**XA1** · Voltage balance relay
1. Applications and features

Relay XA1 of the PROFESSIONAL LINE is a digital relay for voltage balance supervision of 3-phase systems and provides protection for electrical power generators and general equipment against voltage unbalance e.g. due to blown fuse or conductor break.

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 voltage by universal wide range power supply unit
- Wide setting ranges very accurately graded
- Data exchange with process management system by serial interface adapter XRS1 which can be retrofitted
- Extremely short reaction times
- Adjustment of rated data
- Negative sequence measuring of voltage unbalance
- Compact design by SMD-technology

In addition to this relay XA1 has the following special features:
- Different switching hysteresis adjustable
- Measurement phase-to-neutral or phase-to-phase voltage possible
2. Design

3 ~ 35 - 78 Hz; 60 - 400 V

Auxiliary voltage supply

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

Unit XAI 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 conditions

Voltage unbalance tripping

Fig. 2.3: Contact positions of the output relays

Analog inputs

The analog voltage input signals are connected to the protection relay via terminals L1 - L3 and N.
3. **Function**

The XA1 detects unbalanced voltages in terms of value and phase position. Such unsymmetric conditions can occur due to break of a conductor, blown fuses or unbalanced loading of the three phases system. These conditions always result in displacement of the star point. The negative sequence voltage is measured by the XA1 and so correct tripping after the adjusted time delay is ensured.

**Measuring principle:**
A rotating three-phase system can be split according to the method of Symmetrical Components into a positive-sequence system, a negative-sequence system and a zero sequence system. The XA1 calculates the negative-sequence system by rotating the voltage vector $U_1$ by $240^\circ$ and the voltage vector $U_2$ by $120^\circ$ and following addition of the voltage vectors.

![Symmetrical three-phase system](image1)

![Rotation of the voltage vectors for calculation of the negative sequence system](image2)

![Addition of the rotated voltage vectors](image3)

**Fig. 3.1:** Symmetrical three-phase system

A rotating field is produced with opposite direction of rotating field. If the voltages of this negative-sequence system are added, the sum is zero in case of symmetrical voltages and angles.

![Asymmetrical three-phase system](image4)

![Rotation of the voltage vectors for calculation of the negative sequence system](image5)

![Addition of the rotated voltage vectors](image6)

**Fig. 3.2:** Asymmetrical three-phase system

In fig. 3.2 voltages of an asymmetrical system are shown. The XA1 calculates the negative-sequence system by rotating and following addition of the voltage vectors. The adjusting pickup value related to the rated voltage $U_n$. At phase loss (and correct phase angle) the asymmetrical voltage amounts to $33\%$ $U_n$. 
4. Operation and settings

All operating elements needed for setting parameters are located on the front plate unit XA1 as well as all display elements.

Because of this all adjustments of the unit can be made or changed without disconnecting the unit from the DIN-rail.

FIG. 4.1: Front plate

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.

FIG. 4.2: How to open the transparent cover

LEDs

LED “ON” is used for display of the readiness for operation (at applied auxiliary voltage Uv). LED U2st> indicates pickup by flashing, at trip of the voltage unbalance supervision the LED is lit permanently.

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 XA1 is used for adjustment of the nominal values and setting of function parameters:

<table>
<thead>
<tr>
<th>DIP-switch</th>
<th>OFF</th>
<th>ON</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>Un = 60 V</td>
<td>Un = 110 V</td>
<td>Setting of rated voltage</td>
</tr>
<tr>
<td>2*</td>
<td>Un = 60 V</td>
<td>Un = 230 V</td>
<td></td>
</tr>
<tr>
<td>3*</td>
<td>Un = 60 V</td>
<td>Un = 400 V</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Y</td>
<td>Δ</td>
<td>Measurement phase-to-neutral/phase-to-phase voltage</td>
</tr>
<tr>
<td>6*</td>
<td>1 %</td>
<td>2 %</td>
<td>Switching hysteresis for U2s&gt;</td>
</tr>
<tr>
<td>7*</td>
<td>1 %</td>
<td>5 %</td>
<td></td>
</tr>
<tr>
<td>8*</td>
<td>1 %</td>
<td>10 %</td>
<td></td>
</tr>
</tbody>
</table>

Table 4.3: Function at DIP-switches

* Only one of the DIP-switches 1 - 3 and 6 - 8 shall be in „ON“ position at the same time.

Rated voltage

The required rated voltage Un (phase-to-phase voltage) can be set with the aid of DIP-switch 1 - 3 to 60, 110, 230 or 400 V AC. It has to be ensured that only one of the three DIP-switches is switched on.

The following DIP-switch configurations are permissible for adjustment of the rated voltage:

Fig. 4.3: Adjustment of rated voltage

Measurement of phase-to-neutral / phase-to-phase voltage

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. (see fig. 2.1 and 2.2.)

Switching hysteresis

The switching hysteresis for U2s> can be adjusted with the aid of DIP-switches 6 - 8 to 1, 2, 5 or 10 % of the tripping value. As for the rated voltage, it has to be ensured that only one of the two DIP-switches is switched on.

Rated voltage chosen too low, does not cause destruction of the unit but leads to wrong measuring results which may lead to false trippings.
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 10%. A second fine adjustment potentiometer is then used for continuously variable setting of the final 0 - 10%. Adding of the two values results in the precise tripping value.

Asymmetry trip element

The trip element can be set in the range of 0 - 60% Un with the aid of the potentiometer illustrated on the following drawing.

Example:
A pickup value U2s> for 36% Un 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 the marked bar, otherwise no defined setting value).

4.3 Communication via serial interface adapter XRS1

Time delay

The time delay tU2s> can be adjusted continuously variable in the range from 0 - 10 s.
5. Relay case and technical data

5.1 Relay case

Relay XA1 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).

![Dimensional drawing](image_url)

**Fig. 5.1: Dimensional drawing**

**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: 60, 110, 230, 400 V AC
Rated frequency range: 35 - 78 Hz (35 - 66 Hz at communication via serial interface)
Power consumption in voltage circuit: 1 VA/per phase at Un
Thermal capacity of the voltage circuit: continuously 520 V AC

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-) and A2(L+))

Common data

Dropout to pickup ratio: depending on the adjusted hysteresis
Resetting time from pickup: <70 ms
Returning time from trip: 190 - 280 ms
Minimum initialization time after supply voltage has applied: <290 ms
Minimum response time when supply voltage is available: 70 - 130 ms

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 500 VA/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 (16 ms): 20 A
Contact life span: 10⁷ operations at max. breaking capacity

System data

Design standard: VDE 0435 T303; IEC 0801 part 1-4,
VDE 0160; IEC 255-4; BS 142; VDE 0871
Temperature range at storage and operation: - 25 °C to + 70 °C
Constant climate class F
acc. to DIN 40040 and
DIN IEC 68, part 2-3: more than 56 days at 40°C and 95 % relative humidity

High voltage test
acc. to VDE 0435, part 303
Voltage test: 2.5 kV (eff) / 50 Hz; 1 min
Surge voltage test: 5 kV; 1.2/50 µs; 0.5 J
High frequency test: 2.5 kV / 1 MHz

Electrostatic discharge (ESD)
acc. to IEC 0801, part 2: 8 kV

Radiated electromagnetic field
test acc. to IEC 0801, part 3: 10 V/m

Electrical fast transient (burst)
acc. to IEC 0801, part 4: 4 kV/2.5 kHz, 1.5 ms

Radio interference suppression test
acc. to DIN 57871 and VDE 0871: limit value class A

Repeat accuracy: 1 %
Basic time delay accuracy: 0.5 % or ±25 ms

Accuracy of the specific rated values:
Un = 60 V 2 %
Un = 110 V / 230 V / 400 V 1 %

Temperature effect: 0.02 % per K
Frequency effect: 45 - 66 Hz no tolerance
35 - 45 Hz and 66 - 78 Hz 1 %

Mechanical test
Shock: class 1 acc. to DIN IEC 255-21-2
Vibration: class 1 acc. to DIN IEC 255-21-1

Degree of protection:
Front plate: IP40 at closed front cover
Weight: approx. 0.5 kg
Mounting position: any
Relay case material: self-extinguishing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Setting range</th>
<th>Graduation</th>
</tr>
</thead>
<tbody>
<tr>
<td>U2s&gt;</td>
<td>0 - 60 % Un</td>
<td>continuously variable</td>
</tr>
<tr>
<td>tU2s</td>
<td>0 - 10 s</td>
<td>continuously variable</td>
</tr>
<tr>
<td>Hysteresis for U2s</td>
<td>1, 2, 5, 10 %</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.1: Setting ranges and graduation

Technical data subject to change without notice!
Setting-list XA1

Project: ___________________________ SEG job.-no.: ___________________________
Function group: = Location: + Relay code: ___________________________
Relay functions: ___________________________ Date: ___________________________

Setting of parameters

<table>
<thead>
<tr>
<th>Function</th>
<th>Unit</th>
<th>Default settings</th>
<th>Actual settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>U2s&gt; Voltage asymmetrie</td>
<td>% Un</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>tU2s&gt; Time delay for tU2s&gt;</td>
<td>s</td>
<td>0</td>
<td></td>
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<td>Adjustment of rated voltage</td>
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<td></td>
</tr>
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<td>60 V</td>
<td></td>
</tr>
<tr>
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<td>Adjustment of rated voltage</td>
<td>60 V</td>
<td></td>
</tr>
<tr>
<td>4*</td>
<td>Measuring phase-to-neutral / phase-to-phase voltage</td>
<td>Y</td>
<td></td>
</tr>
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