SEG electronics

MANUAL

Professional Line | PROTECTION TECHNOLOGY MADE SIMPLE

XRN2 | MAINS DECOUPLING RELAY

MAINS DECOUPLING RELAY

Original document

English

Revision: E

Contents

1. Introduction and application

The XRN2 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 (XRN2-1) or
- Rate of change of frequency df/dt (XRN2-2)

Because of combination of three protectional functions in one device the XRN2 is a very compact mains decoupling device. Compared to the standardly used single devices it has a very good price/performance ratio.

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.
- 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
- Storage and indication of the tripping values
- In compliance with VDE 0435, part 303 and IEC 255
- 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

This manual is valid for relay software version from D01_7.23 (for XRN2-1) and D04_7.23 (for XRN2 2) onwards.

3. Design

3.1 Connections

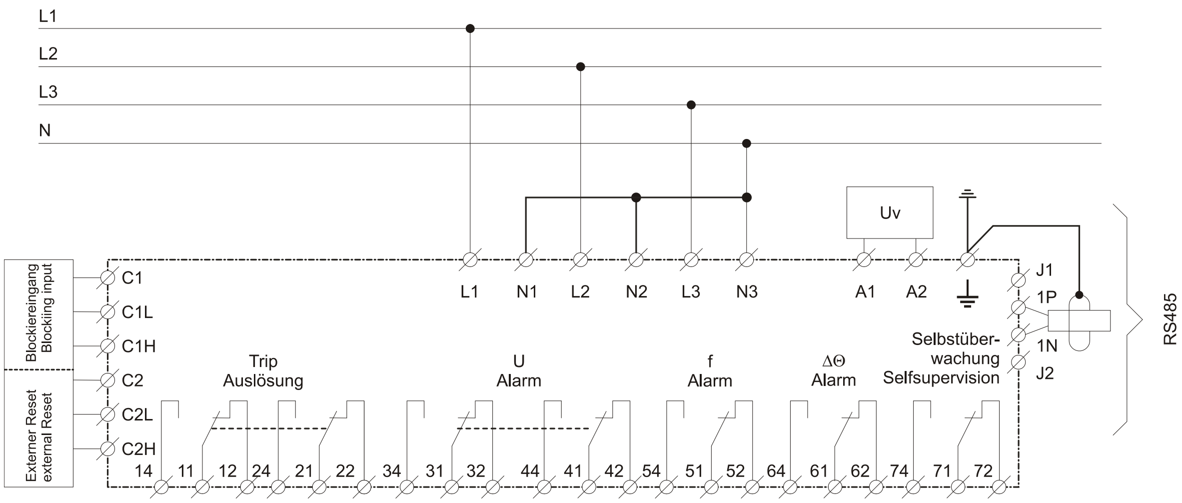


Figure 3.1: Connection diagram XRN2-1 and XRN2-2

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 C1/C1L or C1/C1H, the previously set relay functions are blocked (refer to 4.8 and 6.2.10).

3.1.3 Reset input

Please refer to chapter 6.4.

3.1.4 Output relays

The XRN2 has 5 output relays. One trip relay with two changeover contacts. One alarm relay with two changeover contacts and three alarm relays with one changeover contact.

- Tripping 11, 12, 14 and 21, 22, 24
- Indication of over-/ and undervoltage alarm 31, 32, 34 and 41, 42, 44
- Indication of over-/ and underfrequency alarm 51, 52, 54
- Indication of vector surge 61, 62, 64 (XRN2-1) or df/dt-alarm (XRN2-2)
- Indication self supervision (internal fault of the unit) 71, 72, 74

All trip and alarm relays are normally-off relays, the re-lay for self supervision is a normally-on relay.

3.1.5 Power Supply

The XRN2 has a wide range power supply. It can connect to AC or DC supply. The connection for DC supply don't need to consider for polarity.

3.1.6 Data communication

For data communication with a central control system the XRN2 relay is provided with a serial interface RS485. Simplified and fast reading and changing of parameters and measuring values can be achieved by HTL/PL-Soft3, which will be provided on request together with the relay.

The XRN2 can be connected to other units of the PROFESSIONAL LINE via interface. If there are more than one relay in the system, the last relay of the chain has to be provided with a line termination resistor.

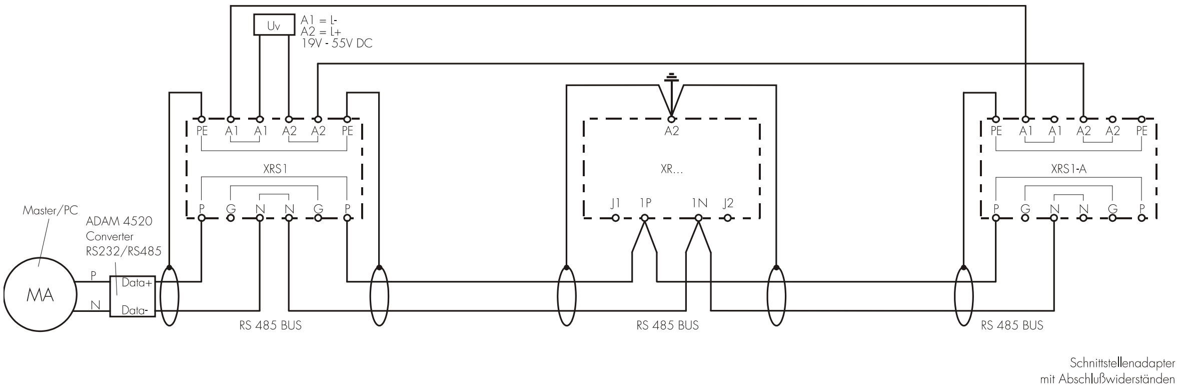


Figure 3.2: Connection example with 3 users, XR ... as linked device

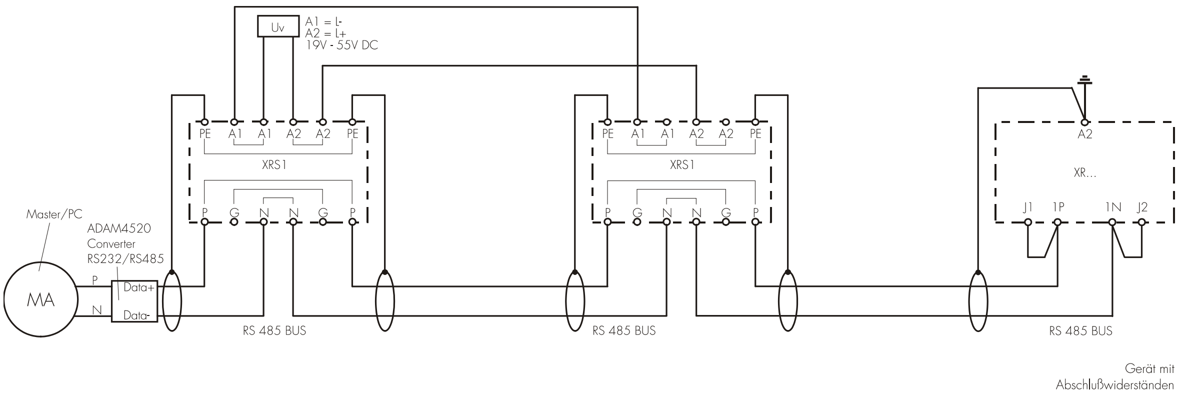


Figure 3.3: Connection example with 3 users, XR ... as last device

3.2 Front plate

3.2.1 Indication- and operation elements

The front plate of the XRN2-protection relay comprises the following operation and indication elements:

- Alphanumerical display (4 Digits)
- Push buttons for setting and other operations
- LEDs for measured value indication and setting

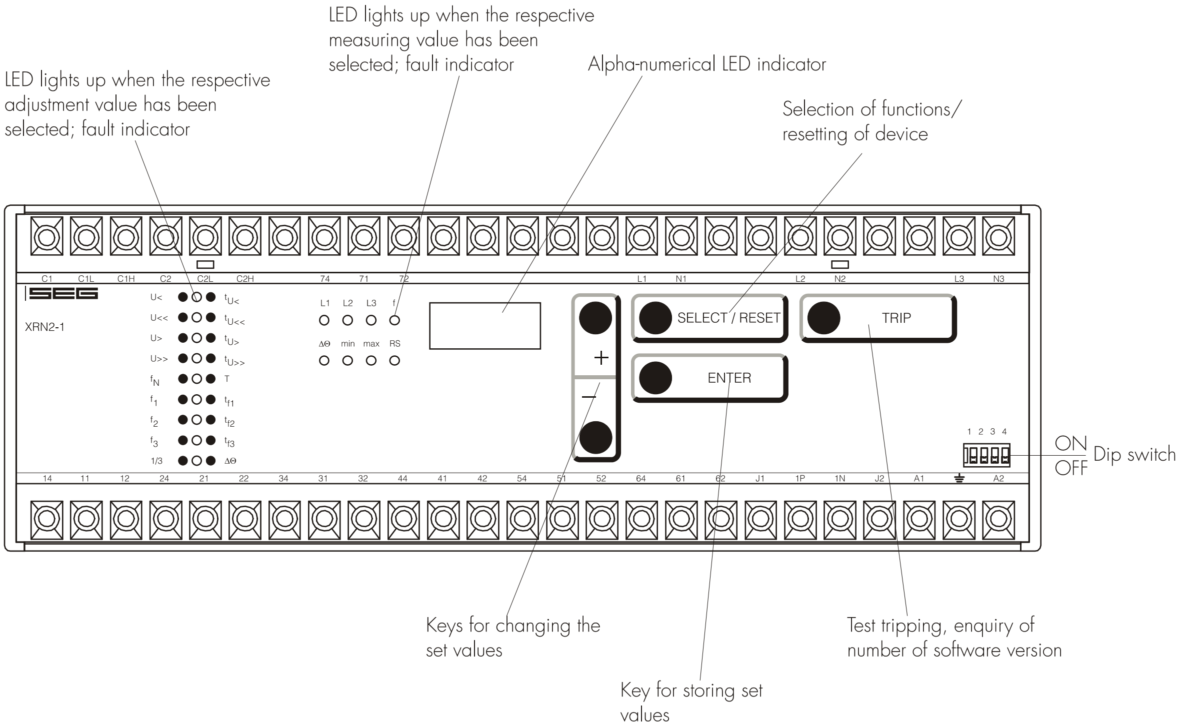


Figure 3.4: Front plate XRN2

3.2.2 Display

Function	Display shows	Pressed pushbutton	Corre-sponding LED	Type of relay
Normal operation	WW			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 $\Delta\Theta$ df	XRN2-1 XRN2-2
Setting values: star/delta connection	Y/DELT	<SELECT/RESET><+><->	Δ/Y	
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	XRN2-1
threshold for vector surge	setting value in degree	<SELECT/RESET><+><->	$\Delta\Theta$	XRN2-1
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	XRN2-2
Blocking	EXIT	<+> until max. setting value	LED of blocked parameter	
Undervoltage blocking of frequency and vector surge measuring (df/dt for *XRN2-2*)	setting value in Volt	<SELECT/RESET><+><->	f, $\Delta\Theta$, df	
Slave address of serial interface	1 – 32	<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	XRN2-2

Function	**Display shows**	**Pressed pushbutton**	**Corre-sponding LED**	**Type of relay**
vector surge	tripping value in de-gree	<SELECT/RESET><+><-> one time for each phase	$\Delta\Theta$ + L1, L2 or L3	XRN2-1
Save parameter?	SAV?	<ENTER>		
Save parameter!	SAV!	<ENTER> for about 3 s		
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	WW	<SELECT/RESET> for about 3 s		

Table 3.1: possible indication messages on the display

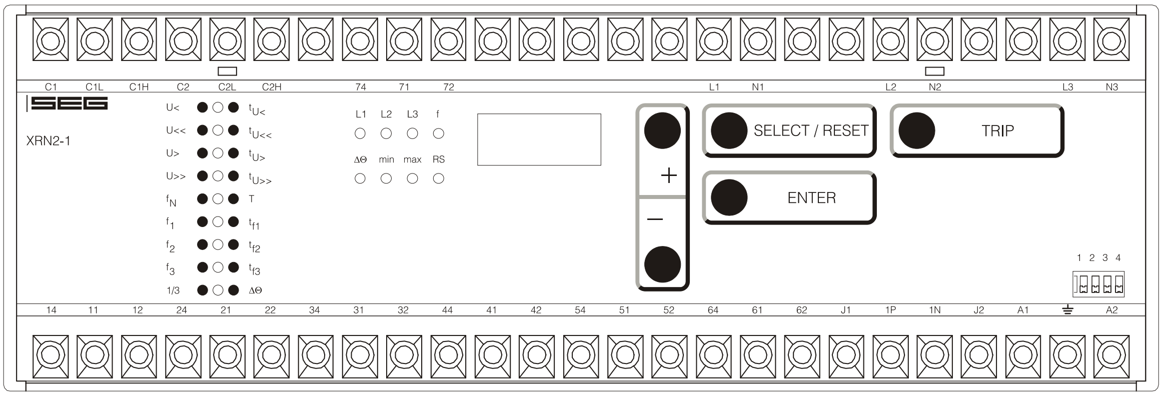
3.2.3 LEDs

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

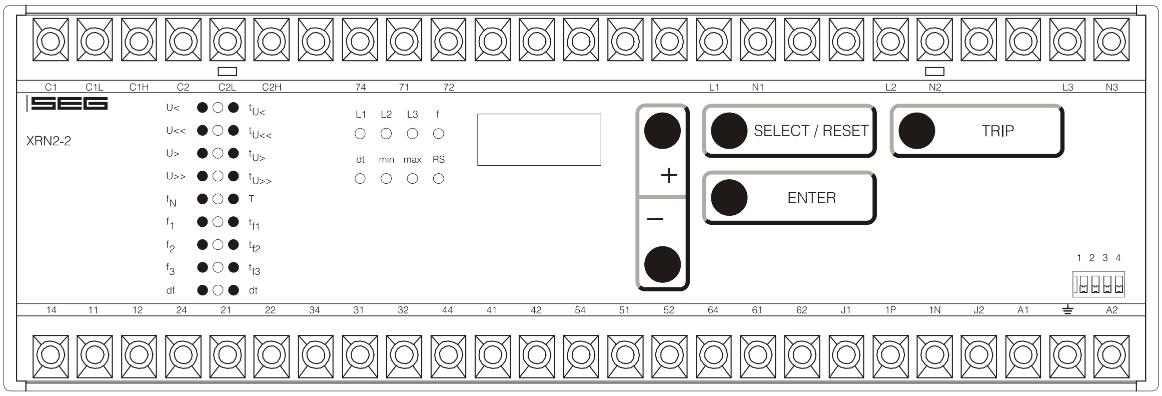
The LEDs below the push button <SELECT/RESET> are lit green during setting and inquiry procedure of the setting values which are printed on the left side next to the LEDs. The LEDs will light up red after activation of the setting values next to their right side.

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

3.2.4 Front plate XRN2-1



3.2.5 Front plate XRN2-2



3.2.6 Parameter settings

Setting parameter	XRN2-1	XRN2-2
Δ/Y	X	X
U<	X	X
tU<	X	X
U<<	X	X
tU<<	X	X
U>	X	X
tU>	X	X
U>>	X	X
tU>>	X	X
fN	X	X
T	X	X
f1	X	X
tf1	X	X
f2	X	X
tf2	X	X
f3	X	X
tf3	X	X
df		X
dt		X
1/3	X	
ΔΘ	X	
UB<	X	X
RS485/		
Slave	X	X

Table 3.2: Sequence of parameter setting of the two relay types

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 suppressed 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 4.2 Digital circuits

The essential part of the XRN2 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 occurs 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 "watch-dog" timer. In case of a failure the watchdog timer re-sets the microprocessor and gives an alarm signal via the output relay "self supervision".

4.3 Voltage supervision

The voltage element of XRN2 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.

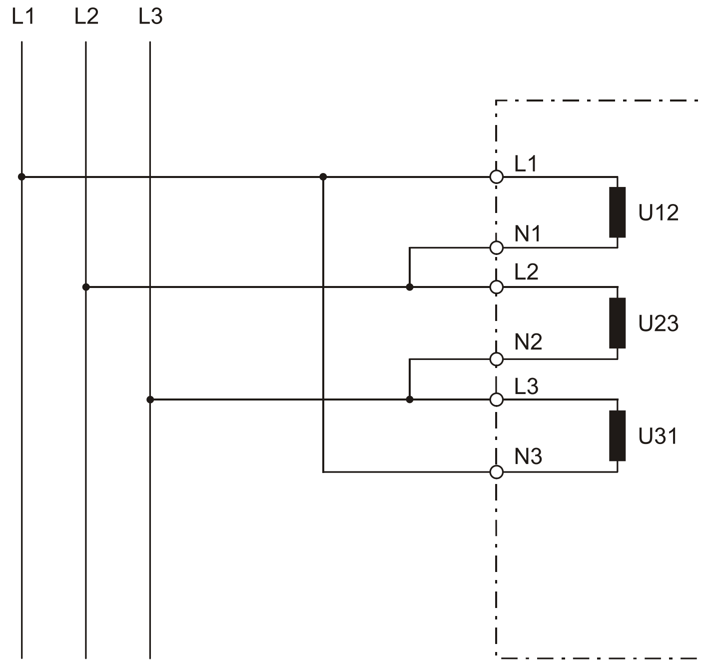


Figure 4.1: Input v.t.s in delta connection (□)

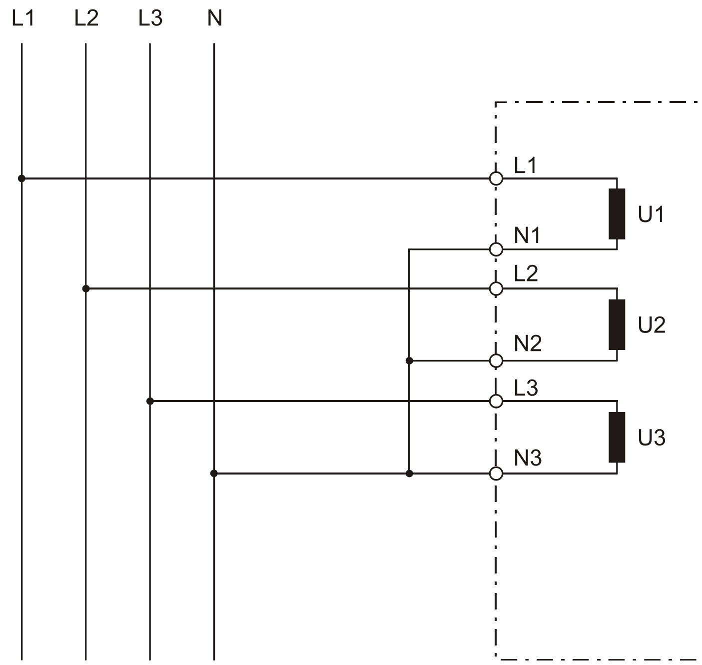


Figure 4.2: Input v.t.s in star connection (Y)

4.4 Principle of frequency supervision

The frequency element of XRN2 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.

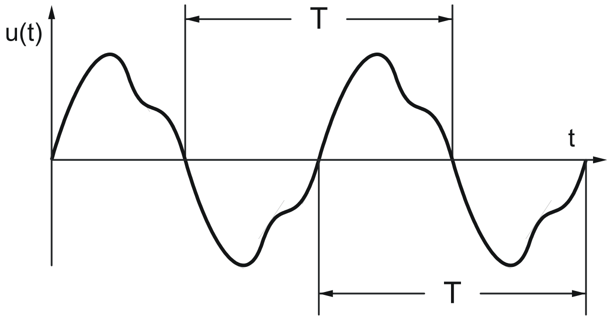


Figure 4.3: Determination of cycle duration by means of zero passages.

In order to avoid false tripping during occurence of interference voltages and phase shifts the relay works with an adjustable measuring repetition (see chapter 6.2.3)

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 UB in case the measured voltage value is below this value.

4.5 Measuring of frequency gradient (XRN2-2)

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 de-coupling" are in the range of 0.5 Hz/s up to over 2 Hz/s. The XRN2 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 stability 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 (XRN2-1)

The vector surge supervision protects synchronous generators in mains parallel operation due to very fast de-coupling 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 de-coupling 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. Volt-age 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 XRN2-1 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 genera-tor/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 6.2.8). 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).

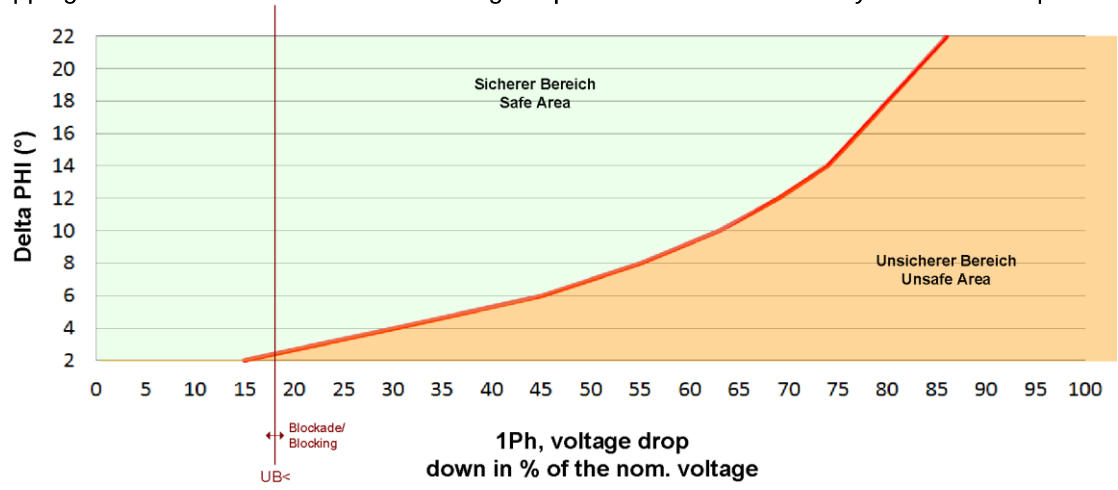
Note:
In order to avoid any adverse interference voltage effects, for instance from contactors or relays, which may cause overfunctions, XRN2-1 should be connected separately to the busbar.

Important Information on the Vector Surge Supervision:

Single Phase Vector Supervision "1-of-3" ("1Ph" on the Display)

Within the Area „Safe Area“ the trip decision depends on the set Angle „Delta phi“ only *(please refer to figure Single Phase Vector Surge Supervision)*.

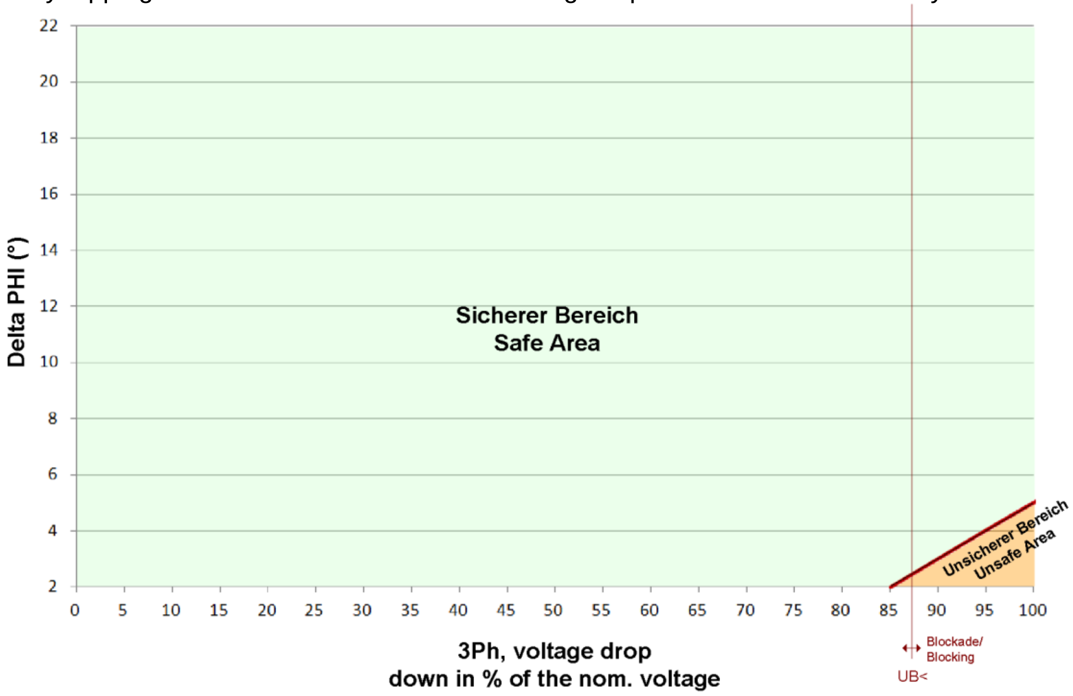
Within the Area „Unsafe Area“ a trip decision is taken if the vector surge angle „Delta phi“ is exceeded or if the magnitude of the voltage vector is shrinked (percental related to the rated voltage). In order to prevent faulty tripping the effective area of the vector surge supervision can be limited by means of the parameter *"UB<"*.



Three Phase Vector Surge Supervision "3-of-3" ("1Ph" on the Display)

Within the Area „Safe Area“ the trip decision depends on the set Angle „Delta phi“ only *(please refer to figure Three Phase Vector Surge Supervision)*.

Within the Area „Unsafe Area“ a trip decision is taken if the vector surge angle „Delta phi“ is exceeded or if the magnitudes of the three voltage vectors are shrinked (percental related to the rated voltage). In order to prevent faulty tripping the effective area of the vector surge supervision can be limited by means of the parameter *"UB<"*.



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 U1) and the synchronous internal voltage (Up). Therefore a voltage is difference ΔU is built between Up and U1 (Fig. 4.4).

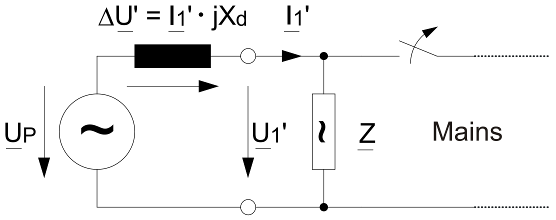


Figure 4.4: Equivalent circuit at synchronous generator in parallel with the mains

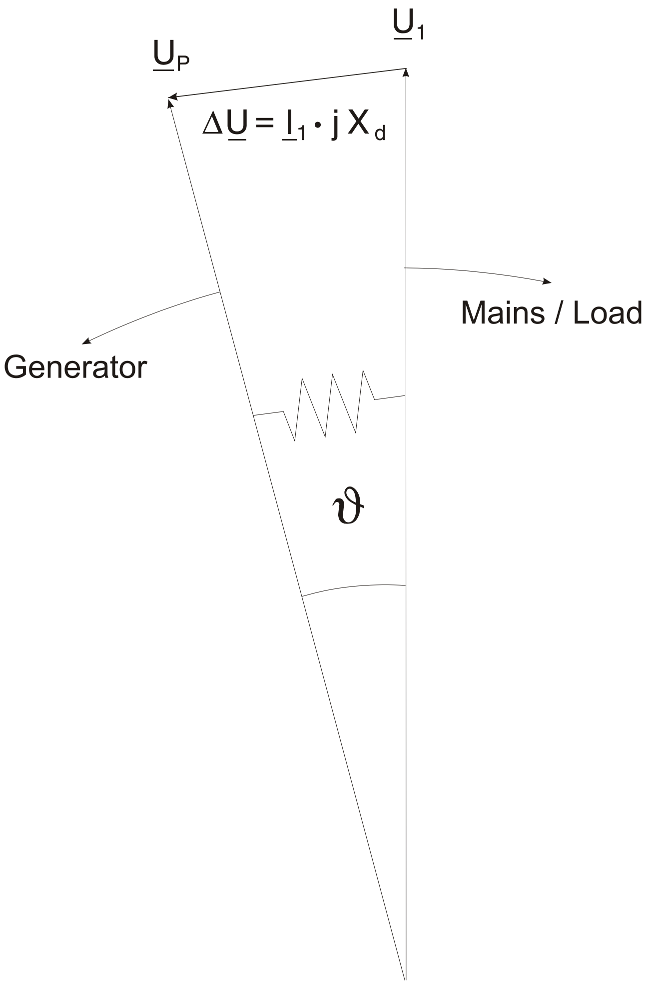


Figure 4.5: Voltage vectors at mains parallel operation

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).

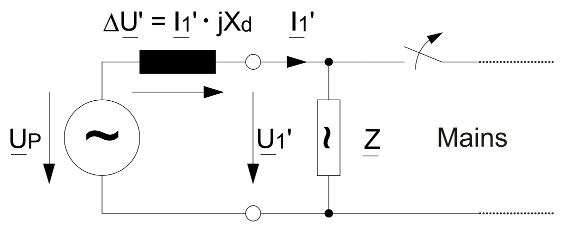


Figure 4.6: Equivalent circuit at mains failure

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).

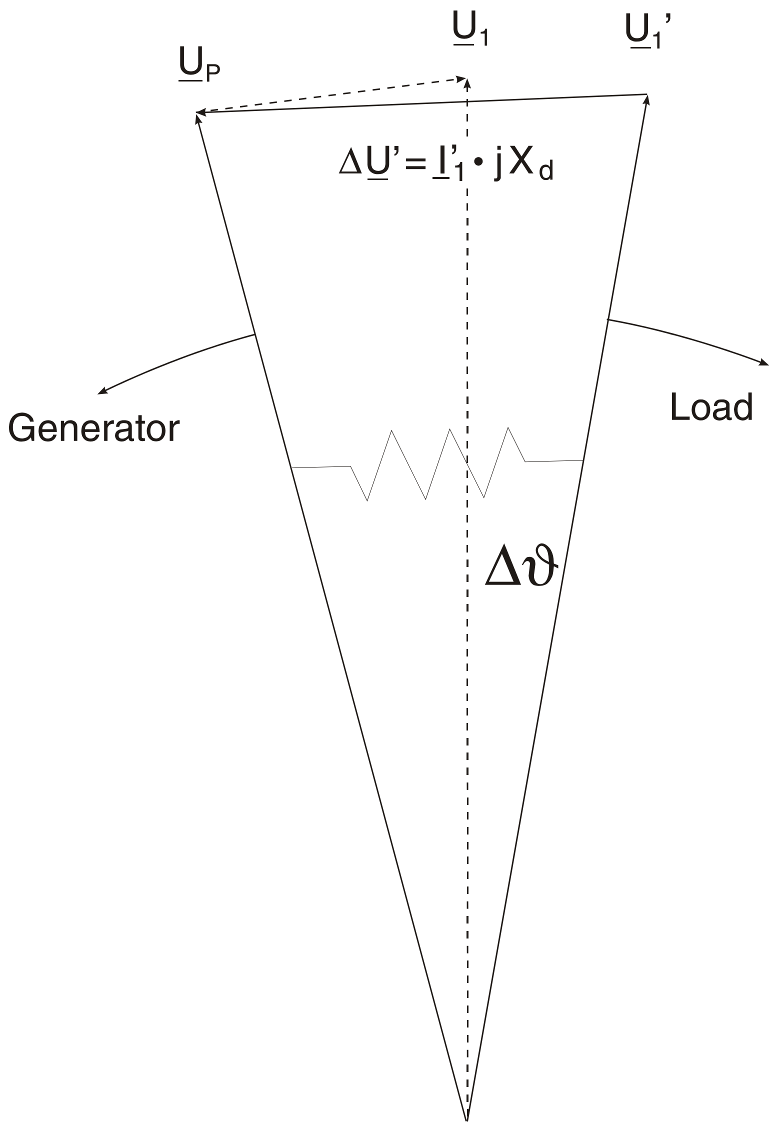


Figure 4.7: Voltage vectors at mains failure

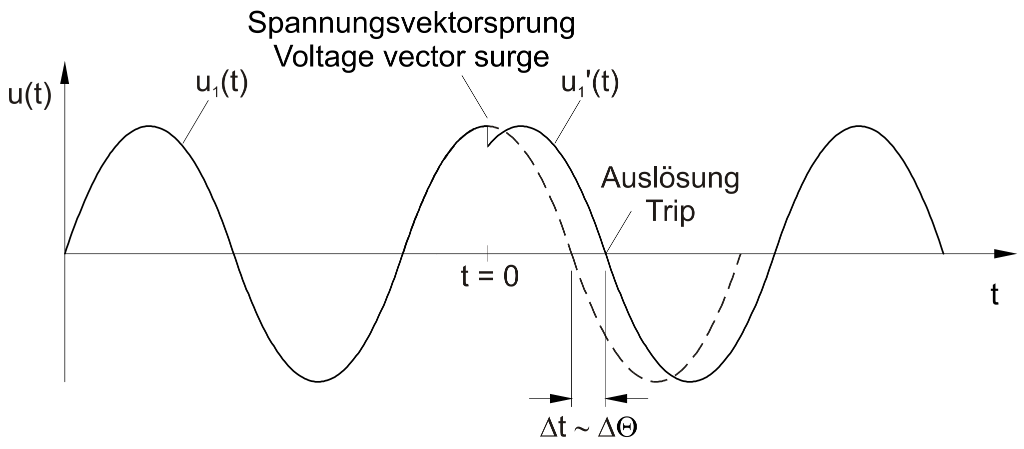


Figure 4.8: Voltage vector surge

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 XRN2-1 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 re-lay 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 XRN2-1 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 occur 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 re-acts 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 df/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>/>>	f1, f2, f3	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 UB< (adjustable voltage thresh-old value)	released	released	blocked	blocked	blocked

Table 4.1: Dynamic behaviour of XRN2 functions

Blocking function set in compliance with requirements:

The XRN2 has an external blocking input. By applying the auxiliary voltage to input C1/C1L or C1/C1H, the requested protection functions of the relay are blocked (refer to 6.2.10).

5. Operation and setting

For adjustment of the unit the transparent cover has to be opened as illustrated. Do not use force! The transparent cover has two inserts for labels.

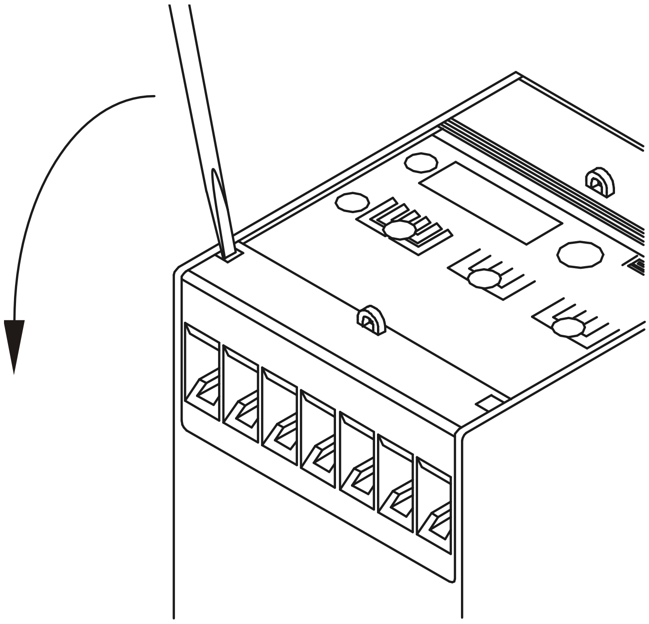


Figure 5.1: How to open the transparent cover

5.1 Push buttons

Push buttons are used for calling up the parameters to be processed, for selection of measuring parameters to be indicated and for changing and storing the parameters.

The individual setting and measuring values can be selected one after another by pressing push button <SELECT/RESET>. This push button is also used for re-setting the display by pressing approx. 3s.

Push buttons <+> <-> are used for in-/decrementing of the parameter indicated on the display. They can be pressed step-by-step or continuously.

After the selected parameter is set by the <+> <-> push button it may be stored using the <ENTER> push button.

Through the push button <ENTER> the set value indicated on the display will be transferred to the internal parameter memory. An unintented or unauthorized change of the selected parameter is avoided by means of a password identification (see 5.4.2).

The <TRIP>-push button is used to test the output relay circuits both for tripping and signaling. During normal operation it is also interlocked by means of the pass-word identification.

5.1.1 Indication of measuring values and fault data

Indication in faultless condition

In normal operation the display always shows WW. After pressing the push button <SELECT/RESET> the dis-play switches cyclically to the next measuring value. After the measuring values had been indicated the set-ting parameters are displayed. Hereby the LEDs in the upper section signalize which measured value is indicated, the LEDs in the lower section signalize which setting parameter is indicated on the display. Longer actuating the push button resets the relay and the dis-play changes into normal operation (WW).

Indication after pickup / tripping

All of the faults detected by the relay are indicated on the front plate optically. Here not only the faults are indi-cated but also the faulty phase(s) and the protection function in operation. During the excitation phase LEDs are flashing, after tripping this changes to continuous light.
In tripped condition "TRIP" appears on the display and the LEDs of the operating measuring data light up red together with the LEDs of the tripping parameter. All operating data, which were measured at the moment of tripping, can now be called one after another by pressing push button <SELECT/RESET>. If in this condition setting parameters are to be indicated, push but-ton <ENTER> has to be pressed.

The graphic below shows again the difference between the different display modes.

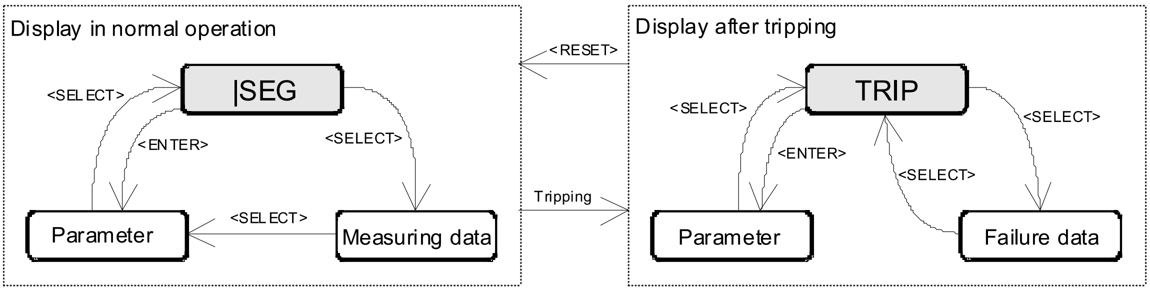


Figure 5.2: Switching over of the display in dependence of the operating mode.

5.2 DIP switches

On the front plate of the XRN2-relay there is one DIP switch to preset the following functions:
- Password programming
- Output relay functions

The figure 3.1 shows the position and designation of the code jumpers:

5.2.1 Function of the output relays

The following functions of the output relays can be preset:
- Alarm relay activation at pickup or after tripping of the relay
- Reset of the output relays manually or automatically

The alarm relays are activated according to the preset-ting:

Dip switch 2 OFF:
The alarm relays pickup directly with energizing of the corresponding measuring circuit. Thus, an alarm signalling can be given before the relay trips.

Dip switch 2 ON:
The alarm relays pickup only after relay trip. That means: the trip relay and the corresponding alarm relay pickup at the same time after the time delay elapsed.

Dip switch 3 OFF:
All output relays will be reset automatically after the fault has been rectified, (e.g. when the fault current is interrupted).

Dip switch 3 ON:
All output relays remains activated and must be reset after fault clearance.
- Manually: By pressing push button <SELECT/RESET>
- External: By connecting aux. voltage to C2/C2L or C2/C2H
- Via RS 485 interface

To let the parameter change take effect, the auxiliary voltage has to be switched on and off again after the dip switches are plugged or unplugged.

Dip switch	Function	Dip switch position	Operation mode
1	Password	OFF	Normal position
		ON	Password selection
2	Alarm relays	OFF	Alarm relays will be activated at pickup
		ON	Alarm relay will be activated at tripping
3	Reset	OFF	Output relays will be reset automatically
		ON	Output relays will be reset manual/external/via software
4	none		

Table 5.1: Summary of coding possibilities

5.3 Reset

Manual reset
By pressing push button <RESET/SELECT> for some time (about 3 s).

External reset-input C2/C2L or C2/C2H
The external reset input has the same function as the <SELECT/RESET> push button on the front plate. Connecting auxiliary voltage to this input, the unit can be reset, provided that the fault is removed.

Software reset via serial interface RS 485
Software reset has the same function as push button <SELECT/RESET>. Please refer to open data protocol of RS 485 interface named RS485-PRO.

5.4 Password

5.4.1 Password programming

The XRN2-relay is delivered with the preset password "++++", it can be programmed new with dip switch 1: Apply dip switch 1. After power on and pressing any push button, the relay XRN2 inquires for a new pass-word. The text "PSW?" appears on the display. The new password is entered by any combination of the push buttons <SELECT> <-> <+> <ENTER>. After the new password is given, the dip switch 1 has to be removed.

5.4.2 Using the password

Step by step, a new relay setting is made according to the following sequence:

- After the present setting value is changed with <+><-> push button, <ENTER>-push button should be pressed.
- A message "SAV?" appears on the display to inquire if the new setting value is really wanted to be stored.
- After pressing the <ENTER>-push button again, the password will be inquired by means of the message "PSW?" on the display.
- After the password is given correctly, which is prompted by message "SAV!" on the display, the new setting value can be stored by pressing the<ENTER>-push button for about 3 seconds.
- The new setting value for the selected parameter appears on the display again.

A password consists of four push button operations. The pressed push buttons and their sequences define the password.

<SELECT>	=	S
<->	=	-
<+>	=	+
<ENTER>	=	E

then a password "-E+S" means pressing push buttons according to the following sequence:
<-> <ENTER> <+> <SELECT>

After the password is given correctly, parameter setting is permitted for five minutes. This means: For a subsequent parameter setting, as long as it is made within five minutes after the password input, a renewed password input is not required. Moreover, the valid period for parameter setting is automatically extended to further 5 minutes after each new push button operation.

If no push button operation follows within the five minute period after password input, the validity for parameter setting will be suspended.

For entering further parameters the password is then called up again. During the validity for parameter set-ting a new set value, after having acknowledged "SAV" two times, is stored by just pressing push button <ENTER> for some time.

As to parameter setting via RS 485 interface: see open data protocol.

5.5 Relay setting principle

By pressing push button <ENTER>, the parameter menu can be called up. By pressing push button <SELECT/RESET> the parameter to be set is reached. The corresponding LED lights up. The actual set value of the selected parameter is indicated on the display. The indicated set value can then be changed by pressing push buttons <+><-> (in-/decrementing). The selected set value is stored by pressing push button <ENTER> and by input of the authority code (password) which means the adjustment of the unit is only possible after the password had been put in. (see 5.4.2)

After a trip the push button <SELECT/RESET> is re-served for the indication of fault data. Now new pa-rameter setting by means of push button <SELECT/RESET> is only possible by pressing <ENTER> first.

5.5.1 Setting of default parameters

Setting of the XRN2 default parameters can be done as follows:

- switch off the auxiliary voltage supply
- press simultaneously push buttons <+><-> and <SELECT/RESET> and
- switch on the auxiliary voltage supply again.

5.5.2 Blocking the protection functions

The blocking function of the XRN2-relays can be set according to requirement. When pressing push buttons <ENTER> and <TRIP> at the same time the blocking mode is entered.

5.6 Display of software version and test-TRIP

By pressing push button <TRIP> the first part of the software version is displayed, the second part appears when this push button is pressed again. When push button <TRIP> is pressed repeatedly, the test trip routine starts.

By entering the password the display shows "TRI?". After pressing <TRIP> again all output relays will be energized one after the other with a time delay of 1 s.

All relays stay energized until manual reset. The protection functions are not affected.

5.7 Low/High range of functions blocking and reset

All relays of the PROFESSIONAL LINE have a wide-range power supply unit allowing to choose a suitable supply voltage. The operating threshold of the blocking and reset inputs, however, has to be defined by taking the supply voltage into account. The following two different operating thresholds can be adjusted:

- Low-range threshold U_{AN} ≥10 V; UAB ≤8 V
- High-range threshold U_{AN} ≥70 V; UAB ≤60 V

Connection terminals

- Low-range blockage input terminal C1/C1L
- Low-range reset input terminal C2/C2L
- High-range blockage input terminal C1/C1H
- High-range reset input terminal C2/C2H

6. Special settings

6.1 Adjustable parameters

The following parameters can be set by the user him-self:

XRN2-1 and XRN2-2:

Δ/Y	-	changing of input transformer connection
U<	-	threshold for undervoltage
tU<	-	tripping delay for undervoltage
U<<	-	threshold for undervoltage
tU<<	-	tripping delay for undervoltage
U>	-	threshold for overvoltage
tU>	-	tripping delay for overvoltage
U>>	-	threshold for overvoltage
tU>>	-	tripping delay for overvoltage
fN	-	rated frequency
T	-	frequency measuring repetition in periods
f_1	-	threshold for frequency element 1
t_{f1}	-	tripping delay for frequency element 1
f_2	-	threshold for frequency element 2
t_{f2}	-	tripping delay for frequency element 2
f_3	-	threshold for frequency element 3
t_{f3}	-	tripping delay for frequency element 3
U_B<	-	voltage threshold value for frequency and vector surge measuring (or df/dt)
RS	-	Slave address of the serial interface

XRN2-2 only:

df	-	threshold for rate of frequency (df/dt) in Hz/s
dt	-	measuring repetition for df/dt in periods

XRN2-1 only:

1/3	-	Vector surge tripping 1-of-3/3-of-3
ΔΘ	-	Pickup value for vector surge in degree

6.2 Setting procedure

In this paragraph the settings for all relay parameters are described in detail. For parameter setting a pass-word has to be entered first (please refer to 5.4).

6.2.1 Parameter setting of over- and undervoltage supervision

The setting procedure is guided by two colored LEDs. During setting of the voltage thresholds the LEDs U<, U<<, U> and U>> are light 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 value directly in volt. The thresh-olds 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 de-activated 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.

6.2.2 Setting of nominal frequency

First the nominal frequency (50 or 60 Hz) has to be correctly set before unit XRN2 is put into operation.
All frequency functions are determined by setting the nominal frequency, i.e. whether the set frequency thresh-olds are evaluated as over- or underfrequency (see also chapter 6.2.4). 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 el-ements f1 - f3 with an adjustable multiplier (see also chapter 6.2.5). During setting of the nominal frequency a value in Hz is shown on the display.

6.2.3 Number of measuring repetitions (T) for frequency functions

In order to avoid false tripping of the unit at short volt-age drops of the system voltage or interference volt-ages, XRN2 works with an adjustable measuring repetition. When the instantaneous frequency measuring value ex-ceeds (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 val-ue 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.

6.2.4 Threshold of frequency supervision

The frequency supervision of XRN2 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.

6.2.5 Tripping delays for the frequency elements

Tripping delays t_{f1} - t_{f3} of the three frequency elements can independently be set from $t_{f,min}$ - 50 s. The minimum tripping delay $t_{f,min}$ of the relay is dependent upon the number of set measuring repetitions T (periods) and amounts to:

$T_{f,min}$ = (T+1) 20 ms

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 alarm relay is also activated.

6.2.6 Parameter setting of vector surge supervision (XRN2-1)

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 dis-play), 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.

6.2.7 Parameter setting of frequency gradient (XRN2-2)

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
TA = inertia time constant of the generators
ΔP = per unit power deficit with reference to the rated active power of the generators

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.

6.2.8 Voltage threshold value for frequency and vector surge measuring (df/dt at XRN2-2)

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 XRN2 in such cases is prevented by an adjustable voltage threshold UB. If the system voltage is below this threshold, these functions of the relay are blocked.
During adjustment of UB< LEDs f and ΔΘ or df light up in the right display part.

6.2.9 Adjustment of the slave address

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

6.2.10 Setting procedure for blocking the protection functions

The blocking function of the XRN2 can be set according to requirement. By applying the aux. voltage to C1/C1L or C1/C1H, 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.

6.3 Indication of measuring values

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 + L1, L2 or L3 green; XRN2-1)
Vector surge (LED ΔΘ green)
Frequency gradient df/dt (LED df green; XRN2-2)

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)

6.3.1 Min./Max.- values

The XRN2 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 XRN2 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. 6.4) 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 but-ton, 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.

6.4 Reset

All relays have the following three possibilities to reset the display of the unit as well as the output relay at switch position 3=ON.

Manual Reset

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

Electrical Reset

- Through applying auxiliary voltage to C2/C2L or C2/C2H

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.

7. 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.

7.1 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 "IWW" appears on the display and the self supervision alarm relay (watchdog) is energized (terminals 71 and 74 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 C1/C1L or C1/C1H) to inhibit the undervoltage functions (refer to 6.2.10) and press the <SELECT/RESET> for app. 3 s to reset the LEDs and "TRIP" message.

7.2 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 de-energized 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>.

7.3 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>.
As relay input energizing quantities, three phase volt-ages should be applied to XRN2 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.

7.4 Secondary injection test

7.4.1 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
- Test leads and tools

7.4.2 Example of test circuit

For testing of the XRN2 relay, a three phase voltage source with adjustable voltage and frequency is required. Figure 7.1 shows an example of a three-phase test circuit energizing the XRN2 relay during test. The three phase voltages are applied to the relay in Y-connection.

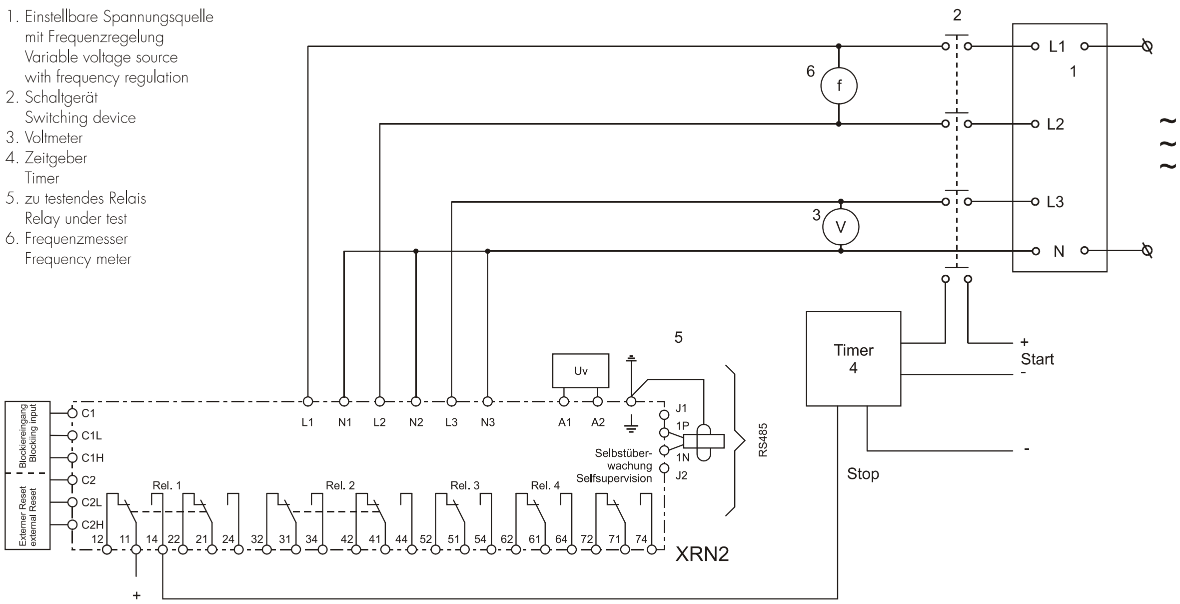


Figure 7.1: Test circuit

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 7.4.8).

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

7.4.3 Checking the input circuits and measuring functions

Apply three voltages of rated value to the voltage input circuits (terminals L1, L2, L3, N1, N2, N3) of the relay. Check the measured voltages, frequency and vector surge on the display by pressing the push button <SELECT/RESET> repeatedly.

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 XRN2-1): LED ΔΘ (Indication ΔΘ in °)
The rate of change of frequency (LED df) is indicated on the display in Hz/s (for XRN2-2)
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 XRN2 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.

7.4.4 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 31/34 and 41/44) 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).

7.4.5 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.

7.4.6 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 energized. 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.

7.4.7 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 7.4.5 for over/undervoltage functions.

7.4.8 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 XRN2 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 7.2 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.

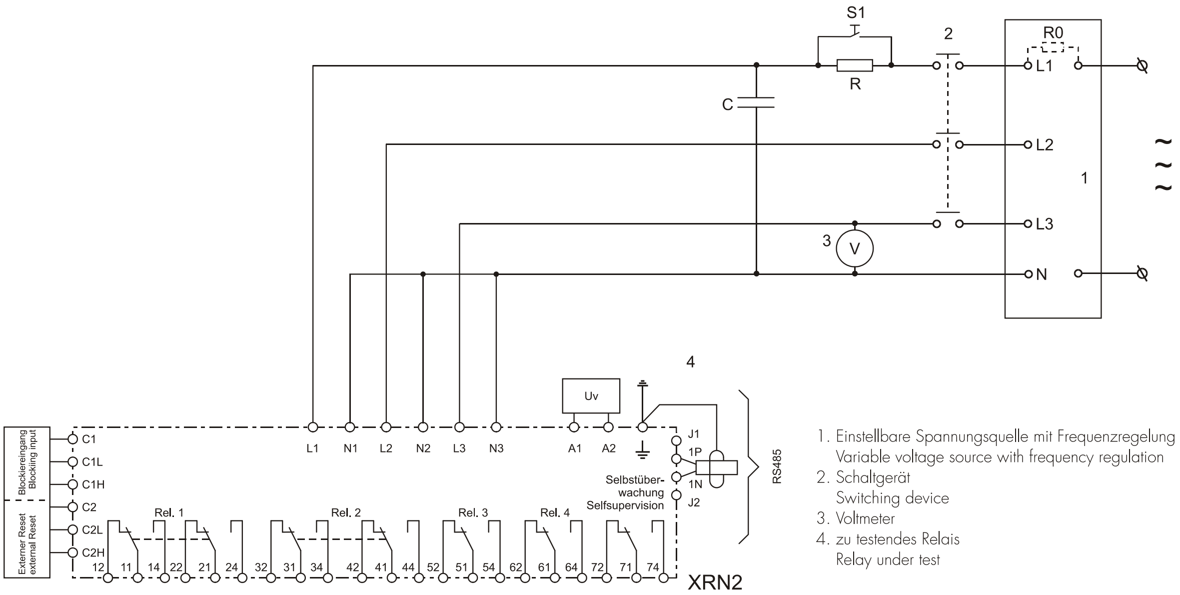


Figure 7.2: Test circuit for the vector surge function

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 ΔΘ can be calculated with the following formula if the parameters R_0, R and C are known:

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

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

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

Usually the voltage source impedance R0 is negligible, hence R0 may be assumed zero. Thus, with a constant C, says 3 µF (400 VAC), the value of R may be calculated using the following simplified formula:

Note!
Using the above test circuit with single-phase vector surge, the resulting measured angle □□ is about half the value of ΔΘ 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".

7.4.9 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 C1/C1L or C1/C1H). 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 C2/C2L or C2/C2H). The display and LED indications should be reset immediately.

7.5 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 XRN2 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 XRN2 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.

7.6 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 re-lay, etc.

For electromechanical or static relays, maintenance testing will be performed at least once a year according to the experiences. For digital relays like XRN2, this interval can be substantially longer. This is because:

- the XRN2 relays are equipped with very wide self-supervision functions, so that many faults in the relay can be detected and signalized during service. Important: The self-supervision output relay must be connected to a central alarm panel!
- the combined measuring functions of the XRN2 relay enable supervision the relay functions during service.
- the combined TRIP test function of the XRN2 relay al-lows 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.

8. Technical data

8.1 Measuring input circuits

Rated data:	Nominal voltage U_N	100 V, 230 V, 400 V
	Nominal frequency f_N	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)	

8.2 Common data

Dropout to pickup ratio:	for U>/U>> : >97%;	for U</U<< : <103%
	for f>/f>> : >99.98%;	for f</f<< : <100.02%
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 <UH/UH$_N$ <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	

8.3 Setting ranges and steps

Function	Para- meter	Setting range	Steps	Tolerance
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
Rated frequency	f_N	f = 50 Hz / f = 60 Hz		
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	0.005 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
$\Delta\Theta$	$\Delta\Theta$	2°...22° (EXIT)	1°	±1°
Vector surge logic	1/3	1Ph / 3Ph		
Voltage threshold for frequency measuring	U_B< (LED 'f'+ $\Delta\Theta$/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
Serial Interface	RS	1 - 32	1	

Table 8.1: 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

8.4 Output relays

Relay type	Trip relays/change-over contacts	Alarm relays/change-over contacts
XRN2	1/2	1/2
		3/1

Table 8.2: Output relays

The output relays have with the following characteristics:

maximum breaking capacity 250 V AC / 1500 VA / continuous current 6 A

for DC voltage:

	ohmic	L/R = 40 ms	L/R = 70 ms
300 V DC	0.3 A/90 W	0.2 A/63 W	0.18 A/54 W
250 V DC	0.4 A/100 W	0.3 A/70 W	0.15 A/40 W
110 V DC	0.5 A/55 W	0.4 A/40 W	0.2 A/22 W
60 V DC	0.7 A/42 W	0.5 A/30 W	0.3 A/17 W
24 V DC	6 A/144 W	4.2 A/100 W	2.5 A/60 W

Max. rated making current: 64 A (VDE 0435/0972 and IEC 65/VDE 0860/8.86)
Making current: max 20 A (16 ms)
mechanical life span: 30 x 10^6 operating cycles
electrical life span: 2 x 10^5 operating cycles at 220 V AC / 6 A
Contact material: silver cadmium oxide (AgCdO)

8.5 8.5 Power supply

Auxiliary voltage 16 – 360 V DC / 16 – 250 V AC

Power consumption: standby 3 W operating 5 W
The connection terminals are A1, A2.

Max. allowed interruption of the auxiliary supply without effecting the function of the device: 50 ms

Propper connection of the earthing terminal ⊥ is essential for the EMC withstand of the relay.
Use wires of min. 1.5 mm^2.

8.6 Inputs, blockage and reset

Low-range:
For rated voltages 24 V, 48 V, 60 V U_{AN} ≤10 V
U_{AB} ≥8 V
Current consumption 1 mA DC at 24 V

High-range:
For rated voltages 100 V, 110 V, 125 V, 220 V, 230 V U_{AN} ≤70 V
U_{AB} ≥60 V
Current consumption 1.5 mA DC 270 V or 11.0 mA AC

8.7 System data and test specifications

Design standards:	
Generic standard:	EN 6100-6-2, EN 61000-6-3
Product standard:	IEC 60255-6, EN 50178
Specified ambient service temperature limits in operation:	-10°C to +55°C
storage :	-25°C to +70°C
Moisture-carrying capacity IEC 60068-2-78:	rel. humidity <93% at 40°C for 56 days
Insulation test voltage, inputs and outputs between themselves and to the relay frame as per IEC 60255-5:	2.5 kV (eff.)/50 Hz.; 1 min.
Impulse test voltage, inputs and outputs between themselves and to the relay frame as per IEC 60255-5:	5 kV; 1.2/50 µs, 0.5 J
High frequency interference test voltage, inputs and outputs between themselves and to the relay frame as per IEC 60255-22-1:	2.5 kV/1 MHz
Electrical discharge (ESD) test as per IEC 61000-4-2, IEC 60255-22-2:	8 kV air discharge, 6 kV contact discharge
Electrical fast transient (Burst) test as per IEC 61000-4-4, IEC 60255-22-4:	4 kV/2.5 kHz, 15 ms
Power frequency magnetic field immunity test IEC 61000-4-8:	100 A/m continuously 1000 A/m for 3 s
Radiated electromagnetic field disturbance test as per IEC 61000-4-3; IEC 60255-22-3:	electric field strength: 10 V/m
Guided radiated electromagnetic field disturbance test as per IEC 61000-4-6:	electric field strength: 10 V
Surge immunity test as per IEC 61000-4-5; IEC 60255-22-5:	2 kV
Radio interference suppression test as per EN 55011; CISPR11:	limit value class B
Radio interference radiation test as per EN 55011; CISPR11:	limit value class B

Mechanical test:	
Shock:	Class 1 as per IEC 60255-21-2
Vibration:	Class 1 as per IEC 60255-21-1
Degree of protection:	IP40
Overvoltage class:	III
Weight:	1.6 kg
Relay case material:	self-extinguishing Technical data subject to change without notice!

8.8 Relay case

Relay XRN2 is designed to be fastened onto a DIN-rail acc. to DIN EN 50022, the same as all units of the PROFESSIONAL LINE.
The front plate of the relay is protected with a sealable transparent cover (IP40).

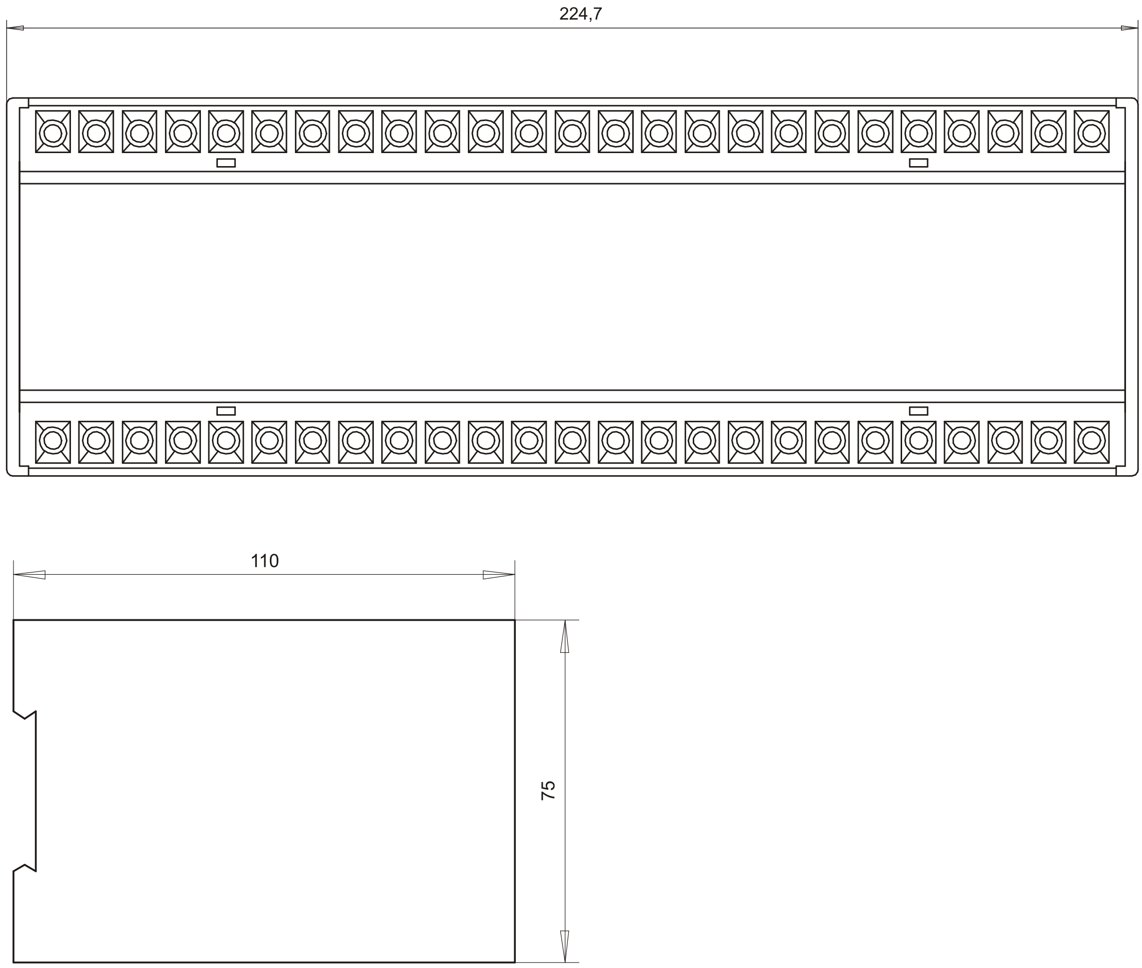


Figure 8.1: Dimensional drawing, dimensions in mm

Connection terminals
The connection of up to a maximum 2 x 2.5 mm^2 cross-section conductors is possible. For this the transparent cover of the unit has to be removed.

9. Order form

Mains decoupling relay	***XRN2-***		
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**

Setting list XRN2

Project: ____________________SEG Electronics GmbH job.-no.: __________________________

Function group: = _________________________Location: + __________Relay code: - _________

Relay functions: __________________________Password: ______________________________

Function		Unit	Default settings	Actual settings
Δ/Y	input transformer connection		Y	
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	
f_N	rated frequency	Hz	50	
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	2	
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	

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

Ext. blocking parameter stetting

	U<	U<<	U>	U>>	f1	f2	f3	ΔΘ	df/dt
Default setting	BLOC	BLOC	NO_B	NO_B	BLOC	BLOC	NO_B	BLOC	BLOC
Actual setting									

Setting of dip switches

Dip switch	**1**		**2**		**3**		**4**	
	Default setting	Actual setting	Default setting	Actual setting	Default setting	Actual setting	Default setting	Actual setting
ON								
OFF	X		X		X		X	

Professional Line

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