements can be assigned separately to the relays. The assignment mode can be terminated at any time by pressing the <SELECT/RESET> push button for some time (abt. 3 s).

Note:
- The function of jumper J2 described in general description "MR Digital Multifunctional Relays" does not apply for *MRN3*. For relays without assignment mode this jumper is used for parameter setting of alarm relays (activation at pickup or tripping).

A form is attached to this description where the setting requested by the customer can be filled-in. This form is prepared for telefax transmission and can be used for your own reference as well as for telephone queries.

Relay function		Output relays				Display- Indication	Correspond-ing LED
		1	2	3	4		
U<	alarm		X			_ 2 _ _	U<; green
tU<	tripping	X				1 _ _ _	tU< red
U<<	alarm		X			_ 2 _ _	U<< green
tU<<	tripping	X				1 _ _ _	tU<< red
U>	alarm		X			_ 2 _ _	U> green
tU>	tripping	X				1 _ _ _	tU> red
U>>	alarm		X			_ 2 _ _	U>> green
tU>>	tripping	X				1 _ _ _	tU>> red
f1	alarm			X		_ _ 3 _	f1 green
tf1	tripping	X				1 _ _ _	tf1 red
f2	alarm			X		_ _ 3 _	f2 green
tf2	tripping	X				1 _ _ _	tf2 red
f3	alarm			X		_ _ 3 _	f3 green
tf3	tripping	X				1 _ _ _	tf3 red
ΔΘ	tripping				X	_ _ _ 4	ΔΘ red
df/dt	tripping				X	_ _ _ 4	df/dt red

Tabelle 5.4: Example of assignment matrix of the output relay (default settings).

5.8 Indication of measuring values

5.8.1 Measuring indication

In normal operation the following measuring values can be displayed.

Voltages (LED L1, L2, L3 green)
- In star connection all phase-to-neutral voltages
- In delta connection all phase-to-phase voltages

Frequency (LED f green *MRN3-1*)
Vector surge (LED ΔΘ green)
Frequency gradient df/dt (LED df green; *MRN3-2*)

Min. and max. values prior to the last reset:
- Frequency (LED f + min or f + max)
- Vector surge (LED ΔΘ + min or ΔΘ + max)
- Frequency gradient (LED df + min or df + max)

5.8.2 Min./Max.- values

The *MRN3* offers a minimum/maximum storage each for the measuring values of the vector surge as well as the frequency gradient. These min./max. values are mainly used to appraise the system quality. Always the highest and lowest values of each cycle are measured and stored until the next reset.

Min./max. frequency measuring:
The *MRN3* ascertains the actual frequency from each cycle of the system voltage. These measuring values are entered into the min./max. storage. The latest entered min./max. values replace the previously stored values.

Dependent on the adjustment of dt and tripping delay, it is possible that the stored min./max. values are higher than the tripping threshold without causing a trip. The reason for this is storage of instantaneous values.

Min./Max. measuring of the frequency gradient:
The procedure described above applies also to storage of min./max. values of df/dt measurement. Since each instantaneous df/dt value is stored, high values can occur which, however, do not cause any tripping.

This can for instance happen during switching procedures where high positive and negative df/dt values occur, but they do not cause any tripping due to the special measuring method.

Min./max. vector surge measuring :
The procedure described above applies also to storage of min./max. values of vector surge measuring. Since each instantaneous ΔΘ value is stored, also here high values are possible which, however, do not cause any tripping.

These min./max. measurements are of great advantage for long-time analysis of the grid quality.

As to operation :
After each reset (ref. 5.9.1) the min./max. storages are cleared. As from this instant there is no time limit for the min./max. storage until the next reset.
By repeatedly pressing the <SELECT/RESET> push button, the measuring values of the min./max. storage can be queried. The respective LEDs light up at the same time; e.g. during minimum frequency is displayed, LEDs "f" and "min" light up.

5.8.3 Unit of the measuring values displayed

The measuring values can optionally be shown in the display as a multiple of the "sec" rated value (x In) or as primary current (A). According to this the units of the display change as follows:

Indication as	Range	Unit
sec. voltage	000V – 999V	V
primary voltage	.000 – 999V	V
	1K00 – 9K99	KV
	10K0 – 99K9	KV
	100K – 999K	KV
	1M00 – 3M00	MV

Table 5.5: Units of the display

5.8.4 Indication of fault data

All faults detected by the relay are indicated on the front plate optically. For this purpose, the four LEDs (L1, L2, L3, f) and the four function LEDs (U<, U<<, U>, U>>, f1, f2, f3, ΔΘ und df/dt) are equipped at *MRN3*. Not only fault messages are transmitted, the display also indicates the tripped protection function. If, for example an overcurrent occurs, first the respective phase LED will light up. LED I> lights up at the same time. After tripping the LEDs are lit permanently.

5.9 Fault memory

When the relay is energized or is energized or trips, all fault data and times are stored in a non-volatile memory manner. The *MRN3* is provided with a fault value recorder for max. five fault occurrences. In the event of additional trippings always the oldest data set is written over.

For fault indication not only the trip values are recorded but also the status of LEDs. Fault values are indicated when push buttons <-> or <+> are pressed during normal measuring value indication.

- Normal measuring values are selected by pressing the <SELECT/RESET> button.
- When then the <-> button is pressed, the latest fault data set is shown. By repeated pressing the <-> button the last but one fault data set is shown etc. For indication of fault data sets abbreviations FLT1, FLT2, FLT3, ... are displayed (FLT1 means the latest fault data set recorded). At the same time the parameter set active at the occurence is shown.
- By pressing <SELECT/RESET> the fault measuring values can be scrolled.
- By pressing <+> it can be scrolled back to a more recent fault data set. At first FLT8, FLT7, ... are always displayed. When fault recording is indicated (FLT1 etc), the LEDs flash in compliance with the stored trip information, i.e. those LEDs which showed a continuous light when the fault occured are now blinking blinking to indicate that it is not a current fault. LEDs which were blinking blinking during trip conditions, (element had picked up) just briefly flash.
- If the relay is still in trip condition and not yet reset (TRIP is still displayed), no measuring values can be shown.
- To delete the trip store, the push button combination <SELECT/RESET> and <->, has to be pressed for about 3s. The display shows "wait".

Recorded fault data:

Measuring	Displayed value	Corresponding LED
Voltage	L1; L2; L3; L1/L2; L2/L3; L3/L1	L1; L2; L3
Frequency	f; f min f max	f; min; max
Frequency changing rate	df	df
Vektorsprung	$\Delta\Theta$	$\Delta\Theta$
Time stamp Date: Time:	 Y = 99 M = 03 D = 10 h = 17 m = 21 s = 14	 🕒 🕒 🕒 🕒 🕒 🕒

5.9.1 Reset

All relays have the following three possibilities to reset the display of the unit as well as the output relay at jumper position J3=ON.

Manual Reset
- Pressing the push button <SELECT/RESET> for some time (about 3 s)

Electrical Reset
- Through applying auxiliary voltage to C8/D8

Software Reset
- The software reset has the same effect as the <SELECT/RESET> push button (see also communication protocol of RS485 interface)

The display can only be reset when the pickup is not present anymore (otherwise "TRIP" remains in display).

During resetting of the display the parameters are not affected.

5.9.2 Erasure of fault storage

To delete the trip store, the push button combination <SELECT/RESET> and <->, has to be pressed for about 3s. The display shows "wait".

6 Relay testing and commissioning

The following test instructions should help to verify the protection relay performance before or during commissioning of the protection system. To avoid a relay damage and to ensure a correct relay operation, be sure that:

- The auxiliary power supply rating corresponds to the auxiliary voltage on site.
- The rated frequency and rated voltage of the relay correspond to the plant data on site.
- The voltage transformer circuits are connected to the relay correctly.
- All signal circuits and output relay circuits are connected correctly.

6.1 Power-On

NOTE!
Prior to switch on the auxiliary power supply, be sure that the auxiliary supply voltage corresponds to the rated data on the type plate.

Switch on the auxiliary power supply to the relay and check that the message "ISEG" appears on the display and the self supervision alarm relay (watchdog) is energized (Contact terminals D7 and E7 closed).
It may happen that the relay is tripped because of under- voltage condition after power-on. (The message "TRIP" on the display and LED L1, L2, L3 and U< light up red). An undervoltage condition has been detected after power-on, because no input voltages are applied to the relay. In this case:

- Press the push button <ENTER>, thus entering into the setting mode. Now set the parameters U< and U<< to "EXIT" to block the undervoltage functions. After that, press the <SELECT/RESET> for app. 3 s to reset the LEDs and "TRIP" message.
- The undervoltage tripping after power on can also be eliminated by applying three phase rated voltages after power-on and reset the LED and "TRIP" message.
- Apply auxiliary voltage to the external blocking input (Terminals E8/D8) to inhibit the undervoltage functions (refer to 6.5) and press the <SELECT/RESET> for app. 3 s to reset the LEDs and "TRIP" message.

6.2 Testing the output relays

NOTE!
Prior to commencing this test, interrupt the trip circuit to the circuit breaker if tripping is not desired.

By pressing the push button <TRIP> once, the display shows the first part of the software version of the relay (e.g. „D08-“). By pressing the push button <TRIP> twice, the display shows the second part of the software version of the relay (e.g. „4.01“. The software version should be quoted in all correspondence. Pressing the <TRIP> button once more, the display shows "PSW?". Please enter the correct password to proceed with the test. The message "TRI?" will follow. Confirm this message by pressing the push button <TRIP> again. All output relays should then be activated and the self supervision alarm relay (watchdog) be deenergized one after another with a time interval of 1 second. Thereafter, reset all output relays back to their normal positions by pressing the push button <SELECT/RESET>.

6.3 Checking the set values

By repeatedly pressing the push button <SELECT>, all relay set values may be checked. Set value modification can be done with the push button <+><-> and <ENTER>. For detailed information about that, please refer to chapter 4.3 of the description "MR – Digital multifunctional relays".

As relay input energizing quantities, three phase voltages should be applied to ***MRN3*** relay input circuits. Depending on the system conditions and the voltage transformer used, three voltages can be connected to the relay input circuits with either star or delta connection. In case of a star connection the phase-to-neutral voltage will be applied to the voltage input circuits, while the phase-to-phase voltages will be connected to the voltage input circuits in case of a delta connection. The voltage input connection must be set as a parameter, and should correspond with the actual voltage input connection:

Star connection:	Phase-to-neutral voltages will be measured and evaluated.
Delta connection:	Phase-to-phase voltages will be measured and evaluated.

6.4 Secondary injection test

6.4.1 Test equipment

- Voltmeter and frequency meter with class 1 or better,
- auxiliary power supply with the voltage corresponding to the rated data on the type plate,
- three-phase voltage supply unit with frequency regulation (Voltage: adjustable from 0 to 2 x U_N; Frequency: adjustable from 40 - 70 Hz),
- timer to measure the operating time (Accuracy class ±10 ms),
- switching device and
- Test leads and tools

6.5 Example of test circuit

For testing of the *MRN3* relay, a three phase voltage source with adjustable voltage and frequency is required. Figure 6.1 shows an example of a three-phase test circuit energizing the *MRN3* relay during test. The three phase voltages are applied to the relay in Y-connection.

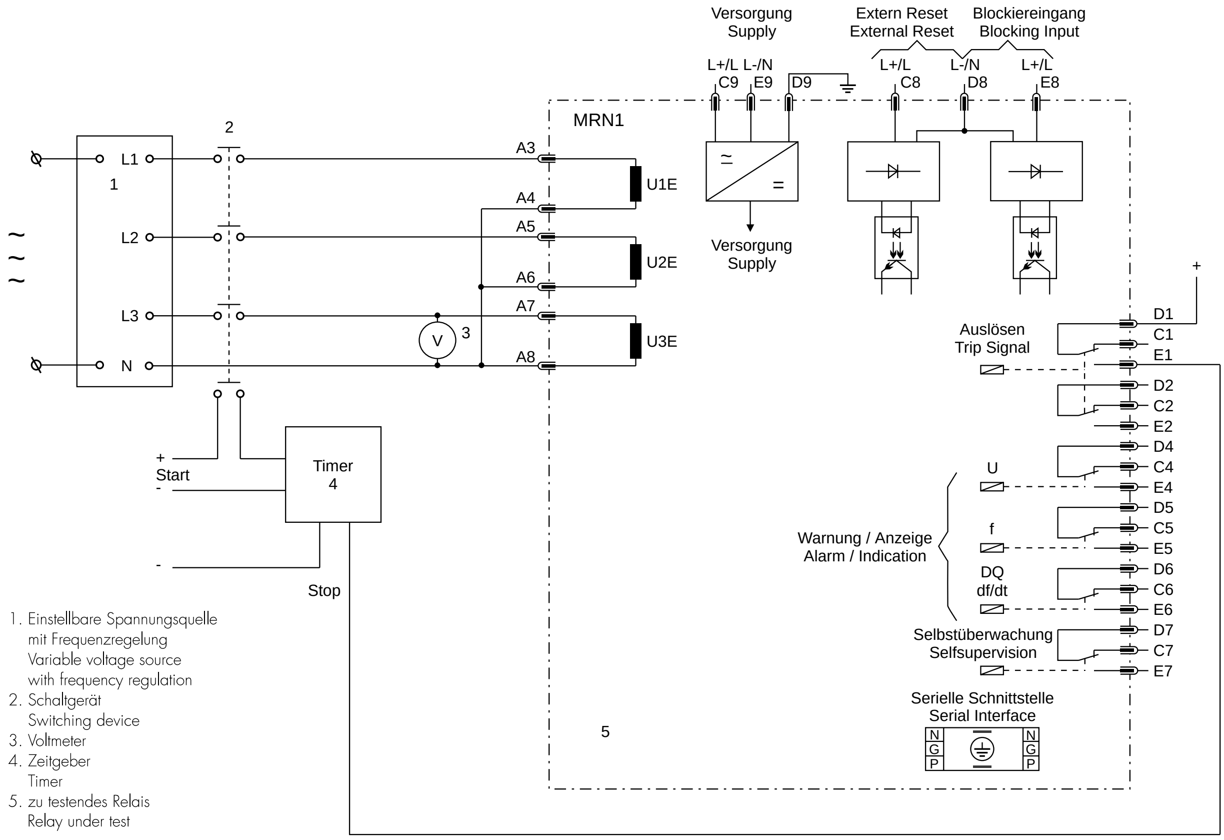


Figure 6.1: Test circuit

For testing the vector surge function of the relay, a test circuit which can produce phase angle change (vector surge) is required to simulate mains failures (please refer to chapter 6.5.6).

For testing the df/dt function of the relay, a special test equipment is required, which produces a constant rate of change of frequency.

6.5.1 Checking the input circuits and measuring functions

Apply three voltages of rated value to the voltage input circuits (terminals A3 - A8) of the relay. Check the measured voltages, frequency and vector surge on the display by pressing the push button <SELECT/RESET> repeatedly. The displayed measuring voltages (shown in Volt) are dependent on the wiring of the input voltage converters and the set transformation ratio.

The voltages are indicated on the display in volts.
At Y-connection:
- Phase-to-neutral voltages: LED L1, L2, L3

At Delta-connection:
- Phase-to-phase voltages: LED L1+L2, L2+L3, L3+L1

The frequency is indicated on the display in Hz: LED f (system frequency = 50.01Hz, Indication = 5001)
The vector surge is indicated on the display in degrees (for *MRN3-1*): LED ΔΘ (Indication ΔΘ in °)
The rate of change of frequency (LED df) is indicated on the display in Hz/s (for *MRN3-2*)

Change the voltages around the rated value and check the measured voltages on the display.
Change the system frequency around the rated frequency and check the measured frequency on the display.

Compare the voltage and frequency on display with the signal on voltmeter and frequency meter. The deviation for the voltage must not exceed 1% and for frequency <0.01 Hz.

By using an RMS-metering instrument, a greater deviation may be observed if the test voltage contains harmonics. Because the *MRN3* relay measures only the fundamental component of the input signals, the harmonics will be rejected by the internal DFFT-digital filter. Whereas the RMS-metering instrument measures the RMS-value of the input signals.

6.5.2 Checking the operating and reset ting values of the over/undervoltage functions

Note:
When the measuring voltage is connected or disconnected, vector surge tripping or df/dt tripping can occur. In order to ensure a trouble-free test procedure, the vector surge function or df/dt function of the relay have to be blocked before tests are started.

Apply three voltages with the rated value and gradually increase (decrease) the voltages until the relay starts, i.e. at the moment when the LED U> (or U<) lights up or the voltage alarm output relay (contact terminals D4/E4) is activated. Read the operating voltage indicated by the voltmeter. The deviation must not exceed 1% of the set operating value.

Furthermore, gradually decrease (increase) the voltages until the relay resets, i.e. the voltage alarm output relay is disengaged. Check that the dropout to pickup ratio for voltage is greater than 0.97 (for overvoltage function) or smaller than 1.03 (for undervoltage).

6.5.3 Checking the relay operating time of the over/undervoltage functions

To check the relay's operating time, a timer must be connected to the trip output relay contact (Contact terminals D1/E1). The timer should be started simultaneously with the voltage change from sound condition to a faulty condition and stopped by the trip relay contact. The operating time measured by timer should have a deviation about 3% of the set value or <20 ms.

6.5.4 Checking the operating and reset ting values of the over/underfrequency functions

Note:
Due to frequency changes, vector surge tripping or df/dt - tripping can occur during frequency tests. In order to ensure a trouble-free test procedure, the vector surge function or df/dt function of the relay have to be blocked before tests are started.
During frequency tests, each of the frequency elements should be tested separately. This makes it necessary that the other frequency elements of the relay have to be blocked by setting the frequency pickup values f_1 - f_3 to "EXIT". For testing the pickup and dropout to pickup values, the test frequency has to be increased (decreased) until the relay is engergized. This is indicated by lighting up of LEDs f_1 - f_3.
When comparing the values displayed with those of the frequency meter, the deviation must not exceed 0.01 Hz. The dropout to pickup values are ascertained by increasing (decreasing) the test frequency slowly until the output relay releases.
The dropout to pickup value for overfrequency must be >0.99, and for underfrequency <1.01.

6.5.5 Checking the relay operating time of the over/underfrequency functions

The operating time of the over/underfrequency functions can be tested in the similar manner as in chapter 6.5.3 for over/undervoltage functions.

6.5.6 Checking the vector surge function

With the help of an advanced relay test equipment a phase shift (vector surge) on the voltage signal can be obtained to test the vector surge function of *MRN3* relay. If there is no such testing facility available, a very simple simulation circuit may be used to test the vector surge function of the relay with a sufficient accuracy. Figure 6.2 shows the possibility to simulate a phase shift by means of a RC circuit. Closing or opening the switch S1 causes the phase angle of the input voltage to change depending on the adjustable resistor R.

The phase angle obtained may be calculated with the following formula and is almost independent on the test voltages.
In case of a 3-phase vector surge, the angle $\Delta\Theta$ can be calculated with the following formula if the parameters R_0, R and C are known:

$$\Delta\Theta = \text{arctg}\frac{1}{R_0 \cdot \omega \cdot C} - \text{arctg}\frac{1}{(R_0 + R)\cdot \omega \cdot C}$$

Example: R_0 = 1 Ohm, R = 363 Ohm, C = 3 µF

then: $\Delta\Theta \cong 19°$

Usually the voltage source impedance R_0 is negligible, hence R_0 may be assumed zero. Thus, the value of R may be calculated using the following simplified formula:

$$\Delta\Theta = 90° - \text{arctg}\frac{1}{R \cdot \omega \cdot C}$$

Note!
Using the above test circuit with single-phase vector surge, the resulting measured angle $\Delta\Theta$ is about half the value of $\Delta\Theta$ calculated for a 3-phase vector surge. To make tripping possible during a one phase test procedure, the vector surge tripping has to be set to "1Ph".

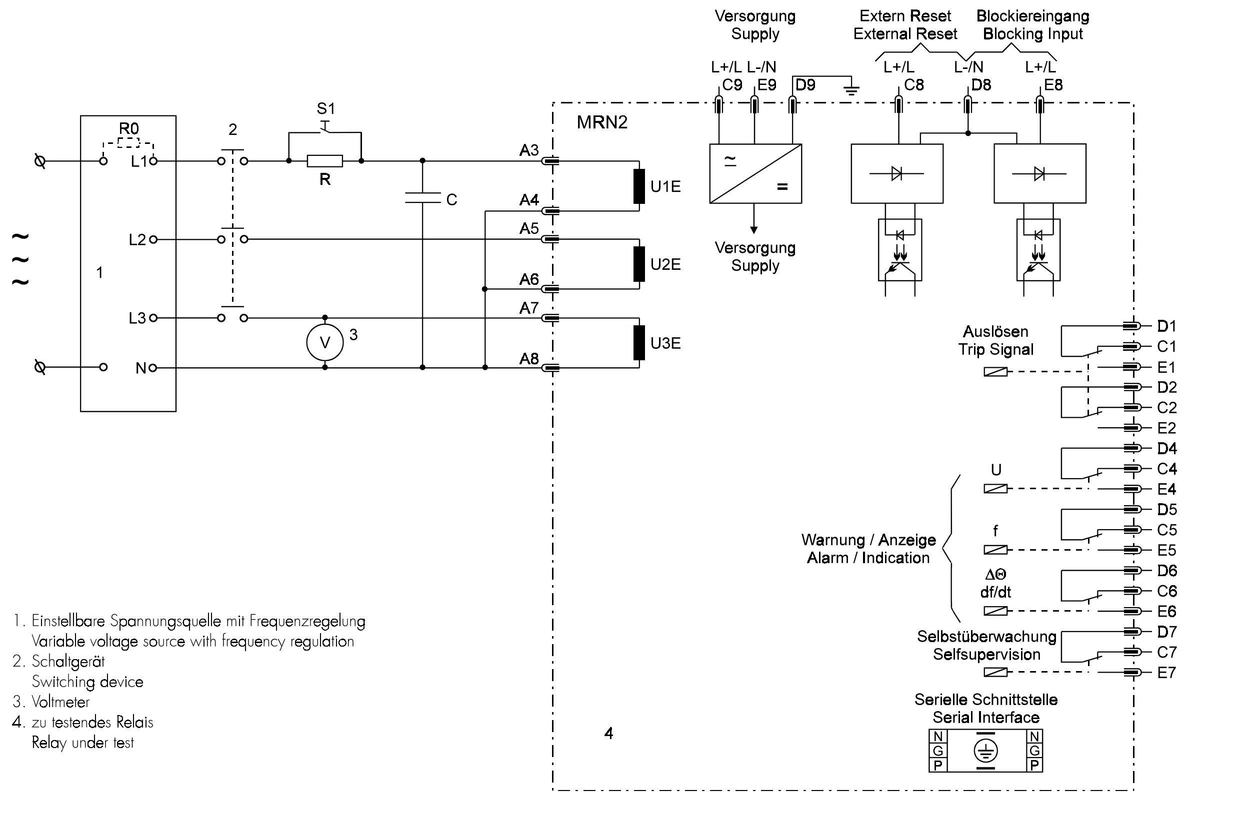


Figure 6.2: Test circuit for the vector surge function

6.5.7 Checking the external blocking and reset functions

The external blocking input is free programmable by the user.
To test the blocking function apply auxiliary supply voltage to the external blocking input of the relay (terminals E8/D8). Inject a test voltage which could cause tripping for the testes functions. Observe that there is no trip and alarm for those functions.

Remove the auxiliary supply voltage from the blocking input. Apply test voltages to trip the relay (message „TRIP" on the display). Return the test voltages to the sound condition and apply auxiliary supply voltage to the external reset input of the relay (terminals C8/D8). The display and LED indications should be reset immediately.

6.6 Primary injection test

Generally, a primary injection test could be carried out in the similar manner as the secondary injection test described above. With the difference that the protected power system should be, in this case, connected to the installed relays under test „on line", and the test voltages should be injected to the relay through the voltage transformers with the primary side energized. Since the cost and potential hazards are very high for such a test, primary injection tests are usually limited to very important protective relays in the power system.

Because of its powerful combined indicating and measuring functions, the *MRN3* relay may be tested in the manner of a primary injection test without extra expenditure and time consumption.

In actual service, for example, the measured voltage and frequency values on the *MRN3* relay display may be compared phase by phase with the concerned indications of the instruments of the switchboard to verify that the relay works and measures correctly.

6.7 Maintenance

Maintenance testing is generally done on site at regular intervals. These intervals vary among users depending on many factors: e.g. the type of protective relays employed; the importance of the primary equipment being protected; the user's past experience with the relay, etc.

For electromechanical or static relays, maintenance testing will be performed at least once a year according to the experiences. For digital relays like *MRN3*, this interval can be substantially longer. This is because:

- The *MRN3* relays are equipped with very wide self-supervision functions, so that many faults in the relay can be detected and signalised during service. Important: The self-supervision output relay must be connected to a central alarm panel!
- The combined measuring functions of *MRN3* relays enable supervision the relay functions during service.
- The combined TRIP test function of the *MRN3* relay allows to test the relay output circuits.

A testing interval of two years for maintenance will, therefore, be recommended.
During a maintenance test, the relay functions including the operating values and relay tripping times should be tested.

7 Technical data

7.1 Measuring input circuits

Rated data:	Nominal voltage U_N Nominal frequency f_N	100 V, 230 V, 400 V 40 - 70 Hz
Power consumption in voltage circuit:	<1 VA	
Thermal rating:	continuously	2 x U_N
Undervoltage lockout for frequency and vector surge measurement:	U< adjustable (5%...100% U_N)	

7.2 Common data

Dropout to pickup ratio:	for U>/U>> : >97%; for f>/f>> : >99.97%;	for U</U<< : <103% for f</f<< : <100.03%
Dropout time:	60 ms	
Time lag error class index E:	±10 ms	
Minimum operating time:	40 ms	
Max. allowed interruption of the auxiliary supply without a facting the function of the device:	50 ms	

Influences on voltage measuring:

Aux. voltage:	in the range 0.8 <U_H/U_{HN} <1.2 no additional influences to be measured
Frequency:	in the range 0.8 <f / f_N <1.4 (for f_N = 50 Hz) <0.15% / Hz
Harmonics:	up to 20% of the 3rd harmonic <0.1% per percent of the 3rd harmonic up to 20% of the 5th harmonic <0.05% per percent of the 5th harmonic

Influences on frequency measuring:

Aux. voltage:	in the range <0.8 U_N/U_{HN} <1.2 no additional influences to be measured
Frequency:	no influences

Influences on delay time: no additional influences to be measured

7.3 Setting ranges and steps

Function	Para- meter	Setting range	Steps	Tolerance
Transformer ratio	U_{prim}/U_{sek}	(SEC) 1.01...6500	0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0; 5.0; 10; 20; 50	
Rated frequency	f_N	f = 50 Hz / f = 60 Hz		
Switch group	Δ/Y	Δ = Delta/Y = Stern		
Switch over	P2/FR	SET1/SET2/B_S2/R_S2/B_FR/R_FR/ S2_FR		
LED blinking at pick-up		FLSH/NOFL		
U</<<	U</<< $t_{U<}$ $t_{U<<}$	U_N = 100 V: 2...200 V (EXIT) U_N = 230 V: 2...460 V (EXIT) U_N = 400 V: 4...800 V (EXIT) 0.04...50 s (EXIT)	 1 V 1 V 2 V 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s	 ± 1 % of set value or < 0.3% U_N ±1% or ±15 ms
U>/>>	U>/>> $t_{U>}$ $t_{U>>}$	U_N = 100 V: 2...200 V (EXIT) U_N = 230 V: 2...460 V (EXIT) U_N = 400 V: 4...800 V (EXIT) 0,04...50 s (EXIT)	 1 V 1 V 2 V 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s	 ±1% of set value or <0,3% U_N ±1% or ±15 ms
Frequency measuring repetition	T	2...99 (Cycles)	1	
Frequency element 1 - 3	f_1 - f_3 t_{f1} - t_{f3}	30...49.99; EXIT; 50.01...70 Hz[1] 40...59.99; EXIT; 60.01...80 Hz[2] $t_{f,min}$[3]...50 s; EXIT	0.1; 0.01 Hz 0.01; 0.02; 0.05; 0.1; 0.2; 0.5; 1.0; 2.0 s	0.03 Hz ±1% or ±20 ms
df/dt-Step df/dt-Measuring repetition	df dt	0,2...10 Hz/s (EXIT) 2...64 Periods	0.1; 0.2; 0.5 Hz/s 1	0.1 Hz/s
ΔΘ	ΔΘ	2°...22° (EXIT)	1°	±1°
Vector surge logic	1/3	1Ph / 3Ph		
Voltage theshold for frequency measuring	U_B< (LED 'f'+ ΔΘ/df)	U_N = 100 V: 5...100 V U_N = 230 V: 12...230 V U_N = 400 V: 20...400 V	 1 V 1 V 2 V	 ±1% of set value or <0.3% U_N

Table 7.1: Setting ranges and steps

1) At 50 Hz rated frequency
2) At 60 Hz rated frequency
3) $t_{f,min}$ min. time delay; $t_{f,min}$ = (T+1) x 20 ms
4) only Modbus

7.3.1 Interface parameter

Function	Parameter	Modbus-Protocol	RS485 Open Data Protocol
RS	Slave-Address	1 - 32	1 - 32
RS	Baud-Rate*	1200, 2400, 4800, 9600	9600 (fixed)
RS	Parity*	even, odd, no	"even Parity" (fixed)

Table 7.1: Interface parameter

*only Modbus Protocol

7.3.2 Parameters for the fault recorder

Function	Parameter	Adjustment example
FR	Number of recordings	(1)* 2 x 8 s; (3)* 4 x 4 s; (7)* 8 x 2 s (with 50 Hz) (1)* 2 x 6.66 s, (3)* 4 x 3.33 s, (7)* 8 x 1.66 s (60 Hz)
FR	Saving of the recording at the occurence	P_UP; TRIP; A_PI; TEST
FR	Pre-trigger-time	0.05 s – 8.00 s

Table 7.2: Parameters for the fault recorder

* is written over when a new trigger signal arrives

7.4 Output relays

Relay type	Trip relays / change-over contacts	Alarm relays / change-over contacts
MRN3	2/2	3/1

Table 7.3: Output relays

8 Order form

Mains decoupling relay	***MRN3-***				
with voltage-, frequency and vector surge supervision		**1**			
Voltage, frequency and df/dt-supervision		**2**			
Rated voltage	100 V		**1**		
	230 V		**2**		
	400 V		**4**		
Housing (12TE)	19"-rack			**A**	
	Flush mounting			**D**	
RS485	Alternatively with Modbus Protocol				**-M**

Technical data subject to change without notice!

Setting list *MRN3*

Project: ______________________________ SEG job.-no.: ______________________

Function group: = ______________ Location: + ________ Relay code: - ______________________

Relay functions: ______________________________ Password: ______________________

Setting of the parameters

System parameter

Function		Unit	Relay type *MRN3-1*	 *MRN3-2*	Default settings Set 1/Set 2	Actual settings Set 1/Set 2
U_{prim}/U_{sek}	Voltage transformer ratio		X	X	SEK	
Δ/Y	Input voltage correction dependent on the connection of the input transformer		X	X	Y	
f_N	Rated frequency	Hz	X	X	v = 50 Hz	
LED Flash	Display of the activation storage		X	X	FLSH	
P2	2 parameter sets/ext. Trigger for FR		X	X	SET1	

Protection parameter

Function		Unit	Default settings	Actual settings
			Set 1 / Set 2	Set 1 / Set 2
U<	pickup value for undervoltage element (low set)	V	90/210/360*	
t_U<	tripping delay for undervoltage element	s	0.04	
U<<	pickup value for undervoltage element (high set)	V	80/190/320*	
t_U<<	tripping delay for undervoltage element	s	0.04	
U>	pickup value for overvoltage element (low set)	V	110/250/440*	
t_U>	tripping delay for overvoltage element	s	0.04	
U>>	pickup value for overvoltage element (high set)	V	120/270/480*	
t_U>>	tripping delay for overvoltage element	s	0.04	
T	frequency measuring repetition in periods	cycles	4	
f_1	pickup value for frequency element 1	Hz	4800	
t_{f1}	tripping delay for frequency element 1	s	0.1	
f_2	pickup value for frequency element 2	Hz	4900	
t_{f2}	tripping delay for frequency element 2	s	0.1	
f_3	pickup value for frequency element 3	Hz	5100	
t_{f3}	tripping delay for frequency element 3	s	0.1	
df	pickup value for rate of frequency (dt/dt) in	Hz/s	EXIT	
dt	measuring repetition for df/dt	periods	4	
1/3	vector surge tripping logic		1PH	
ΔΘ	pickup value for vector surge	°	2.0	
U_B<	voltage threshold value for frequency and vector surge measuring (or df/dt)	V	10/23/40*	
RS	Slave address of the serial interface		1	
RS**	Baud-Rate		9600	
RS**	Parity-Check		even	

* thresholds dependent on rated voltage 100 V / 230 V / 400 V

** only Modbus

Fault recorder

Function		Unit	Default settings	Actual settings
FR	Number of recordings		4	
FR	Saving of the recording at the occurrence		TRIP	
FR	Time prior to trigger impulse	s	0.05	
◷	Year setting	year	Y=00	
◷	Month setting	month	M=00	
◷	Day setting	day	D=00	
◷	Setting of the hour	hour	h=00	
◷	Setting of the minute	minute	m=00	
◷	Setting of the setting	second	s=00	

Blocking function

	Default settings				Actual settings			
	Blocking		Not blocking		Blocking		Not blocking	
Parameter set	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2
U<	X		X					
U<<	X		X					
U>		X		X				
U>>		X		X				
f1	X		X					
f2	X		X					
f3		X		X				
ΔΘ	X		X					
df/dt	X		X					

Assignment of the output relays

Function	Relay 1		Relay 2		Relay 3		Relay 4	
	Default settings	Actual settings	Default settings	Actual settings	Default settings	Actual settings	Default settings	Actual settings
U< alarm			X					
$t_{U<}$ tripping	X							
U<< alarm			X					
$t_{U<<}$ tripping	X							
U> alarm			X					
$t_{U>}$ tripping	X							
U>> alarm			X					
$t_{U>>}$ tripping	X							
f1 alarm					X			
tf1 tripping	X							
f2 alarm					X			
tf2 tripping	X							
f3 alarm					X			
tf3 tripping	X							
ΔΘ tripping							X	
df/dt tripping							X	

Setting of code jumpers

Code jumper	J1		J2		J3	
	Default settings	Actual settings	Default settings	Actual settings	Default settings	Actual settings
Plugged						
Not plugged	X		No function		X	

Code jumper	Low/High-range for Reset input		Low/High-range for blockage input	
	Default settings	Actual settings	Default settings	Actual settings
Low=plugged	X		X	
High=not plugged				

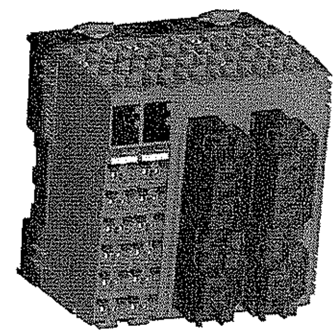
All settings must be checked at site and should the occasion arise, adjusted to the object/item to be protected.

This technical manual is valid for
software version number: D01-8.08 (*MRN3-1*)
D04-8.08 (*MRN3-2)*

Modbus version number: D51-1.13 (*MRN3-1*)
D54-1.13 (*MRN3-2)*

Blank Page for Notes

Order data

Model number	Short description	Image
X20CM0985	X20 digital and analog mixed module, Multi-measurement transformer / synchronization module 5 x DO, 24 VDC, 0.5 A source; 1 relay 0.5 A 8 x AI ±480 V/120 V, 16-bit converter resolution 3 x AI ±5 A/1 A, 16-bit converter resolution	
X20TB12	X20 standard terminal 12x	
0TB3102-7011	Accessory 2-pin SCREW CLAMP (7.62) cod. A	
0TB3104-7011	Accessory 4-pin SCREW CLAMP (7.62) cod. A	
0TB3102-7012	Accessory 2-pin SCREW CLAMP (7.62) cod. B	
0TB3104-7012	Accessory 4-pin SCREW CLAMP (7.62) cod. B	

Technical data

Name	X20CM0985
General information	
Module type	X20 digital and analog mixed module
Ambient temperature during operation	
Vertical installation	55°C
Horizontal installation	50°C
Relative humidity	5 – 95%, non-condensing
Power consumption Bus I/O internal	 1.4 W 4 W
Digital outputs	
Number of outputs	5
Wiring	Source
Supply voltage Minimum Nominal Maximum	 18 VDC 24 VDC 30 VDC
Maximum continuous current at nominal voltage	500 mA
Max. frequency	500 Hz
Short circuit protection	Yes
Overload protection	Yes
Readable	Yes
Open circuit recognition	No
Electrical isolation	Yes
Relay outputs	
Number of outputs	1
Relay contacts	Max. 230 VAC; 0.5 A
Capability of contacts to withstand surges	500 V

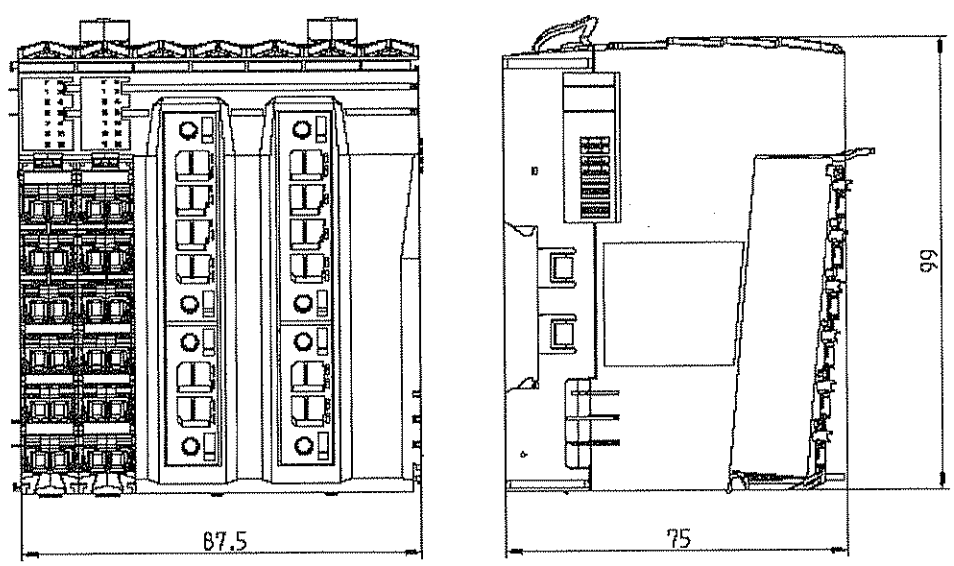
Measured variables	
Analog input voltage (generator mains network)	
Number of inputs	3
Digital converter resolution	16-bit
Value range / input signal Range1 Range2	Configurable ± 120 VAC L1-L2 +10% ±480 VAC L1-L2 +10%
Output format	INT $8000 - $7FFF
Input resistance	~3 MΩ
Input filter Frequency limit Attenuation	 10 kHz 60 dB
Basic accuracy	0.5% (MBE)
Analog input current (generator mains network)	
Number of inputs	3
Digital converter resolution	16-bit
Value range / input signal Range 1 Range 2	Configurable ±1A ±5A
Thermal over-current	15 x I_{Nom} for 0.2 s
Monitored over-current	4 x I_{Nom}
Output format	INT $8000 - $7FFF
Input filter Frequency limit Attenuation	 10 kHz 60 dB
Basic accuracy	0.5% (MBE)
Analog input voltage (bus bar)	
Number of inputs	3
Digital converter resolution	16-bit
Value range / input signal Range1 Range2	Configurable ± 120 VAC L1-L2 +10% ±480 VAC L1-L2 +10%
Output format	INT $8000 - $7FFF
Input resistance	~3 MΩ
Input filter Frequency limit Attenuation	 10 kHz 60 dB
Basic accuracy	0.5% (MBE)
Analog input voltage (synchronization mains network 1)	
Number of inputs	1
Digital converter resolution	16-bit
Value range / input signal Range1 Range2	Configurable ± 120 VAC L1-L2 +10% ±480 VAC L1-L2 +10%
Output format	INT $8000 - $7FFF
Input resistance	~3 MΩ
Input filter Frequency limit Attenuation	 10 kHz 60 dB
Basic accuracy	0.5% (MBE)
Analog input voltage (synchronization mains network 2)	
Number of inputs	1
Digital converter resolution	16-bit
Value range / input signal Range1 Range2	Configurable ± 120 VAC L1-L2 +10% ±480 VAC L1-L2 +10%
Output format	INT $8000 - $7FFF
Input resistance	~3 MΩ

Input filter Frequency limit Attenuation	10 kHz 60 dB
Basic accuracy	0.5% (MBE)
Power supply	
Supply voltage Minimum Rated Maximum	18 VDC 24 VDC 30 VDC
Electrical isolation to PLC	No
Voltage monitoring	Error for voltages under 18 VDC

Environmental and general conditions	
Ambient temperature Operation Horizontal installation Vertical installation Storage	0 - 55°C 0 - 50°C - 25 to + 70°C
Relative humidity	5 - 95%, non-condensing
Protection type	IP20
Standards Temperature Shock / tests carried out Vibration / tests carried out Emission / tests carried out Immunity / tests carried out	IEC 61131-2 / IEC 60068-2-x IEC61131-2 / IEC60068-2-27 IEC61131-2 / IEC60068-2-6 EN 50081-2 / EN 55022+A1 IEC 61131-2 / IEC 61000-4-x

The device is provided with a CE mark. A UL label is in preparation.

Mechanical dimensions



X20CM0985 module- Pin assignments

X1 – Digital outputs

Connection	Name	Image
11	DO1 normally closed contact	
21	DO1 normally open contact	
12	DO2	
22	DO1 COM	
13	DO3	
23	DO4	
14	DO5	
24	DO6	
15	+24 VDC	
25	+24 VDC	
16	GND	
26	GND	

- DO1: This digital output is designed as changeover switch. The monitoring relay allows chosen monitoring of: overvoltage and undervoltage, over-frequency and under-frequency, voltage asymmetry, current asymmetry, calculated neutral conductor current (maximum), short-circuit-current, thermal over-current and the limit value of the capacitive reactive power (exciter failure).
- DO2: Serves as counter output, using pulses for an external energy counter (kWh)
- DO3: The output is set when there is no current on the bus bar (below the lower limit of the defined parameter). The bus bar voltage is monitored in 3-phases.
- DO4: Serves as synchronization pulse. The power switch is activated by setting this output. The output is deactivated again after the output pulse and after the configured time has elapsed (exception: operating mode Synchro – Check)
- DO5, DO6: Digital outputs for other purposes of use

  Terminals X1 and X2 are each differently coded in order to avoid being plugged into the wrong module.

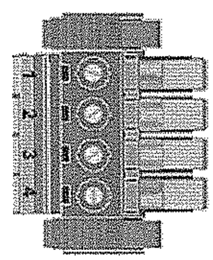
X2 – analog current inputs (generator mains network)

Connection	Name	Image
11	1A I1+ current L1	
12	1A I1- current L1	
21	5A I1+ current L1	
22	5A I1- current L1	
13	1A I2+ current L2	
14	1A I2- current L2	
23	5A I2+ current L2	
24	5A I2- current L2	
15	1A I3+ current L3	
16	1A I3- current L3	
25	5A I3+ current L3	
26	5A I3- current L3	

The X2 terminal measures the three phase currents of the generator mains network. It is possible to configure the measurement range for the current inputs between 1 A and 5 A.

X3 – analog voltage inputs (generator mains network)

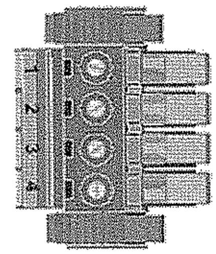
4-pin terminal
7.62 mm grid

Connection	Name	Image
1	GN - L1	
2	GN - L2	
3	GN - L3	
4	GN- N	

X3 and X5 terminals are each coded differently to avoid being plugged into the wrong module.

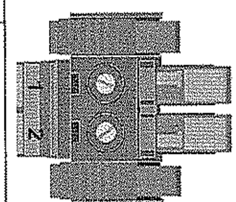
X5 – analog voltage inputs (bus bar)

4-pin terminal
7.62 mm grid

Connection	Name	Image
1	SS - L1	
2	SS - L2	
3	SS - L3	
4	SS - N	

X4 – analog voltage inputs (synchronization mains network 1)

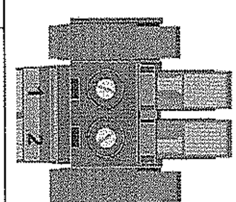
2-pin terminal
7.62 mm grid

Connection	Name	Image
1	Sync-mains1 - L1	
2	Sync-mains1 - L2	

X4 and X6 terminals are each coded differently to avoid being plugged into the wrong module.

X6 – analog voltage inputs (synchronization mains network 2)

2-pin terminal
7.62 mm grid

Connection	Name	Image
1	Sync-mains2 - L1	
2	Sync-mains2 - L2	

The voltage inputs X4 and X6 are used to determine the external line voltages for the synchronization between two different mains networks.
The X3 and X5 terminals are used to measure and monitor the external line voltages, phase voltages of the generator mains network and the bus bar.

Synchronizing - functions

Synchronizing with slip

The following applies to synchronization mains network 1 and synchronization mains network 2:
50% < U < 125% of the nominal voltage UN
80% < f < 110% of the nominal frequency fN
The generator voltage is adjusted to the synchronization voltage in amplitude and frequency. Taking into account the configured phase angle (dalpha), a defined transformer vector group, and the switching response time, the switch-on command is calculated and transmitted in advance so that the main contacts of the power switch are closed at the point of synchronicity.

Synchronization occurs under the following conditions:

- The "Synchronization selection" command is set using a software application
- The device is ready
- The defined limit for voltage difference is not exceeded (dUmax)
- The defined limits for frequency difference are not exceeded (dfmax and dfmin)
- The defined limit for the phase angle (incl. transformer vector group dalpha) is maintained (phimax)

The actual synchronization is activated if the conditions for the phase angle are met the first time and the phase window is exited. It should be noted that the conditions for voltage and frequency difference do not need to be fulfilled the first time.
This means that if the phase difference lies within the phase window when making the demand, a new entry for "activation" is no longer necessary. In order to cancel synchronization when in an activated state, the command "Synchronization with slip" must be reset.
Following the activation of the synchronization command, the synchronization window of all the above synchronization conditions must be opened from any direction of phase movement in order to obtain a synchronization impulse according to the switch lead time.

At very low frequencies, or equivalent frequency, and in adherence to the conditions described above, synchronization will also take place when entering the synchronization window a second time. The synchronization impulse is first issued only at a phase angle = 0°.
In low differential frequencies, the switch is not immediately engaged when the phase window is reached, but only when synchronization is possible at the point of synchronicity.

DO4 changes its state from LOW to HIGH when all conditions are met. It changes back from HIGH to LOW after the defined pulse duration has elapsed.

Synchro – Check

The device can be used as synchronization check in this operating mode. The "DO4" relay stays on, as long as the following conditions have been met:

- The "Enable Synchro Check" command is set using a software application
- The device is ready
- The defined limit for voltage difference is not exceeded (dUmax)
- The defined limits for frequency difference are not exceeded (dfmax and dfmin)
- The defined limit for the phase angle is not exceeded (phimax)

DO4 stays at HIGH as long as all conditions have been met.

Switching to voltage-free "dead bus"

The switch-on command for the power switch is output without synchronization if the following conditions have been met:

- The "Enable Dead Bus" command is set using a software application
- The device is ready
- The bus bar is voltage-free (USS < 5% UN)
- The generator voltage and frequency can be any valid value.

DO4 changes its state from LOW to HIGH when all conditions are met. It changes back from HIGH to LOW after the defined pulse duration has elapsed.

Bus bar voltage measurement and zero voltage monitoring

The bus bar voltage is monitored for 3 phases. The measured values are represented as combined values as well as phase values. The D03 output is set when there is no voltage (below the lower limit of the defined parameter) on the bus bar (X5 terminal).

Measurement functions

General measured parameters

- External line voltages
- Phase voltages
- Frequency

Measured parameters for generator mains network (X3)

- Phase currents
- Current average
- Dynamic current average
- Neutral conductor current
- External line voltages
- Phase voltages
- Voltage average
- Total apparent power
- Total reactive power
- Total effective power
- Active power factor
- Frequency

Measured parameters between synchronization mains networks

- Differential angle
- Differential voltage

Thermal over-current

Thermal overload monitoring is in accordance with IEC 255-8 "Electrical relays; Relays for protecting against thermal overload (overload relays)" and IEC 255-17 "Electrical relays; Relays for protecting against the thermal overload of motors (overload relays for motors).

Unbalanced load monitoring

Unbalanced load monitoring protects against unbalanced load in three-phase producers and three-phase networks. Changeable parameters make it possible to match the tripping characteristics to different generator types while taking their special thermal time constants into consideration.

An unbalanced load can be caused by uneven distribution of current in the network due to unbalanced load, asymmetrical conductor short-circuits, line interruptions and even switching operations. Unbalanced loads result in reverse system currents in the stator, which cause harmonics with an uneven ordinal number in the stator winding and harmonics with an even ordinal number in the rotor winding. In this situation, the rotor is at particular risk because the harmonics cause additional load on the rotor winding and induce turbulent flow in the rotor's solid iron, which could melt the metal or damage the metal structure. An unbalanced load can be permissible under certain conditions and by accounting for the thermal load limit of the generator. To avoid premature failure of the generator when an unbalanced load occurs, the trigger characteristic of the unbalanced load protection should be adjusted to the thermal characteristics of the generator. Unbalanced load protection can also be triggered by external errors on the power mains caused by asymmetric short-circuits.

Short-circuit current monitoring

The error message "Over-current/Short-circuit" is generated after the defined delay time has elapsed if an over-current/short-circuit occurs and the limit is exceeded.

Voltage asymmetry monitoring

The trigger value, which is adjustable by percentage, is always based on the defined nominal range of the generator mains network. This value describes the maximum deviation from one of the three differential voltages between the three monitored, combined phase voltages.

The error message "Voltage asymmetry" is signaled after the defined delay time has elapsed if this value is exceeded above the upper limit or below the lower limit.

Exciter failure

Reactive power monitoring can be used to protect a generator against operating outside the permissible range. The capacitive reactive power monitor offers protection against underexcitation (exciter failure). The error message "Exciter failure" is generated after the defined delay time has elapsed if the lower limit is exceeded.

Register description

Asynchronous register

Register	ID	Description				Configuration	
				Resolution	Length in bytes	Read	Write
2578	ConfigOutput01	Synchronization mains network nominal voltage 70 V..65k V (U_{NomSyn})	UINT	1 V	2		•
2582	ConfigOutput02	Generator mains network nominal voltage 70 V..65 kV (U_{NomGen})	UINT	1 V	2		•
2586	ConfigOutput03	Bus bar nominal voltage 70 V..65 kV (U_{NomBBr})	UINT	1 V	2		•
2590	ConfigOutput04	Nominal generator current 0 .. 65 kA (I_{Nom})	UINT	1 A	2		•
2594	ConfigOutput05	Multiplier for bus bar	UINT	0.01	2		•
2598	ConfigOutput06	Multiplier for generator mains network	UINT	0.01	2		•
2602	ConfigOutput07	Multiplier for synchronization mains network 1	UINT	0.01	2		•
2606	ConfigOutput08	Multiplier for synchronization mains network 2	UINT	0.01	2		•
2610	ConfigOutput09	Multiplier for current transformer	UINT	1	2		•
2614	ConfigOutput10	Nominal frequency 48.0 .. 62.0 Hz	UINT	0.1 Hz	2		•
2626	ConfigOutput11	Max. differential frequency 0.02 .. 0.49 Hz (df Max)	UINT	0.01 Hz	1		•
2630	ConfigOutput12	Min. differential frequency 0.00 .. -0.49 Hz (df Min)	INT	0.01 Hz	1		•
2634	ConfigOutput13	Max. differential voltage 0.1% - 30.0% U_{NomSyn} (d Umax)	UINT	0.1%	2		•
2638	ConfigOutput14	Max. differential angle 0..60° (phimax))	UINT	0.1°	2		•
2618	ConfigOutput15	Phase rotation of sync mains network 1(dalpha)	UIINT	0.1°	2		•
2561	ConfigOutput20	Nominal voltage range of generator mains network 100V/400 V	BOOL	0 – 1			•
2563	ConfigOutput21	Nominal voltage range of bus bar 100V/400 V	BOOL	0 – 1			•
2565	ConfigOutput22	Nominal voltage range of sync – mains network 1 100 V/400 V	BOOL	0 – 1			•
2567	ConfigOutput23	Nominal voltage range of sync – mains network 2 100 V/400 V	BOOL	0 – 1			•
2569	ConfigOutput24	Nominal current range 1 A/5 A	BOOL	0 – 1			•
2571	ConfigOutput25	ARON connection	BOOL	0 – 1			•
2658	ConfigOutput16	Overvoltage of a phase 0.0% - 200.0% U_{NomGen}	UINT	0.1%	2		•
2710	ConfigOutput26	Reaction time for umax	UINT	0.1 s	2		•
2662	ConfigOutput27	Undervoltage of a phase 0.0% - 200.0% U_{NomGen}	UINT	0.1%	2		•
2718	ConfigOutput28	Reaction time for umin	UINT	0.1 s	2		•
2666	ConfigOutput29	Over-frequency	UINT	0.1%	2		•
2726	ConfigOutput30	Reaction time for fmax	UINT	0.1 s	2		•
2670	ConfigOutput31	Under-frequency	UINT	0.1%	2		•
2734	ConfigOutput32	Reaction time for fmin	UINT	0.1 s	2		•
2674	ConfigOutput33	Voltage asymmetry 0.0% – 30.0% U_{NomGen}	UINT	0.1%	2		•
2742	ConfigOutput34	Reaction time for Uas	UINT	0.1 s	2		•
2774	ConfigOutput35	Load time constant for current asymmetry	UINT	0.1 s	2		•
2678	ConfigOutput36	Neutral conductor current, maximum 0.0% - 100.0% I_{Nom}	UINT	0.1%	2		•
2750	ConfigOutput37	Reaction time for ingw	UINT	0.1 s	2		•
2682	ConfigOutput38	Short-circuit current 100.0% - 500.0% I_{Nom}	UINT	0.1%	2		•
2758	ConfigOutput39	Reaction time for ks	UINT	0.01 s	2		•
2650	ConfigOutput40	Bus bar voltage min. 0.0% - 100% U_{NomBBr}	UINT	0.1%	2		•
2622	ConfigOutput58	Dead bus voltage 0.0% – 100% $U_{Nom Syn}$	UINT	0.1%	2		•
2782	ConfigOutput41	Lower-pass filter for total power 0 – 300ms	UINT	1 ms	2		•

2686	ConfigOutput42	Thermal over-current 100.0% - 200.0% I_{Nom}	UINT	0.1%	2		•
2690	ConfigOutput43	Integration coefficient for iths 0.1 – 2.0	UINT	0.1	2		•
2694	ConfigOutput44	Capacitive reactive power	INT	1 kVAr	2		•
2766	ConfigOutput45	Reaction time for qsmin	UINT	0.1 s	2		•
2790	ConfigOutput46	Pulse value of counter output energy	UINT	1 kWh/Imp	2		•
2794	ConfigOutput47	Min. pulse length of switch-on relay 0.040 .. 0.500 s	UINT	0.001 s	2		•
2798	ConfigOutput48	Switching response time of power switch 40 .. 300 ms	UINT	0.001 s	2		•
2050	ConfigOutput49	Phase current of generator I1, maximum	INT	1 A	2	•	
2054	ConfigOutput50	Phase current of generator I2, maximum	INT	1 A	2	•	
2058	ConfigOutput51	Phase current of generator I3, maximum	INT	1 A	2	•	
2062	ConfigOutput52	Total effective power, max.	INT	1 kW	2	•	
2066	ConfigOutput53	Neutral conductor current, max.	INT	1 A	2	•	
2076	ConfigOutput54	Active energy counter	DINT	100 kWh	4	•	
2084	ConfigOutput55	Reactive energy counter	DINT	100 KVrh	4	•	
2654	ConfigOutput56	Synchronization configuration	UINT	-	1		•
2698	ConfigOutput57	Function DO1	UINT	-	2		•
2834	ConfigOutput60	Reset phase current of generator I1, max.	INT	1 A	2		•
2838	ConfigOutput61	Reset phase current of generator I2, max.	INT	1 A	2		•
2842	ConfigOutput62	Reset phase current of generator I3, max.	INT	1 A	2		•
2846	ConfigOutput63	Reset total effective power, max.	INT	1 kW	2		•
2850	ConfigOutput64	Reset neutral conductor current, max.	INT	1 A	2		•
2860	ConfigOutput66	Write to the active energy counter	DINT	100 kWh	4		•
2868	ConfigOutput67	Write to the reactive energy counter	DINT	100 kVrh	4		•

Nominal voltage for synchronization (U_{NomSyn}) 70V .. 65 kV

For converting various synchronization voltage limits from a percentage into physical units.

Nominal voltage for generator (U_{NomGen}) 70V .. 65 kV

For converting various generator voltage limits from a percentage into physical units.

Nominal voltage for bus bar (U_{NomBBr}) 70V .. 65 kV

For converting various bus bar voltage limits from a percentage into physical units.

Nominal generator current (I_{Nom}) 0A .. 65 kA

For converting various generator current limits from a percentage into physical units.

Multiplier for bus bar 0.01 .. 655.35

A multiplier is used based on the input of the bus bar voltage for converting the bus bar voltage to V.

Multiplier for generator voltage 0.01 .. 655.35

A multiplier is used based on the input of the generator voltage for converting the generator voltage to V.

Multiplier for synchronization mains network 1 0.01 .. 655.35

A multiplier is used based on the input of the synchronization mains network 1 for converting the synchronization mains network 1 to V.

Multiplier for synchronization mains network 2 0.01 .. 655.35

A multiplier is used based on the input of the synchronization mains network 2 for converting the synchronization mains network 2 to V.

Multiplier for current transformer

A multiplier is used based on the input of the generator current for converting the generator currents to A.

Nominal frequency 48.0 .. 62.0 Hz

For converting various nominal frequency limits from a percentage into physical units.

Max. differential frequency 0.02 .. 0.49 Hz (df Max)

This value specifies the upper frequency deviation (positive slip – synchronization mains network frequency 1 is greater than synchronization mains network frequency 2).
The condition for a switch-on command is not met as long as this limit is not exceeded at the low end.

Min. differential frequency 0.00 .. -0.49 Hz (df Min)

This value specifies the lower frequency deviation (negative slip – synchronization mains network frequency 1 is smaller than synchronization mains network frequency 2).
The condition for a switch-on command is not met as long as this value is not exceeded.

Max. differential voltage 0.1% - 30.0% U_{NomSyn} (dUmax)

The condition for a switch-on command is not met as long as the differential voltage between both synchronization mains networks is greater than the defined differential voltage.

Max. differential angle 0..60° (phimax)

The condition for a switch-on command is met if the value of the defined differential angle between the synchronization mains networks is below the lower limit.

Phase rotation of sync mains network 1(dalpha)

For correcting any phase shifting of transformer vector groups.

Synchro – Check

Bit for setting the synchronization Synchro – check. (see Synchro Check function)
This mode requires that the value is less than the maximum differential angle.

Nominal voltage range of generator mains network 100V/400V

Bit for configuring the generator mains network voltage range (100 V/400 V)

Nominal voltage range of bus bar 100V/400V

Bit for configuring the bus bar voltage range (100 V/400 V)

Nominal voltage range of sync – mains network 1 100V/400V

Bit for configuring the synchronization mains network voltage range 1 (100 V/400 V)

Nominal voltage range of sync – mains network 2 100V/400V

Bit for configuring the synchronization mains network voltage range 2 (100 V/400 V)

Nominal current range

Bit for configuring the measurement current range (1A/5A)

ARON connection

Configuration bit for switching to the power measurement principle of the Aron connection

Overvoltage on a phase 0.0% - 200.0% U_{NomGen}

Adjustable limit for overvoltage on a phase. The error message "Overvoltage" is generated after the defined delay time has elapsed when this value, based on the nominal voltage of the generator mains network, is exceeded.

Reaction time for umax

Umax is signaled after this reaction time has elapsed.

Undervoltage on a phase 0.0% - 200.0% U_{NomGen}

Adjustable limit for undervoltage on a phase. The error message "Undervoltage" is generated after the defined delay time has elapsed when the lower limit of this value, based on the nominal voltage of the generator mains network, is exceeded.

Reaction time for umin

Umin is signaled after this reaction time has elapsed.

Over-frequency (f_{max})

The error message "Over-frequency" is generated after the defined delay time has elapsed if the limit, based on the nominal frequency, for over-frequency is exceeded.

Reaction time for f_{max}

fmax is signaled after this reaction time has elapsed.

Under-frequency (f_{min})

The error message "Under-frequency" is generated after the defined delay time has elapsed if the limit, based on the nominal frequency, for Under-frequency is not reached.

Reaction time for f_{min}

fmin is signaled after this reaction time has elapsed.

Voltage asymmetry 0.0% – 30.0% U_{NomGen}

The trigger value, which is adjustable by percentage, is always based on the defined nominal range of the generator mains network. This value describes the maximum deviation from one of the three differential voltages between the three monitored, chained phase voltages.
The error message "Voltage asymmetry" is signaled after the defined delay time has elapsed if the value is exceeded.

Reaction time for U_{as}

Uas is signaled after this reaction time has elapsed.

Load time constant for current asymmetry (t_{per})

Value of the load time constant for current asymmetry (see the description of unbalanced load protection).

Neutral conductor current, maximum 0.0% - 100.0% I_{Nom}

Configurable limit for the neutral conductor current. The error message "Neutral conductor current" is signaled after the defined delay time has elapsed if the value is exceeded.

Reaction time for I_{ngw}

Ingw is signaled after this reaction time has elapsed.

Short-circuit current 100.0% - 500.0% I_{Nom}

Configurable limit for the short-circuit current. The error message "Over-current/Short-circuit" is signaled after the defined delay time has elapsed if an over-current/short-circuit occurs and the limit is exceeded.

Reaction time for ks

ks is signaled after this reaction time has elapsed.

Bus bar voltage min. 0.0% - 100% U_{NomBBr}

Configurable threshold for zero voltage monitoring of the bus bar based on the nominal voltage of the bus bar.

Dead bus voltage 0.0% – 100% UNom Syn

Configurable threshold for Dead Bus synchronization of the respectively configured Sync mains network, based on the nominal voltage of the Sync mains network.

Lower-pass filter for total power 0 – 300ms

Parameter for delay time of the low-pass filter of the total power P, Q and S. The maximum values of the total power should be recorded unfiltered.

Thermal over-current 100.0% - 200.0% INom

(see the description of Thermal over-current)

Integration coefficient for this 0.1 – 2.0

(see the description of Thermal over-current)

Exciter failure

Reactive power monitoring can be used to protect a generator against operating in an invalid range. The capacitive reactive power monitor offers protects against underexcitation (exciter failure). The error message "Exciter failure" is generated after the defined delay time has elapsed if the lower limit is exceeded.

Reaction time for qsmin

qsmin is signaled after this reaction time has elapsed.

Min. pulse length of switch-on relay 0.040 .. 0.500 s

The duration of the switch-on pulse can be configured for DO4 here.

Switching response time of power switch 40 .. 300 ms

The actuation time of the power switch is equal to the lead time of the switch-on command. The switch-on command is made at the defined amount of time before the point of synchronicity.

DO1 functions (Reg 2698, ConfigOutput 57)

The digital output can be set after the defined delay time has elapsed according to the assignment of the monitoring variables of generator mains network (X3).
The monitoring variables mentioned above can be assigned to this input either individually or using an OR operation with additional monitoring variables. This makes it possible to set the relay when there are multiple monitoring variables.

The monitoring functions that can be assigned to the monitoring relay:

Bit	Monitoring variables
0	Overvoltage (of one phase)
1	Undervoltage (of one phase)
2	Over-frequency
3	Under-frequency
4	Voltage asymmetry
5	Current asymmetry
6	Neutral conductor current, maximum
7	Short circuit current
8	Over-current, thermal
9	Capacitive reactive power (exciter failure)
10	Ready

Note:
The minimum pulse duration when addressing a monitoring function on the error bit via X2X as well as on the relay is 500 ms.

Maximum value buffer (Reg 2834 -- 2850)

Nonvolatile maximum value buffer for storing maximum values that occur in operation. After restarting, the stored maximum values are loaded back into their register. It is possible to reset the stored maximum values using an asynchronous register.
The maximum values are recorded by measurement values before a configurable filter. The maximum values must be able to be read and written as an asynchronous register.

Measurement variables:

- Max. phase currents $I1_{max}$, $I2_{max}$, $I3_{max}$
- Max. neutral conductor current In_{max}
- Max. total effective power P_{max}

Synchronization configuration (Reg 2654)

Parameter for configuring which mains networks or voltages should be synchronized with each other. This configuration makes it possible to synchronize the AC network on the X4 terminal with either the X3, X5 or X6 terminal.
In all cases, the synchronization mains network 1 (X4) is the mains network to synchronize with.

Terminals	Configuration
X4 – X6	00
X4 – X5	01
X4 – X3	10
Reserved	11

Synchronous register

Register	Description	Data type	Resolution	Length (bytes)	Configuration Read	Write
2	Phase current of generator I1	INT	1 A	2	•	
6	Phase current of generator I2	INT	1 A	2	•	
10	Phase current of generator I3	INT	1 A	2	•	
14	Current average I1, I2, I3	INT	1 A	2	•	
18	Neutral conductor current In	INT	1 A	2	•	
22	Current average, dynamic (in the dyn)	UINT	0.1%	2	•	
26	External line voltage of generator UG12	INT	1 V	2	•	
30	External line voltage of generator UG23	INT	1 V	2	•	
34	External line voltage of generator UG31	INT	1 V	2	•	
38	Line voltage of generator UG1	INT	1 V	2	•	
42	Line voltage of generator UG2	INT	1 V	2	•	
46	Line voltage of generator UG3	INT	1 V	2	•	
50	External line voltage of bus bar US12	INT	1 V	2	•	
54	External line voltage of bus bar US23	INT	1 V	2	•	
58	External line voltage of bus bar US31	INT	1 V	2	•	
62	Line voltage of bus bar US1	INT	1 V	2	•	
66	Line voltage of bus bar US2	INT	1 V	2	•	
70	Line voltage of bus bar US3	INT	1 V	2	•	
74	Total effective power, filtered P	INT	1 kW	2	•	
78	Total reactive power, filtered Q	INT	1 kVAr	2	•	
82	Total apparent power, filtered S	INT	1 kVA	2	•	
86	Voltage average UG12, UG23, UG31	INT	1 V	2	•	
90	Power factor cosφ	INT	0.01	2	•	
94	Frequency of the generator mains network	UINT	0.1 Hz	2	•	
98	External line voltage of sync mains network 1 US1	INT	1 V	2	•	
102	External line voltage of sync mains network 2 US2	INT	1 V	2	•	
106	Frequency of sync mains network 1	UINT	0.1 Hz	2	•	
110	Frequency of sync mains network 2	UINT	0.1 Hz	2	•	
114	Differential angle between synchronization mains networks	UINT	0.1°	2	•	
118	Differential voltage between synchronization mains networks	UINT	1 V	2	•	
122	Error register	UINT	-	2	•	
126	Status Digital OUT	UINT	-	2	•	
514	Digital_OUT	USINT	-	1		•
518	Synchronization with slip	BOOL	0 – 1			•
518	Dead bus	BOOL	0 – 1			•
518	Synchro – Check	BOOL	0 – 1			•

Current average, dynamic (in the dyn)

Display of the maximum value of the average of the three phase currents, decaying via an e-function. The dynamic current average characterizes how smooth the generator motor runs.

Error-Register (Reg 122)

Bit		Description
15..11		RESERVED
10	1	Not ready
	0	Ready, OK
9	1	Capacitive reactive power (exciter failure), present
	0	Capacitive reactive power (exciter failure), OK
8	1	Over-current, thermal, present
	0	Over-current, thermal, OK
7	1	Short-circuit-current, present
	0	Short-circuit-current, OK
6	1	Maximum neutral conductor current exceeded
	0	Maximum neutral conductor current, OK
5	1	Current asymmetry, present
	0	Current asymmetry, OK
4	1	Voltage asymmetry, present
	0	Voltage asymmetry, OK
3	1	Under-frequency, present
	0	Under-frequency, OK
2	1	Over-frequency, present
	0	Over-frequency, OK
1	1	Undervoltage (of one phase), present
	0	Undervoltage (of one phase), OK
0	1	Overvoltage (of one phase), present
	0	Overvoltage (of one phase), OK

Digital_OUT (Reg 514)

Bit		Description
15..2		RESERVED
1		DO6
0		DO5

Blank Page for Notes

Engineering information
DIA.NE WIN

DIA.NE WIN 1.1

DIALOG NETWORK FOR WINDOWS SYSTEMS

GE Jenbacher
Tel. +43 | 5244 | 600-0
Fax +43 | 5244 | 63255
info@gejenbacher.com
www.gejenbacher.com

GE Jenbacher

1 Introduction

DIA.NE WIN is a new Windows-based man/machine interface for GE Jenbacher gas engines. The system offers both customers and GE Jenbacher maintenance staff a wide range of functionalities for commissioning, monitoring and maintaining installations and for diagnostic purposes.

DIA.NE WIN makes it possible to control and monitor the engines using a standard PC and Internet Explorer. The operating stations can be connected to the central on-site computer (server) via a local area network (LAN), a dial-in connection (modem) or via the Internet. Various operating stations can be operated parallel to and independent of one another.

GE Jenbacher has used state-of-the-art technology to develop DIA.NE WIN. DIA.NE WIN expands the functionality of DIA.NE XT when it comes to ease-of-operation, historical data analysis and remote control of the installation. DIA.NE WIN is the ultimate step in PC-based systems and offers accessibility via standardised interfaces.

The system is built around a fast industrial PC (server) which is integrated into the switch cabinet of the installation and which stores historical data and generates alarms. This computer also functions as a web server and modem server. The system is operated (by the customers) via ordinary PCs. Internet Explorer is used as an operating platform.

DIA.NE WIN is one of the applications of the HERMES remote data transmission program and comes as an option with DIA.NE XT.

2 Structure and interfaces

2.1 Network structure and interfaces

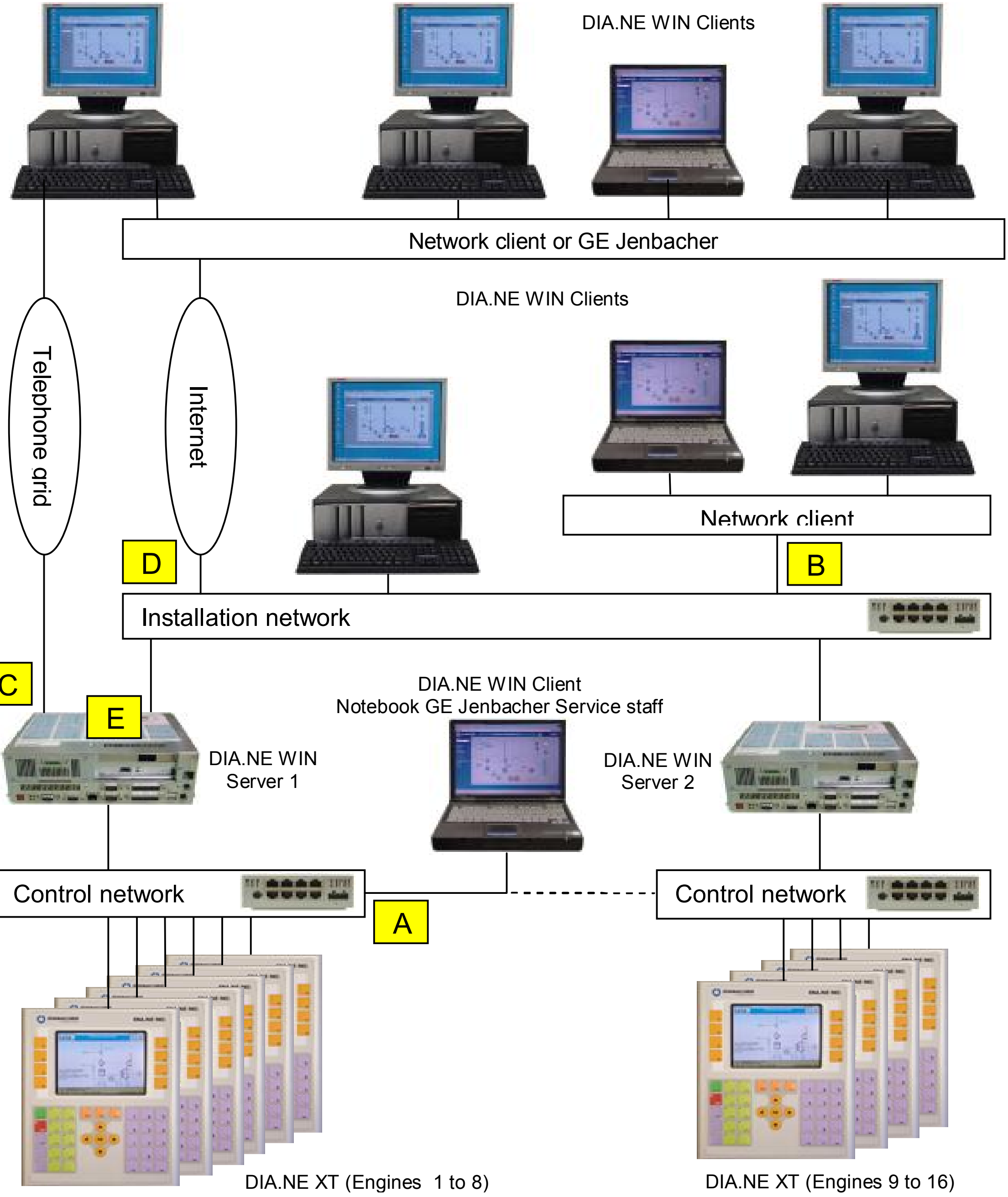


Illustration 1: Network structure for a system with up to 16 engines

2.2 Control network

The control network connects the engine controls (DIA.NE XT) to the DIA.NE WIN server(s). Up to 8 engines can be operated with a single DIA.NE WIN server. In the case of installations with more than 8 engines, an additional DIA.NE WIN server is used. All participants within the network are arranged radially (Ethernet 10/100BaseT) around the hub.

2.3 Installation network

In the case of installations with more than 8 engines, the installation network interconnects all DIA.NE WIN servers. Once again, a radially arranged Ethernet network (Ethernet 100BaseT) is used.

2.4 Interface A: Direct connection to the control network

This interface is intended solely to connect the notebooks of GE Jenbacher service staff while they are commissioning and maintaining the installation. This interface is not meant to be used by the customer.

2.5 Interface B: LAN connection

This interface is used to connect DIA.NE WIN clients to the DIA.NE WIN server(s) via a local area network (LAN). If an installation-specific network is installed, the network hub will be equipped with a connection (Ethernet 100BaseT) for this purpose. In all other cases, the customer’s network is connected directly to the network card in the DIA.NE WIN server.

2.6 Interface C: Modem connection

This interface is used to connect DIA.NE WIN clients to the DIA.NE WIN server(s) via a dial-in and/or modem connection. To that end the DIA.NE WIN server is equipped with an integrated, analog dial-in modem that can be used worldwide.

2.7 Interface D: Internet connection

This interface is used to connect DIA.NE WIN clients to the DIA.NE WIN server(s) via an Internet connection. Communication is only HTTP-based (port 80).

Available as of 2nd quarter 2004.

2.8 Interface E: OPC

OPC (OLE for process control) is a standardised interface for data communication which is generally used in automation and is supported by almost all control systems. Various measurement values are made available on the DIA.NE WIN Server in the OPC DA 2.0 format. These measurement data can be read by other control systems (OPC Clients).

3 Functionality

The goal when developing DIA.NE WIN was to offer both customers and GE Jenbacher maintenance staff a multi-purpose tool for supporting commissioning, ongoing management, monitoring and maintenance of installations and for diagnostic purposes. DIA.NE WIN was developed to add value to DIA.NE XT in terms of ease of control, historical data analysis and remote control of the installation.

3.1 Process screens

The system consists of various process screens in which all measurement data are displayed in a structured way. Special attention was paid to the clear presentation of the control processes. All cylinder-specific measurement values (e.g. ignition voltages) are displayed using bar graphs. With DIA.NE WIN, all setpoints can be set and control commands can be issued.

All process screens can be displayed by working through a menu at the left side of the display (A). Important information, such as the engine status (B), the alarm status (collective alarm) (C) and the actual electrical output of the engine (D) are always displayed, irrespective of the selected process screen. The actual time (local time at the installation site), the user who is logged in and his authorisation group are always displayed. In the case of multi-engine installations, a specific engine can be selected using a combobox.

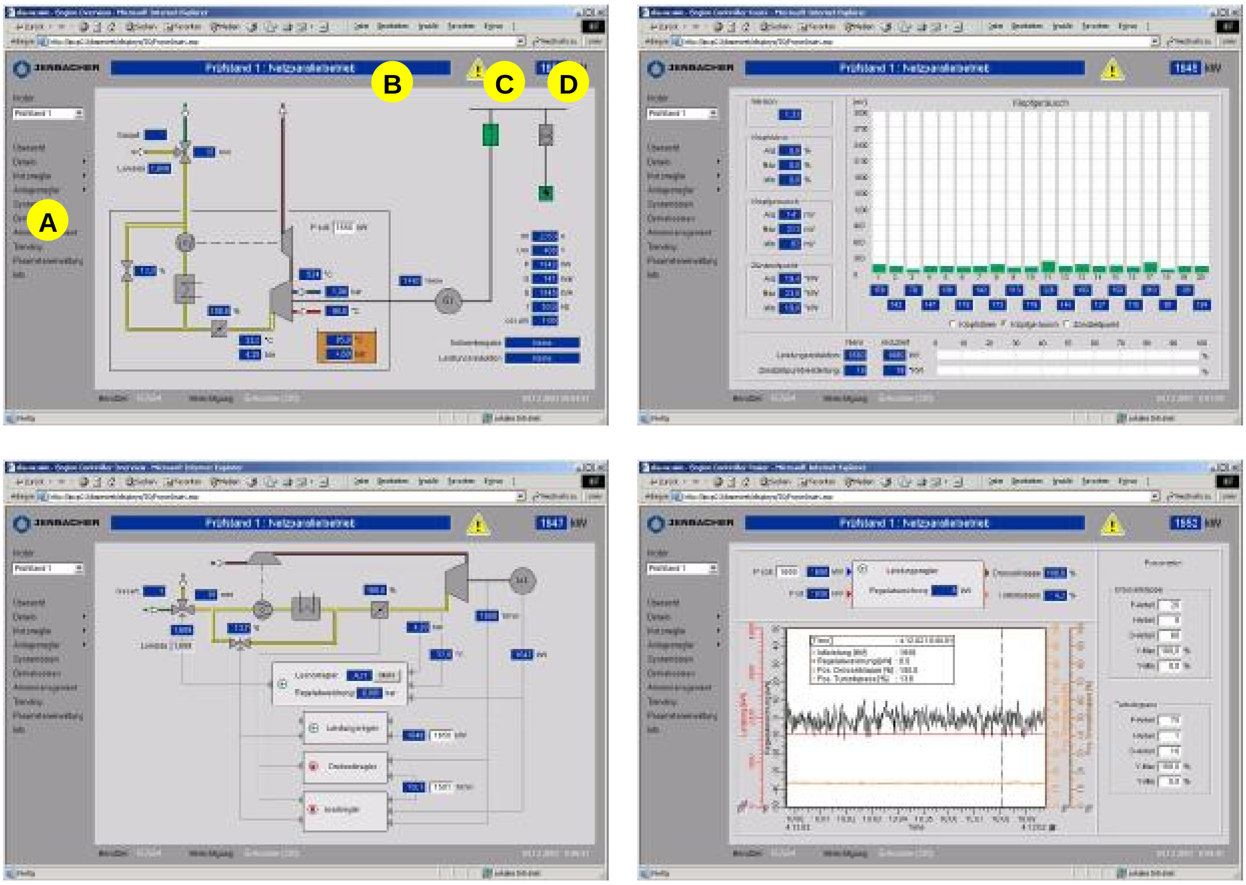


Illustration 2: Various process screens

3.2 Trends

The extensive trend-monitoring functionalities enable current and historical measurement data to be displayed as trends. Users can load various trend configurations, enabling them to display or hide every single bar and the relevant Y axis. Various trend configurations with different refreshment rates (1 second to 30 minutes) and registration periods (1 hour to 6 months) can be set. Users also have a ruler and easy-to-use zoom functionalities at their disposal. The trend display can be printed or exported into a file (CSV file).

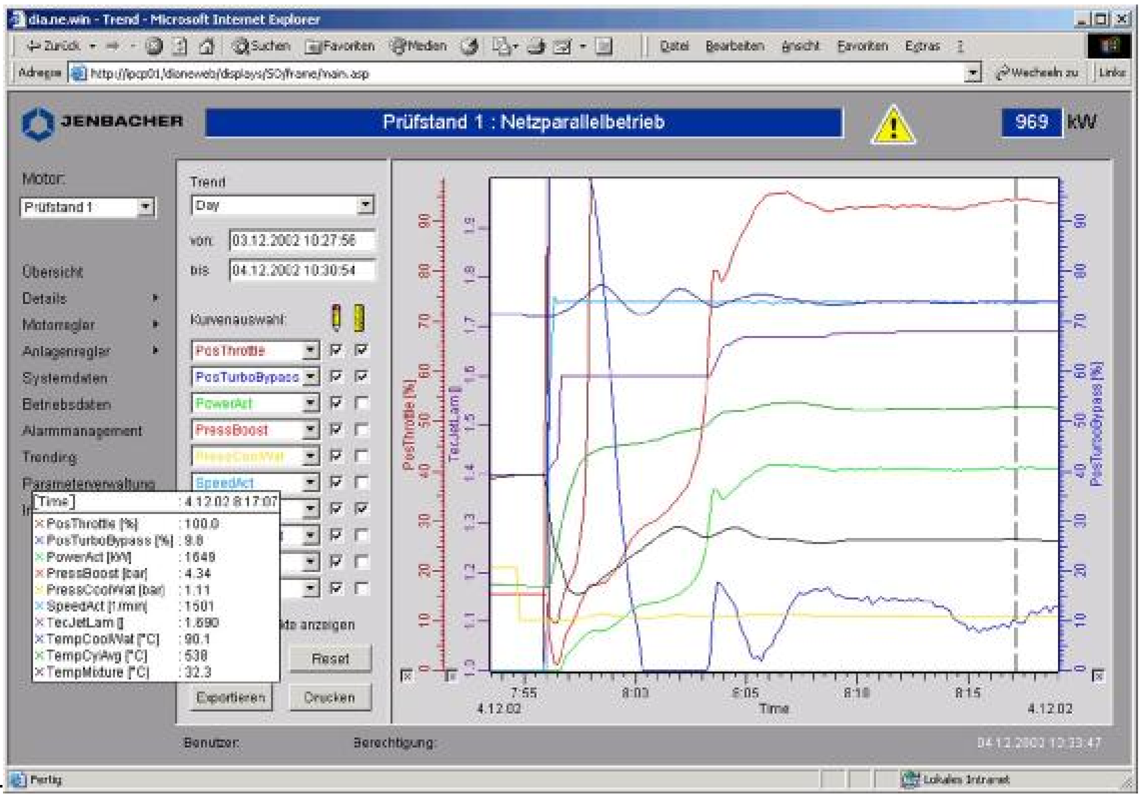


Illustration 3: Trend overview

3.3 Alarm management

To facilitate current monitoring and the historical diagnosis of the installation, DIA.NE WIN is equipped with a powerful alarm management functionality. The current messages and the recorded messages (history) are displayed in tables. The various message types (operational messages, warnings and failures that have resulted in the installation being switched off) and message conditions are displayed using different colours. All messages are recorded for up to one year. The message list can be exported into a file (CSV file).

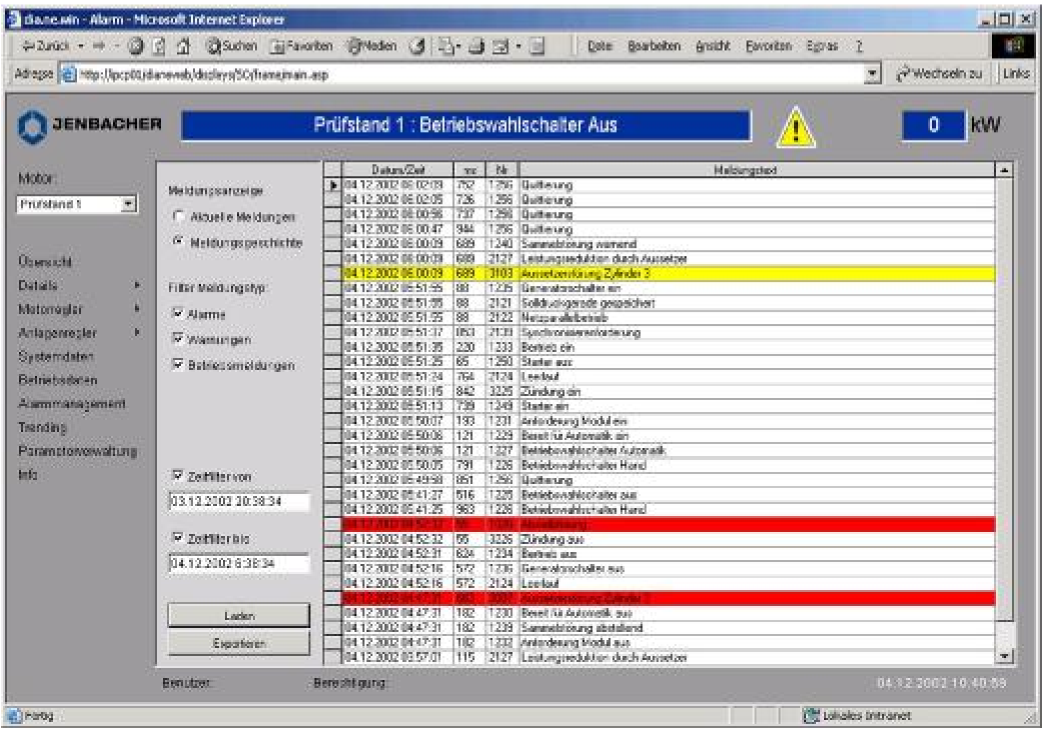


Illustration 4: Message overview

3.4 Parameter management

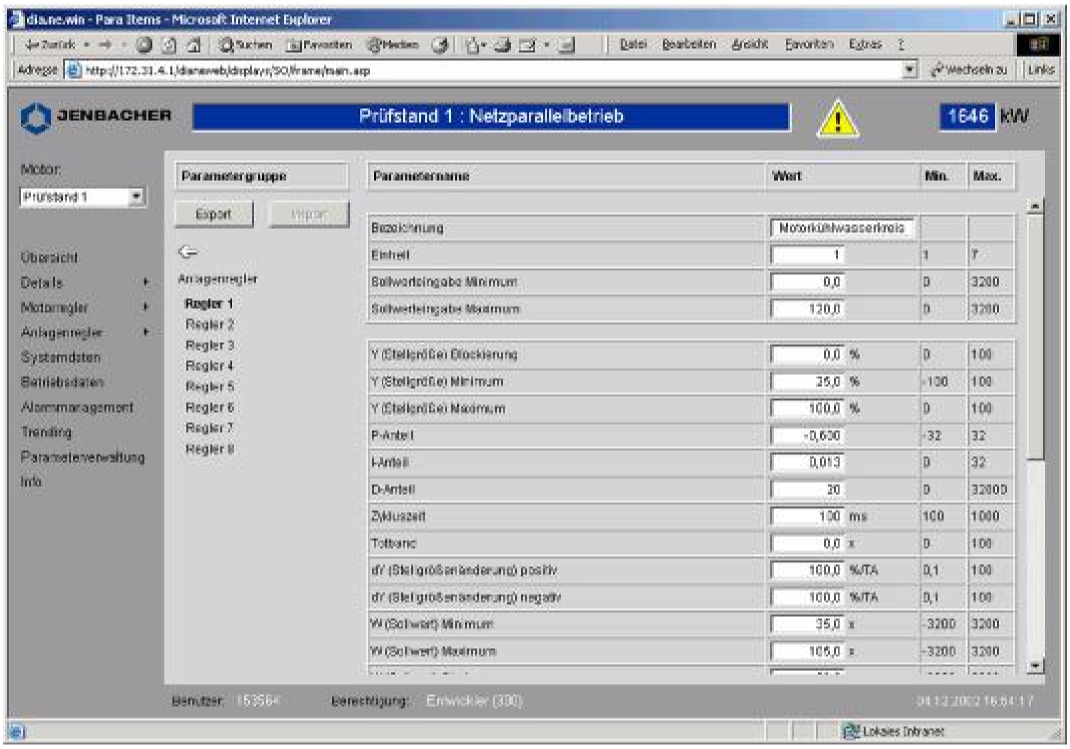


Illustration 5: Parameter management

Parameters are used to enter basic engine settings before commissioning (engine type, options) and for certain re-adjustments during commissioning. All parameters can be set using integrated parameter management. The values can be exported to and imported into a file. The parameters are divided into so-called parameter groups according to theme. A parameter group can be selected using a tree structure (several levels). To ensure user friendliness and reliability of operation, only those parameters are displayed and/or released for editing that are important for the specific user authorisation group.

3.5 Access protection

When accessing the system, every user must log in using his own user name and user code. This enables user identification and the release of specific functionalities and allows the user interface to be adapted to the specific user authorisation group.

3.6 Activity recording

All user activities, e.g. login, logout, set-point changes, parameter changes, etc. are recorded (activity logging).

3.7 Operational data protocol

Measurement values (current value, maximum and minimum) are saved in a databank according to a regular cycle for the operational data log. These logs can be easily displayed and printed.

Available as of mid-2004.

3.8 Multilinguality

The user interface is available in several languages. You can select the language of your choice or switch between languages any time. The pressure and temperature display values can be changed between "Bar" and "Psi" and/or between "degrees Celsius" and "degrees Fahrenheit". Any country-specific format settings of the operating system (e.g.: decimal comma, date and time format, etc.) are also modified.

<u>The following languages are available</u>:

German, English, Spanish, Finnish, French, Hungarian, Italian, Dutch, Norwegian, Portuguese, Russian, Turkish, Danish.

Greek (available as of 2nd quarter 2004)

The following languages can be requested as needed:

Estonian, Latvian, Polish, Slovakian, Slovenian, Czech, Serbian

3.9 Multi-station system

The system is built around a Client/Server structure. Various operating stations (clients) can access the server and operate and monitor the installation simultaneously and independently. A single client can be used to access various servers simultaneously. All active users of a server can be shown separately.

3.10 Remote data transfer using HERMES

The customer's DIA.NE WIN Client is always connected to the DIA.NE WIN server using the connection option of the HERMES remote data transfer program. The following connection options are possible:

- LAN (local area network)
- Modem (dial-in connection)
- Internet (*available as of 2nd quarter 2004*).

4 DIA.NE WIN server

The DIA.NE WIN server is an industrial PC without any peripherals (keyboard, mouse, VDU). The computer is installed in the control cabinet (system control cabinet) and has the following main tasks:

- Data communication with the engine control systems (DIA.NE XT)
- Data preparation
- Measured value recording
- Message recording
- Activity recording
- Data base server (MS SQL 2000)
- OPC server
- HTTP server for the web application "DIA.NE WIN"
- FTP server for data transmission
- Operational data registration

Windows 2000 is used as the operating system for the DIA.NE WIN server.

5 DIA.NE WIN Client

The DIA.NE WIN clients are ordinary PCs. They can be the notebooks of GE Jenbacher service staff, a desk PC belonging to the customer or an operating station in the control room. The operating systems Windows 98, Windows NT, Windows 2000 and Windows XP are all compatible. Every client must be connected with the DIA.NE WIN server via TCP/IP. The platform for the user interface is Microsoft Internet Explorer (Version 6.0 or higher). The client must be equipped with a keyboard, a mouse and a VDU with a resolution of at least 1024 * 768 pixels. The DIA.NE WIN client hardware is not part of DIA.NE WINs scope of supply.

5.1 Prerequisites

- Standard PC with monitor, mouse and keyboard
- Performance equivalent to at least a PIII
- At least 128 MB of RAM

- Monitor resolution at least 1024 x 768 pixels
- Operating system Windows 98, Windows NT, Windows 2000 or Windows XP
- Microsoft Internet Explorer, version 6.0 or higher
- JAVA support ("Java Virtual Machine" from Microsoft)
- Network connection to DIA.NE WIN server based on TCP/IP

6 Licence

A (first) “DIA.NE WIN” license includes user access rights for 2 simultaneous users (e.g. local operating station and access via remote connection) to the DIA.NE WIN server or serves of a system. Each additional license allows another user simultaneous access to the system.

After on-site training by the service personnel, 5 different user IDs and the associated access codes for DIA.NE XT are provided. If a license has already been purchased, these user IDs can also be used for accessing DIA.NE WIN.

The installation of DIA.NE WIN Client on the operating-station will be carried out by service personnel or by the client according to the manual.

Regardless of the licensing, a maximum of 5 users can access a DIA.NE WIN server at any given time.

7 Advantages of DIA.NE WIN

- Clear visualisation and user comfort (mouse, VDU, Windows technology)
- Resolution 1024 * 768 pixels
- Extensive trend-monitoring functionalities
- Clear alarm management
- Storage over long periods of time of measured values and alarm messages in a standard database
- Multi-station system
- Remote control
- Hardware-independent control stations
- Internet Explorer as an operating platform
- Open (standardised) interfaces to PC-based systems
- Export/import functionality of parameter settings
- Export/printing of alarm-message listings and trend diagrams
- Operational data logs

8 Summary

DIA.NE WIN means that the GE Jenbacher gas engines can be remotely monitored, controlled and diagnosed. DIA.NE WIN is the easy-to-use man/machine interface for both specialist and ordinary users. The open system was developed by GE Jenbacher based on state-of-the-art technologies and functions as an add-on to the engine visualisation DIA.NE XT.

GLOBAL – USER FRIENDLY - POWERFUL