MANUAL

Professional Line | PROTECTION TECHNOLOGY MADE SIMPLE

XP2R | POWER AND REVERSE POWER RELAY

POWER AND REVERSE POWER RELAY

Original document

English

Revision: D

Contents

1. Applications and Features

Relay XP2-R of the PROFESSIONAL LINE is a digital relay for reverse power detection of gen.-sets in parallel and active power supervision of power systems.

For generators operating in parallel with a mains or another generator, it is imperative to supervise the power direction. If for example the prime mover fails the alternator operates as a motor and drives the prime mover (diesel or turbine). The XP2-R detects the reverse of the power direction and - in case of this error - switches off the alternator. This way, power losses and damages of the prime mover are avoided.
When compared to conventional protection equipment all relays of the PROFESSIONAL LINE reflect the superiority of digital protection technique with the following features:

- High measuring accuracy by digital processing
- Fault indication via LEDs
- Extremely wide operating ranges of the supply volt-age by universal wide range power supply unit
- Very fine graded wide setting ranges
- Data exchange with process management system by serial interface adapter XRS1 which can be retrofitted
- True power measurement by multiplication of current and voltage
- Extremely short response time
- Adjustment of rated data
- Compact design by SMD-technology

In addition to this relay XP2-R has the following special features:
- Measurement phase-to-neutral or phase-to-phase voltage possible
- Tripping times for supervision P and PR adjustable

2. Design

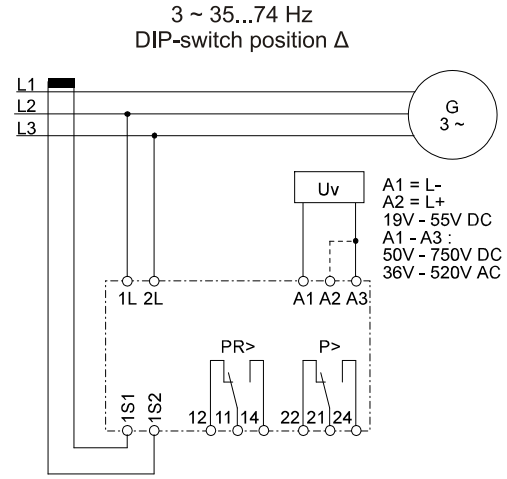


Figure 2.1: Connection three-wire system

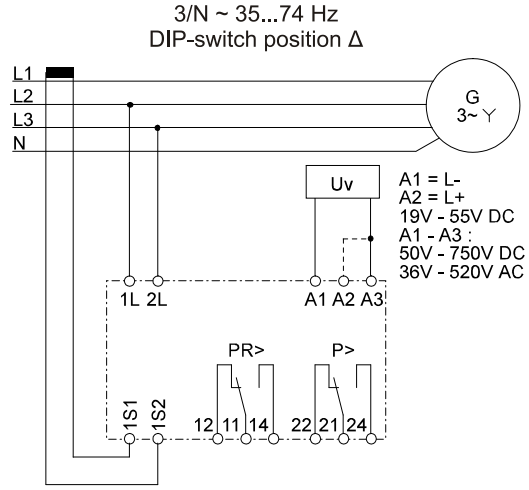


Figure 2.2: Connection phase-to-phase voltage in four-wire system

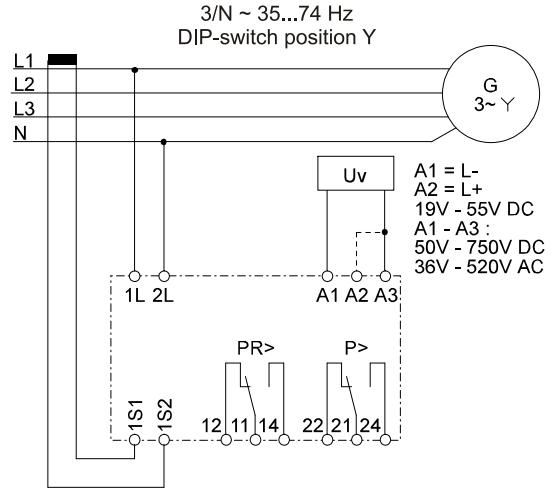


Figure 2.3: Connection phase-to-neutral voltage in four-wire system

Analog inputs

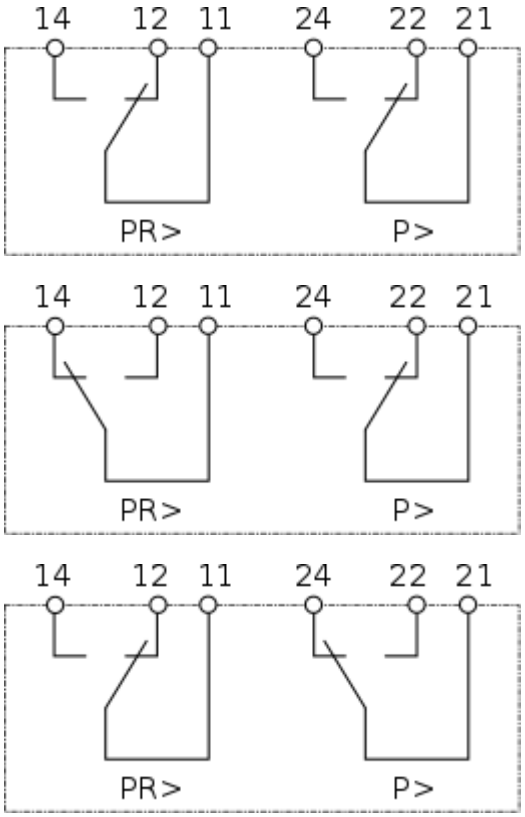
The analog input signals are connected to the protection device via voltage terminals1L - 2L and current terminals 1S1 (K-terminal of transformer) - 1S2 (L-terminal of transformer).

Auxiliary voltage supply

The XP2-R can be supplied directly from the measuring quantity itself or by secured aux. supply. Therefore a DC or AC voltage must be used.

Unit XP2-R has an integrated wide range power supply. Voltages in the range from 19 - 55 V DC can be applied at connection terminals A1(L-) and A2(L+). Terminals A1/A3 are to be used for voltages from 50 - 750 V DC or from 36 - 520 V AC.

Contact positions



Operation without fault or dead condition

Reverse power tripping PR>

Active power tripping P>

Figure 2.4: Contact positions of the output relays

3. Function

The incoming current from the main current transformer of the protected object is converted to a voltage signal in proportion to the current via the input transformer and burden. 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 measuring value detection takes with a sampling frequency of 12 x fn, namely, a sampling rate of 1.66 ms for every measuring quantity at 50 Hz.

3.1 Measuring Principle

Through multiplication of the actual current and voltage values p(t) = u(t) • i(t), the microprocessor calculates the phase power. 12 instantaneous values are measured and recorded per cycle. Afterwards the power value during one cycle is determined.

$$P = \frac{1}{T}\int_{0}^{2\pi} p(t)dt$$

Consequently, the total three phase current is calculated from: P_{total} = P1 + P2 + P3

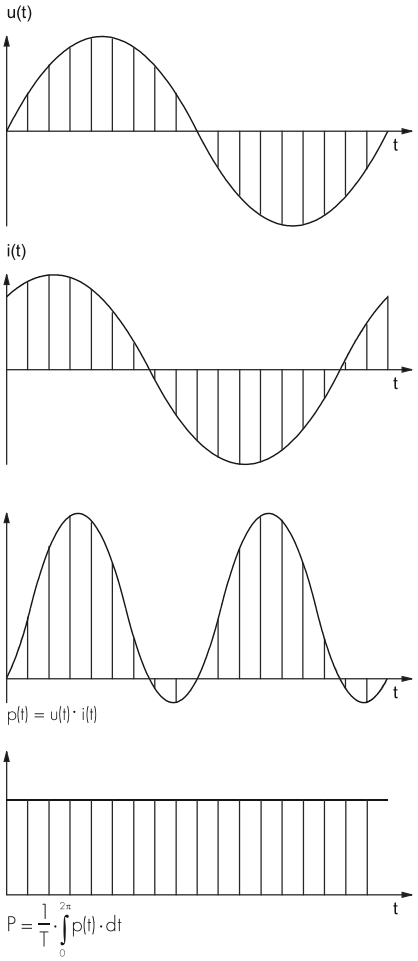


Figure 3.1: Diagram of power calculation

3.2 Calculation of the Setting Value at Reverse Power

Should the relay, for instance, trip at a generator re-verse power of 10 %, this does not mean that the set-ting value of the XP2-R is 10 %. Based on the trans-former transformation ratio, the switch-ing point has to be calculated.

The XP2-R measures the power in one phase of the transformer secondary side. The power is as-sumed to be symmetrical

The generator phase power must be related to the transformers secondary side.

Essential data

SG[kVA]	rated generator apparent power
cos(φ):	rated generator power factor
In:	rated current of XP2-R
Un:	rated voltage of XP2-R
n_I:	transformation ratio of the CT
n_U:	transformation ratio of the VT

Connection of the XP2-R to phase-to-phase voltage:

Conversion of the generator phase power PGS based on the CT secondary side:

$$P_{GS} = \frac{S_G \cdot \cos(\varphi)}{\sqrt{3} \cdot n_U \cdot n_I}$$

With the permissible generator reverse power PGS , the setting value PR is then calculated as follows:

$$P_R > (\%) = \frac{\frac{S_G \cdot \cos(\varphi)}{\sqrt{3} \cdot n_U \cdot n_I}}{Un \cdot In} \cdot P_{RG}(\%)$$

Calculation example 1: Medium voltage 10 kV (see fig. 2.1)

- generator apparent power: SG = 1875 kVA
- rated power factor: cos(φ) = 0,8
- rated voltage of XP2-R: Un = 110 V (phase-to-phase voltage)

When the relay is expected to trip at a generator re-verse power of 6 %, calculation of the setting value is as follows:

$$P_R > (\%) = \frac{\frac{1875kVA \cdot 0.8}{\sqrt{3} \cdot 20 \cdot 100}}{110V \cdot 5A} \cdot 6(\%) \approx 5\%$$

According to the above example, the XP2-R has to be set to 5 % so that it trips at a generator re-verse power of 6 % (rated generator active power).

Connection of the XP2-R to phase-to-neutral voltage

Conversion of the generator phase power PGS based on the transformer secondary side:

$$P_{GS} = \frac{S_G \cdot \cos(\varphi)}{3 \cdot n_U \cdot n_I}$$

With the permissible generator reverse power P_{GS}, the setting value P_R is then calculated as follows:

$$P_{GS} = \frac{S_G \cdot \cos(\varphi)}{3 \cdot n_U \cdot n_I}$$

Calculation example 2: Low voltage 400 V, connec-tion to phase voltage (see fig. 2.3)

- generator apparent power: S_G = 625 kVA
- rated power factor: cos(φ) = 0,8
- rated current of XP2-R: In = 5 A
- rated voltage of XP2-R: Un = 230 V (phase-to-neutral voltage)
- transformation ratio of the CT: n_I = 1000 A / 5 A
- no VT required

When the relay is expected to trip at a generator re-verse power P_{RG} of 5 %, calculation of the setting value $P_{R>}$ is as follows:

$$P_R > (\%) = \frac{\frac{625kVA \cdot 0{,}8}{3 \cdot 1 \cdot 200}}{230V \cdot 5A} \cdot 5(\%) = 3.6\% \approx 4\%$$

According to the above example, the XP2-R has to be set to 4 % so that it trips at a generator reverse power of 5 % (rated generator active power).

4. Operation and Settings

All operating elements needed for setting parameters are located on the front plate of unit XP2-R as well as all display elements.
Because of this all adjustments of the unit can be made or changed without disconnecting the unit from DIN-rail.

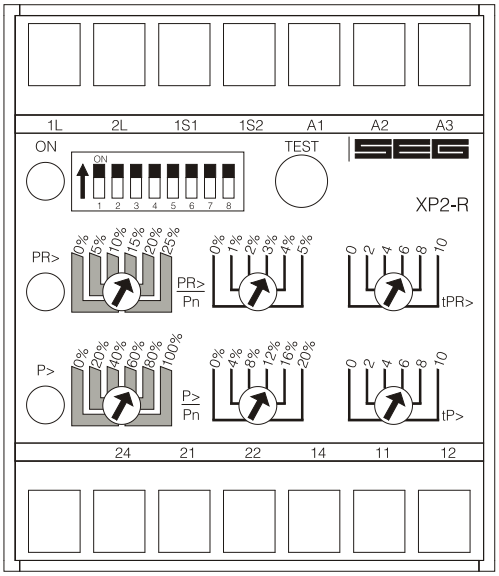


Figure 4.1: Front plate

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

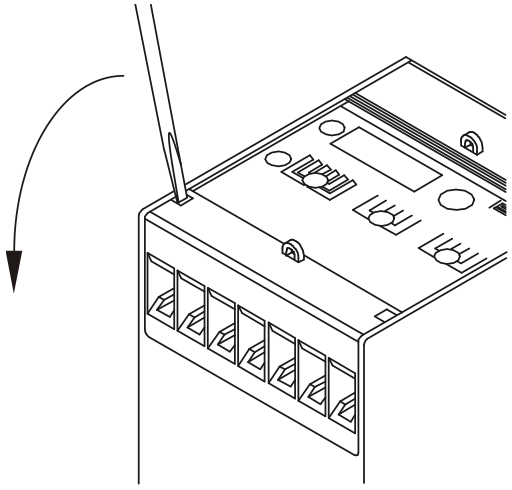


Figure 4.2: How to open the transparent cover

LEDs
LED "ON" is used for display of the readiness for ser-vice (at applied auxiliary voltage Uv) and be-sides this it flashes at wrong phase sequence (see table under para. 4.1). LEDs P> and P< signal pickup (flashing) or tripping (steady light) of the respective function.

Test push button
This push button is used for test tripping of the unit and when pressed for 5 s a check-up of the hardware takes place. Both output relays are tripped and all tripping LEDs light up.

4.1 Setting of DIP-Switches

The DIP-switch block on the front plate of unit XP2-R is used for adjustment of the nominal values and setting of function parameters:

DIP-switch	OFF	ON	Function
1*	Un = 100 V	Un = 110 V	Setting of rated voltage
2*	Un = 100 V	Un = 230 V	
3*	Un = 100 V	Un = 400 V	
4			
5	Y	□	Measuring phase-to-neutral/phase-to-phase voltage
6	500 ms	40 ms	Returning time
7	x 1	x 10	Multiplier for tPR>
8	x 1	x 10	Multiplier for tP>

Table 4.1: Function of DIP-switches

*Only one of the DIP-switches 1 - 3 shall be in „ON“ position at the same time.

Rated voltage
The required rated voltage can be set with the aid of DIP-switch 1 - 3 to 100, 110, 230 or 400 V AC. The rated voltage is defined as the real connected voltage applied to connection terminals 1L - 2L. It has to be ensured that only one of the three DIP-switches is switched on. The following DIP-switch configurations for adjustment of the rated voltage are allowed.

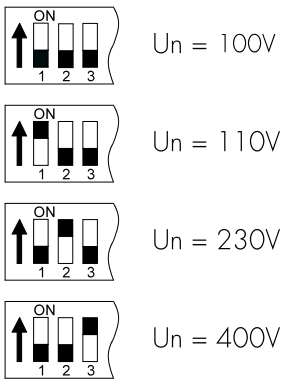


Figure 4.3: Adjustment of rated voltage

Rated voltage chosen too low does not cause destruction of the unit but leads to wrong measuring results which may lead to false trippings.

Measuring of phase-to-neutral/phase-to-phase volt-age
The phase-to-neutral (position „OFF“) or phase-to-phase voltage (position „ON“) can be adjusted by means of switching over the DIP-switch 5.

Hysteresis of P> and PR>
The hysteresis of both trip elements are fixed to 0.8 % Pn.

Example:
The chosen rated voltage is 400 V.
The rated current is 5 A.
400 V x 5 A x 0.8 % = 16 W hysteresis

Returning time
If DIP-switch 6 is in ON position, the returning time of P> and PR> is 40 ms. At the same time the tripping values of tPR> and tP> are set to their minimum values irrespectively of their potentiometer setting.
This setting is only used together with a XG2 relay as power direction controlled vector surge tripping for synchronous motors.

4.2 Setting of the Tripping Values

The PROFESSIONAL LINE units have the unique possibility of high accuracy fine adjustments. For this, two potentiometers are used. The course setting potentiometer can be set in discrete steps of 5 % (or 20 %). A second fine adjustment potentiometer is then used for continuously variable setting of the final 0 - 5 % (or 0 - 20 %). Adding of the two values results in the precise tripping value.

Active power supervision
The tripping value can be set in the range from
1 - 120 % Pn with the aid of the potentiometer illustrated on the following diagram.

Example:
A tripping value P> of 72 % Pn is to be set. The set value of the right potentiometer is just added to the value of the coarse setting potentiometer. (The arrow of the coarse setting potentiometer must be inside of the marked bar, otherwise no defined setting value).

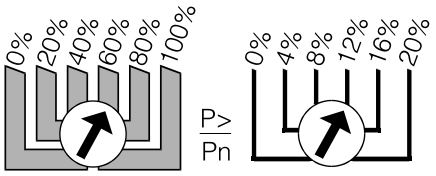


Figure 4.4: Adjusting example

Reverse power supervision
The tripping value at reverse power is adjustable in the range from 1 - 30 % Pn. The adjustment is made as shown above.

Time delay
The time delays of both power elements can be adjusted in the range from 0 - 10 s or 0 - 100 s continuously variable (pay attention to range shifting of DIP-switch 7 and 8)

4.3 Communication via Serial Interface Adapter XRS1

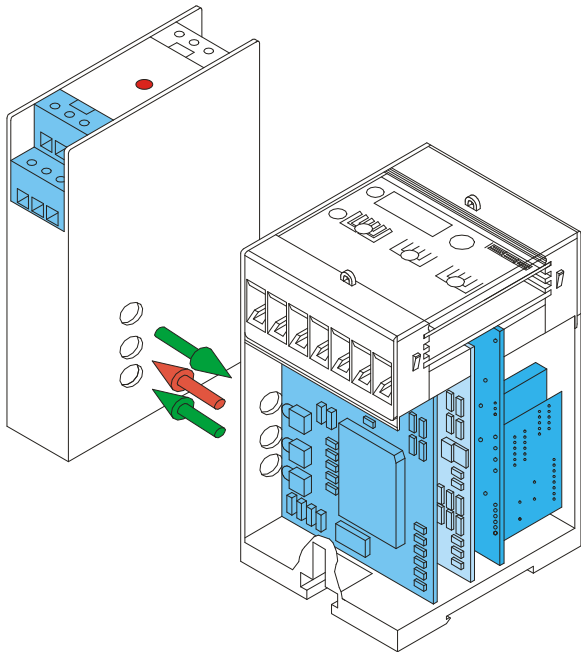


Figure 4.5: Communication principle

For communication of the units with a superior management system, the interface adapter XRS1 is avail-able for data transmission, including operating software for our relays. This adapter can easily be retrofitted at the side of the relay. Screw terminals simplify its installation. Optical transmission of this adapter makes galvanic isolation of the relay possible. Aided by the software, actual meas-ured values can be processed, relay parameters set and protection functions programmed at the output relays. Information about unit XRS1 in detail can be taken from the description of this unit.

5. Relay Case and Technical Data

5.1 Relay Case

Unit XP2-R is designed to be fastened onto a DIN-rail acc. to DIN EN 50022, same as all units of the PROFESSIONAL LINE.
The front plate of the unit is protected with a sealable transparent cover (IP40).

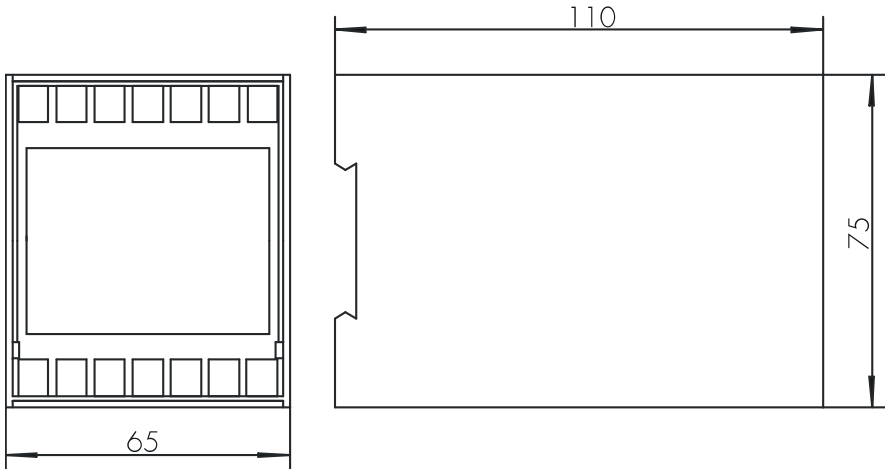


Figure 5.1: Dimensional drawings

Connection terminals
The connection of up to a maximum of 2 x 2.5 mm2 cross-section conductors is possible. For this the transparent cover of the unit has to be removed (see para. 4).

5.2 Technical Data

Measuring input circuits

Rated voltage Un:	100,110, 230, 400 V AC
Rated frequency range:	35 - 74 Hz
Power consumption in voltage circuit:	1 VA
Power consumption in current circuit:	In = 1 A/0,075 VA In = 5 A/0,1 VA
Working range of power supervision voltage:	40 - 130 % Un
current:	0 - 120 % In
Thermal capacity of the voltage circuit:	continuously 520 V AC
Thermal load carrying capacity of the current circuit:	continuously 4 x In

Auxiliary voltage

Rated auxiliary voltage UV/	36 - 520 V AC (f = 35 - 78 Hz) or 50 - 750 V DC / 4 W (terminals A1 - A3)
Power consumption:	19 - 55 V DC/3 W (terminals A1(L-) - A2(L+))

Common data

Dropout to pickup ratio:	0,8 % von Pn
Resetting time from pickup:	<50 ms
Returning time from trip:	500 ms (DIP-switch 6 = OFF) or 40 ms (DIP-switch 6 = ON)
Minimum initialization time after supply voltage has applied:	260 ms
Minimum response time when supply voltage is available:	50 - 200 ms
Repeat accuracy:	1 %
Basic time delay accuracy:	0.5 % or ±50 ms
Accuracy of the specific rated values:	Un = 100 V / 110 V / 230 V / 400 V 1 % Pn
Temperature effect:	0.02 % as per K
Frequency effect:	45 - 66 Hz no tolerance 35 - 45 Hz and 66 - 74 Hz 1%
Min. threshold value of power elements:	1 % of Pn

Output relay

Number of relays:	2
Contacts:	1 changeover contact for each trip relay
Maximum breaking capacity:	ohmic 1250 VA / AC resp. 120 W / DC inductive 500VA / AC resp. 75 W / DC
Max. rated voltage:	250 V AC 220 V DC ohmic load Imax. = 0,2 A inductive load Imax. = 0,1 A at L/R ≤ 50 ms 24 V DC inductive load Imax. = 5 A
Minimum load:	1 W / 1 VA at Umin ≥ 10 V
Maximum rated current:	5 A
Making current (16ms):	20 A
Contact life span:	10^5 hysteresis at max. breaking capacity
Contact material:	AgCdO

Design standards

Generic standard:	EN 61000-6-2 EN 61000-6-3
Product standard:	IEC 60255-1

Environmental Tests

Temperature range for storage and operation:	- 25°C to + 70°C
Climatic capability acc IEC 60068-2-78:	over 56 days at 40°C and 95 % relative humidity

High Voltage Tests

Voltage test acc IEC 60255-27:	2.5 kV (eff.) / 50 Hz; 1 min
Surge voltage test acc IEC 60255-27:	5 kV; 1.2/50 ms, 0.5 J
High frequency test acc IEC 60255-26:	2.5 kV / 1 MHz
Electrostatic discharge (ESD) acc. to IEC 61000-4-2:	8 kV

EMC Immunity Tests

Radiated electromagnetic field test acc. to IEC 61000-4-3:	10 V/m
Electrical fast transient (burst) acc. to IEC 61000-4-4:	4 kV / 2,5kHz, 15 ms
Radio interference suppression test acc. to DIN 55011:	limit value class A

Mechanical test:

Shock:	class 1 to DIN IEC 255-21-2
Vibration:	class 1 to DIN IEC 255-21-1
Degree of protection	
Front plate:	IP40 at closed front cover
Weight:	ca. 0.7 kg
Mounting position:	any
Relay case material:	self-extinguishing

Parameter	Setting range	Graduation
PR>	1 - 30 % Pn	continuously variable
P>	1 - 120 % Pn	continuously variable
tPR>	0 - 10 s/0 - 100 s	continuously variable
tP>	0 - 10 s/0 - 100 s	continuously variable

Table 5.1: Setting ranges and graduation

6. Order Form

Power and reverse power relay		*XP2-R-*	
Rated current	1 A		**1**
	5 A		**5**

Technical data subject to change without notice!

Setting-list XP2-R

Project: _____ SEG job.-no.: _____

Function group: = _____ Location: + _____ Relay code: - _____

Relay functions: _____ Date: _____

Setting of parameters

Function		Unit	Default settings	Actual settings
P>	Power supervision	% Pn	1	
PR>	Reverse power supervision	% Pn	1	
tP>	Tripping delay of power element	s	0	
tPR>	Tripping delay of reverse power element	s	0	

DIP-switch	Function	Default settings	Actual settings
1*		100 V	
2*	Adjustment of rated voltage	100 V	
3*		100 V	
4			
5	Measuring phase-to-neutral/phase-to-phase voltage	Y	
6	Returning time	500 ms	
7	Multiplier for PR>	x 1	
8	Multiplier for P>	x 1	

*Only one of the DIP-switches 1 - 3 shall be in „ON“-position at the same time.

Professional Line

https://docs.SEGelectronics.de/xp2_r

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