AZT+

Static self-powered overcurrent protection

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User's manual version information

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CONTENTS

1 Application and main features

1.1 Application

In case of a fault to be cleared, the expected operation of a protection system is to switch the battery voltage to the trip coil of the circuit breaker. If the auxiliary battery power is not available for any reason, this system is inoperable. The fault can be cleared only by the remote backup protection devices. In this case the fault clearing is not selective and it is performed with additional time delay. In some applications, e.g. in meshed networks, if the remote backup protections cannot operate, there are no protection at all to clear the fault.

The AZT+ devices can be applied to provide safe protection without auxiliary batteries. The features have main advantages in case of failure of the auxiliary DC power supply of the substation; this device provides back-up protection. It can save transformers, cables, overhead lines and other primary equipment in case of loss of DC power supply. Due to the special IDMT characteristics, it can be applied for selective protection also in mashed networks.

The AZT+ device stores energy in internal capacitors, which is sufficient to operate the trip coil of the circuit breaker. Additionally, the operation of the electronic circuits is also supplied by internal capacitors; the power of auxiliary battery is not needed at all.

If the electronic circuits indicate overcurrent related to the setting value then after the selected time delay a TRIP command is generated after the selected time delay by connecting the charged capacitance to the trip circuits of the circuit breakers. The operating characteristic is a certain kind of inverse (IDMT) characteristic, described in chapter *Setting*.

The device is planned to operate safely, and to clear the fault with high reliability.

The device is constructed for three phase connection to dedicated measuring transformer cores to ensure autonomous operation. The electronic circuits select the phase with the largest current for processing and comparison with the special IDMT characteristics. The internal capacitance can store sufficient power to operate all three phases of a circuit breaker set with individual drives. To ensure full autonomy, the circuit breaker is to be operated by an independent trip coil.

The device can be applied as a zero sequence back-up protection with unchanged structure. In this case the internal circuits of the protection are unchanged, only the external connections are to be modified.

1.2 Features

The main characteristics of the self-powered AZT+ electronic overcurrent protection are as follows:

- The device is self-powered; it does not need auxiliary battery power supply for the operation. The power source is the current and/or voltage transformer set.
- The device has power storage capacity; no auxiliary battery power is needed to operate the circuit breaker.
- The power is stored in internal capacitors, charged from the voltage and/or current transformers. Optional long-life capacitor set is also available. The device continuously checks the healthy state of the capacitors.
- The overcurrent protection has special IDMT characteristics. The energizing quantities can be optionally two or three phase currents or the residual current.
- The characteristics can be shifted by time delay parallel along the time axis.
- The voltage condition check prevents operation in case of single phase open state.
- The device continuously checks the healthy state of the trip circuits.
- The operating state of the device is signaled by status LEDs.

- Start and for the trip command counters on the front panel.
- The state of the internal capacitors is continuously monitored; the device generates a warning signal if the capacitance is decreased by aging.
- Wide temperature range (-40°C to +65°C) for outdoor applications.

2 Construction, arrangement

The AZT+ device is housed in a closed metal case (See *Figure 2-1*). The capacitors for power storage are mounted internally and/or in a separate box of similar construction.

The Weidmüller external terminals of the device are located on the bottom part of the casing.

Figure 2-1: AZT+ construction

The front panel of the device contains five LED indicators and two counters. The LED lights indicate the following:

- READY (green) LED for normal operation of the device
- STARTED (red) LED for started state
- TRIPPED (red) LED for TRIP command state
- C< (red) LED warning for degraded state of the power storage capacitors
- LOCK LOGIC (green) LED for status of the special block logic.

The LED signals will be explained below in details related to the operation of the device.

The two counters display:

- STARTED: the count of started states,
- TRIPPED: the count of the generated TRIP commands.

The setting of the device is made by DIP switches. The top cover of the device needs to be opened for setting.

3 External connections

The device needs the following connections:

- Power supply connection to CTs and VTs
- Energizing quantity (phase currents and/or the residual current)
- To the trip circuits
- To the status signals of the circuit breaker
- To the external indication about the healthy/faulty state of the device.

These external connections are explained below, related to the recommended “Basic connection”. For connector arrangement see *Figure 6-3*.

The AZT+ device can be applied also in several different ways. These applications are compared to the “Basic connection” in the description below.

3.1 Basic connection

3.1.1 Application as phase overcurrent backup protection

For applying the AZT+ device as three-phase back-up overcurrent protection the recommended connection is indicated in *Figure 3-1*.

In this connection version:

- All three phase voltages are connected. They supply the charging of the internal capacitors, when only a normal small current is flowing through the protected network element.
- All three phase currents are connected to both sets of currents inputs. One of them (CT2) supplies the charging of the capacitors even if the voltage is small due to close-in fault. The other current transformer set (CT1) is used for supplying the overcurrent measuring element.
- In case of fault, the stored power of the internal capacitor is switched by three trip relays (with common operation) to the trip coils of the circuit breakers.
- The special blocking logic is not applied.
- The trip signal, which is generated together with to the trip command, is not indicated in the drawing.
- The application of the faulty/healthy signal of the device is not indicated in the drawing.

NOTE: To keep reliability the serial connection of the CT circuits with other devices is not recommended.

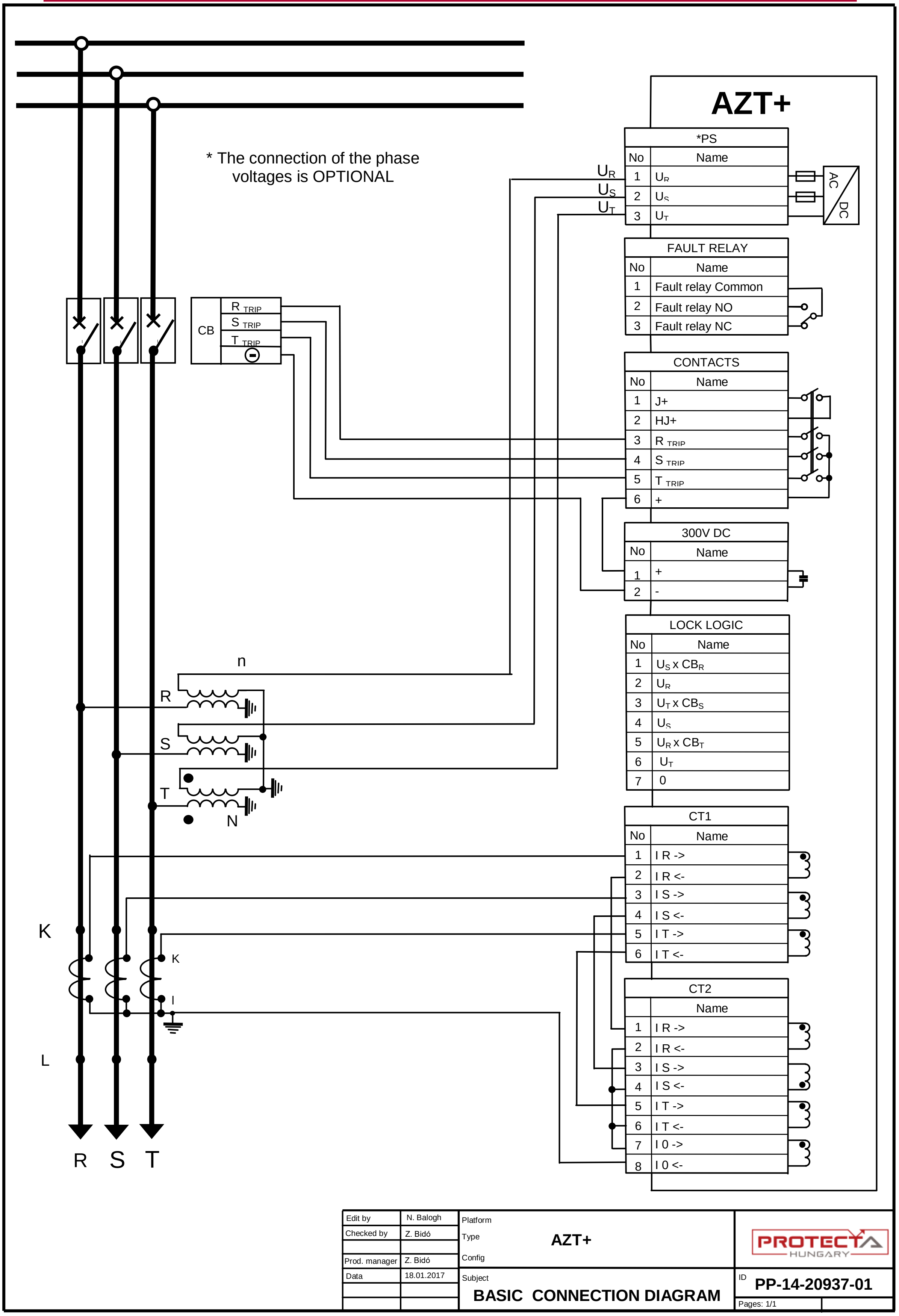


Figure 3-1: AZT+ application as three-phase overcurrent back-up protection

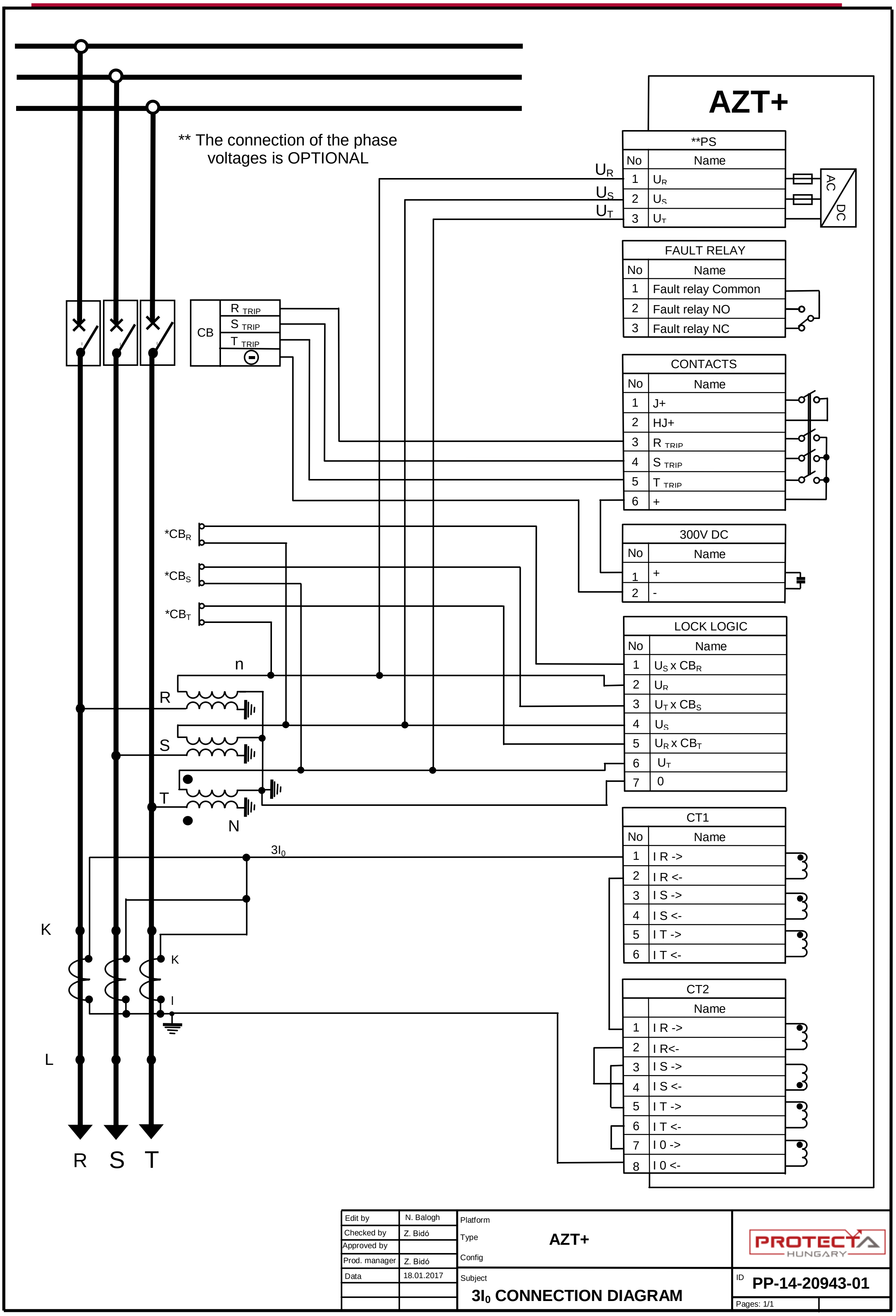
3.1.2 Application as residual overcurrent backup protection

For application of the AZT+ device as a residual back-up overcurrent protection the recommended connection is indicated in *Figure 3-2*.

In this connection version:

- All three phase voltages are connected. They supply the charging of the internal capacitors, when only normal small residual current is flowing in the protected network.
- The residual current is connected to both sets of currents inputs. One of them (CT2) supplies the charging of the capacitors even if the voltage is small due to close-in fault. The residual current is connected series to all inputs of the CT current input set. The other current transformer set (CT1) is used for supplying the overcurrent measuring element. The residual current is connected to one input of the CT1 current input set only.
- In case of fault, the stored power of the internal capacitors is switched by three parallel operated trip relays to the trip coils of the circuit breakers.
- The special blocking logic can be applied (See *Figure 3-2*).
- The trip signal, which is generated together with the trip command, is not indicated in the drawing.
- The application of the faulty/healthy signal of the device is not indicated in the drawing.

NOTE: To keep reliability the serial connection of CT circuits with other devices is not recommended.



* Auxiliary contact belongs to open state of the CB.

Figure 3-2: AZT+ application as residual overcurrent back-up protection

3.2 The power supply modes

No auxiliary battery is needed for the operation of the device. The power is delivered from the current transformers and from the voltage transformers.

3.2.1 Power supply in case of "Basic connection"

The "Basic connection" of the device applies both VT and CT connections (connectors of CT2 input module). In normal operation of the network, the power from the voltage transformers keeps the internal capacitors charged. In case of faults the voltages drop, but the increased fault current keeps the electronic circuits in operation and the capacitors charged. This is the full and recommended operating mode of the device. In this mode the full setting range for the starting current is available. (For setting the characteristic, see chapter *Setting*.)

The recommended connection of the CTs is shown in *Figure 3-3*. This connection results the optimal charging power in case of any fault types.

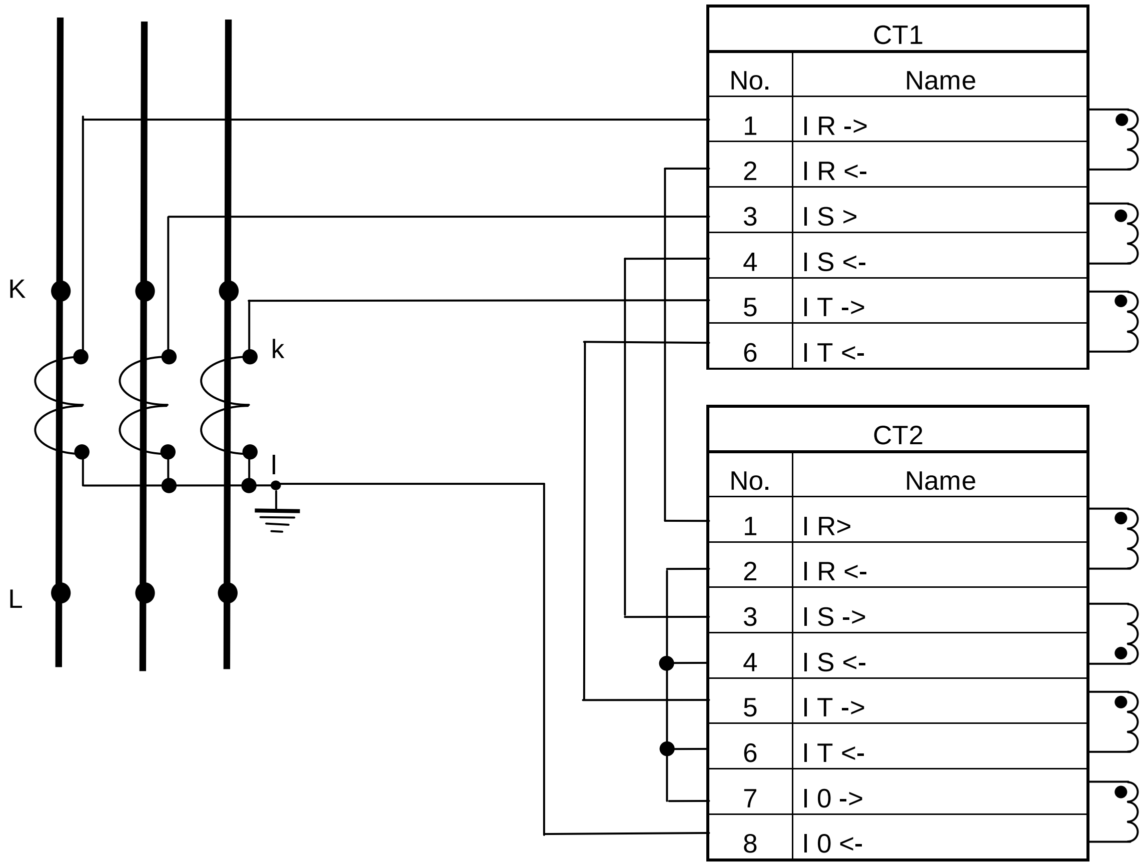


Figure 3-3: CT power supply in application as phase overcurrent back-up protection

Figure 3-4 shows the recommended connection to VTs. In normal operation of the network, the power from the voltage transformers keeps the internal capacitors charged.

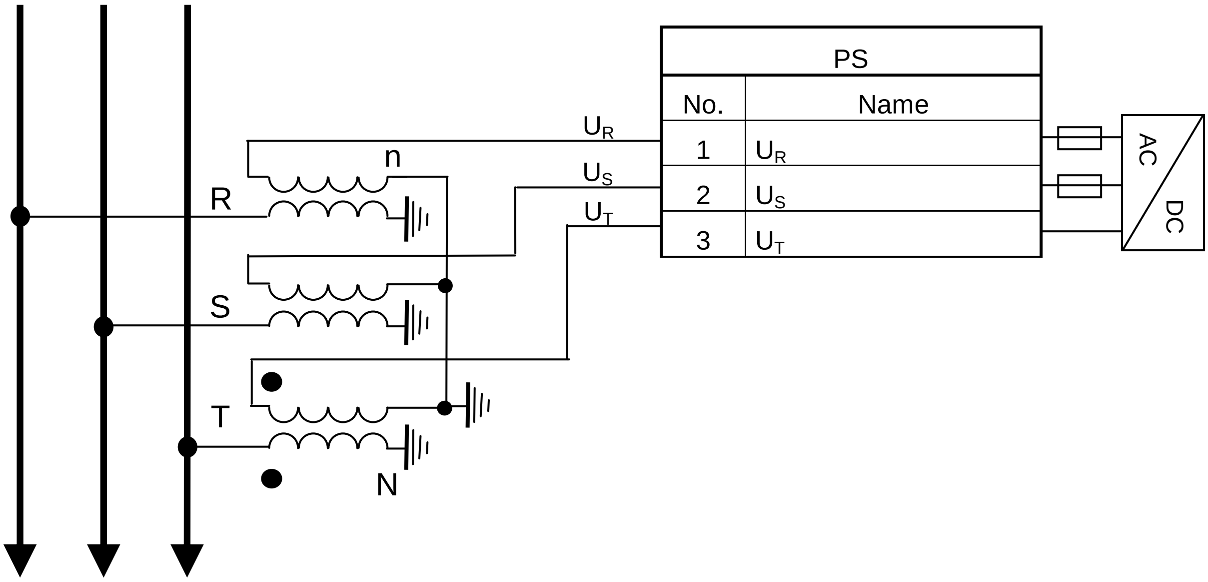


Figure 3-4: VT power supply, recommended connection

3.2.2 Power supply from CTs only

The voltage transformer connection is not available in some applications. If the voltage transformers are not connected then the relatively small load currents may not be sufficient to keep the capacitors charged. At the moment of fault inception the high fault current starts to charge the capacitors. The measuring element starts measurement only if the voltage reaches the minimum level. This results an additional time delay in the operation. This time delay depends on the fault current level, the value can be hundreds of milliseconds. For the evaluation of this time delay, do not forget that the role of this device is backup protection for emergency situations, usually with a time delay of several seconds. Consequently this additional time delay can be tolerated.

The device generates the trip command only if the capacitors are fully charged; otherwise the trip coil of the circuit breaker does not get sufficient energy for operation. This means that small fault currents would result too long time delay, and below a certain level the operation of the device cannot be guaranteed. To prevent this wrong behavior, in this case when the power is delivered by CTs only and the VTs are not connected, the small current range of the setting values is not permitted. For technical details see chapter *Setting*.

3.2.3 Power supply from VTs only

The AZT+ device is basically operable if the power is continuously delivered by VTs. However, in case of close-in faults the voltage is too small to charge the capacitors. Additionally in case of switch-onto fault, when in pre-fault conditions the voltage is zero, and during close-in faults the voltage remains zero or a small value, the device cannot operate.

Because of this, the operation of the device without supply from the CTs is not recommended.

3.2.4 Power supply with residual current only

If the AZT+ device is used as a residual backup overcurrent protection, the power supply needs a special connection, shown in *Figure 3-5*.

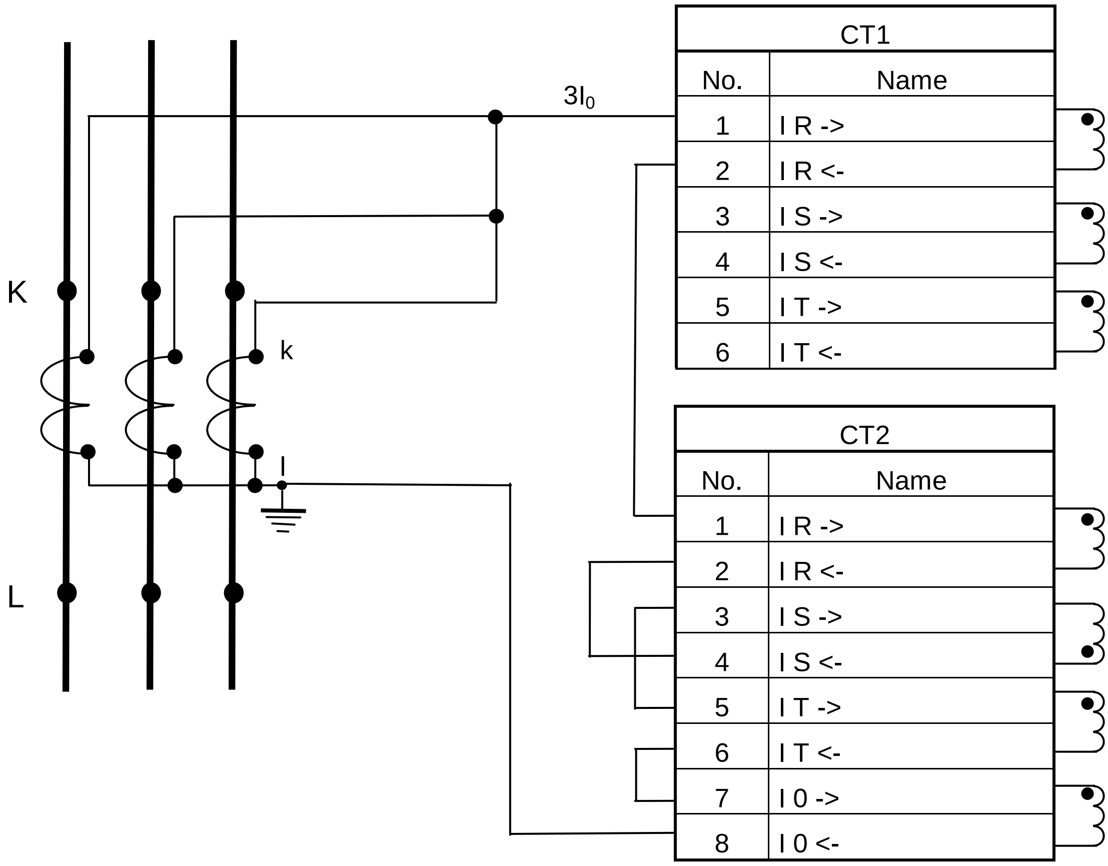


Figure 3-5: CT power supply in application as residual overcurrent back-up protection

This connection results the optimal charging power in case of earth-faults.

3.2.4.1 Connection of the reduced load current circuit

If the load of the current transformer circuit is too high with the previous connection (4 wired input on CT2 input), it may cause loss of operation because of the current transformer saturation. In long term, this can damage the current transformers. To reduce the load of the current circuit, we recommend connecting the device as it shown in *Figure 3-6*. In that case only 2 CT inputs are used, so the load of the current circuit has been reduced to the half value. This way less power is available to charge the capacitors, which cause more additional time delay in the operation in case of power supply only from CT. On the other hand, this additional time delay mostly affects the small current range. In this connection, the device is going to operate like at the single phase fault in the basic connection, as *Figure 3-15* shows.

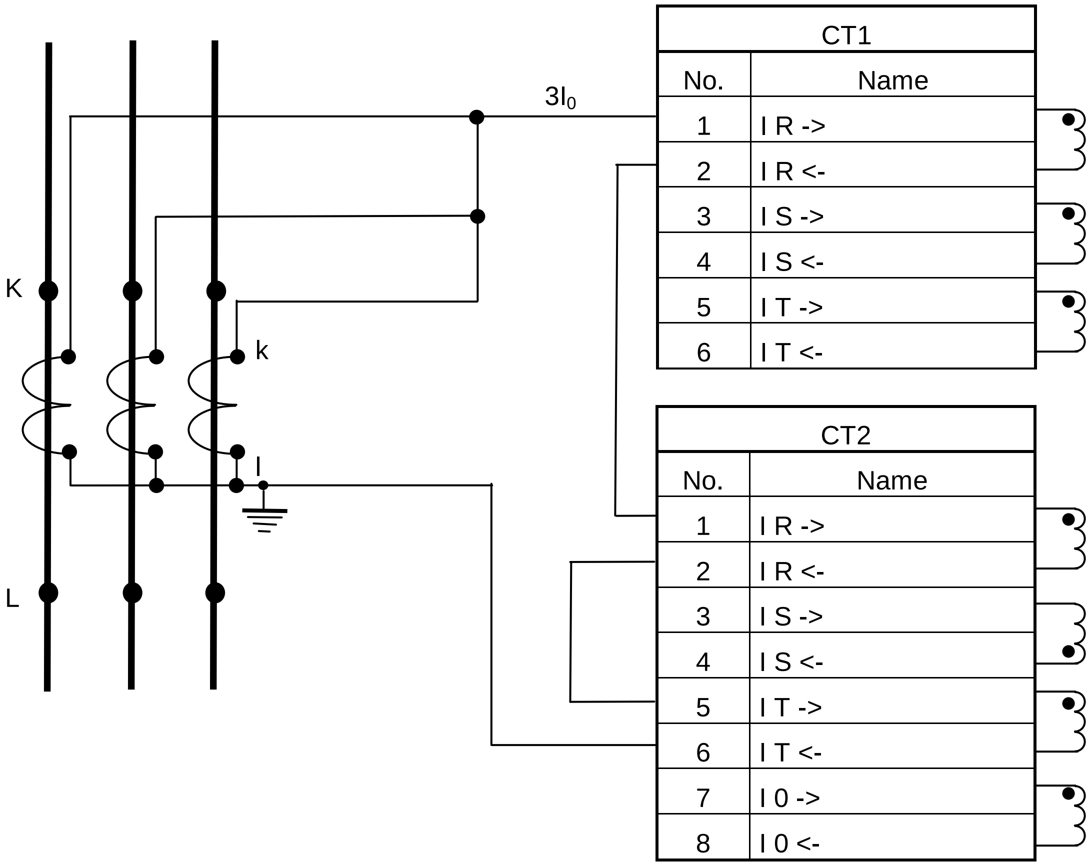


Figure 3-6: CT power supply in application as residual overcurrent back-up protection with reduced load current circuit

3.2.5 Connection with VTs in two phases only

If only two VTs are available, connect the device according to *Figure 3-7*.

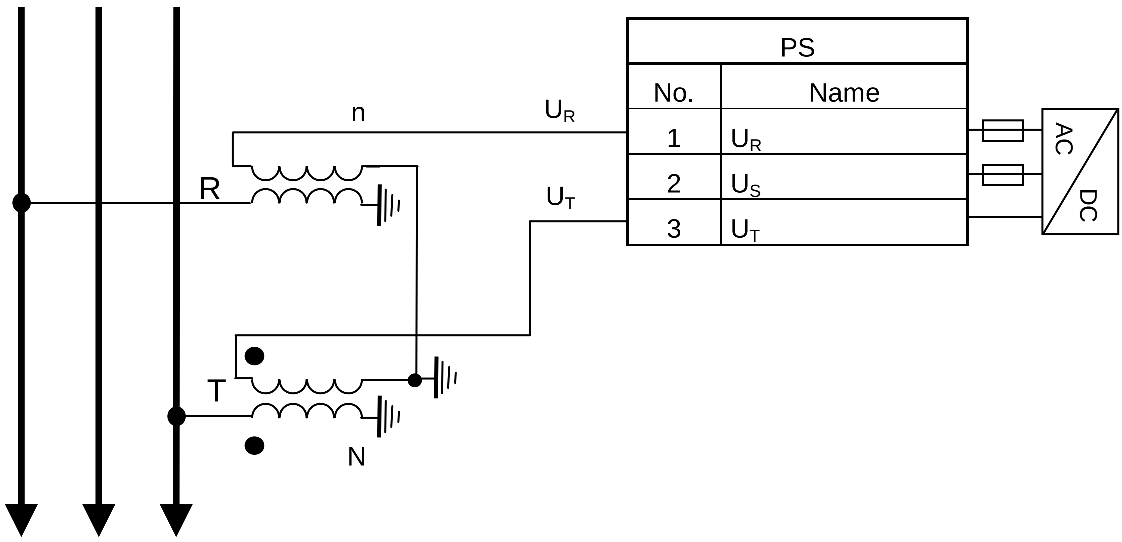


Figure 3-7: VT power supply in application with VTs in two phases only

3.2.6 Connection with CTs in two phases only

If only two CTs are available, connect the device according to *Figure 3-8*.

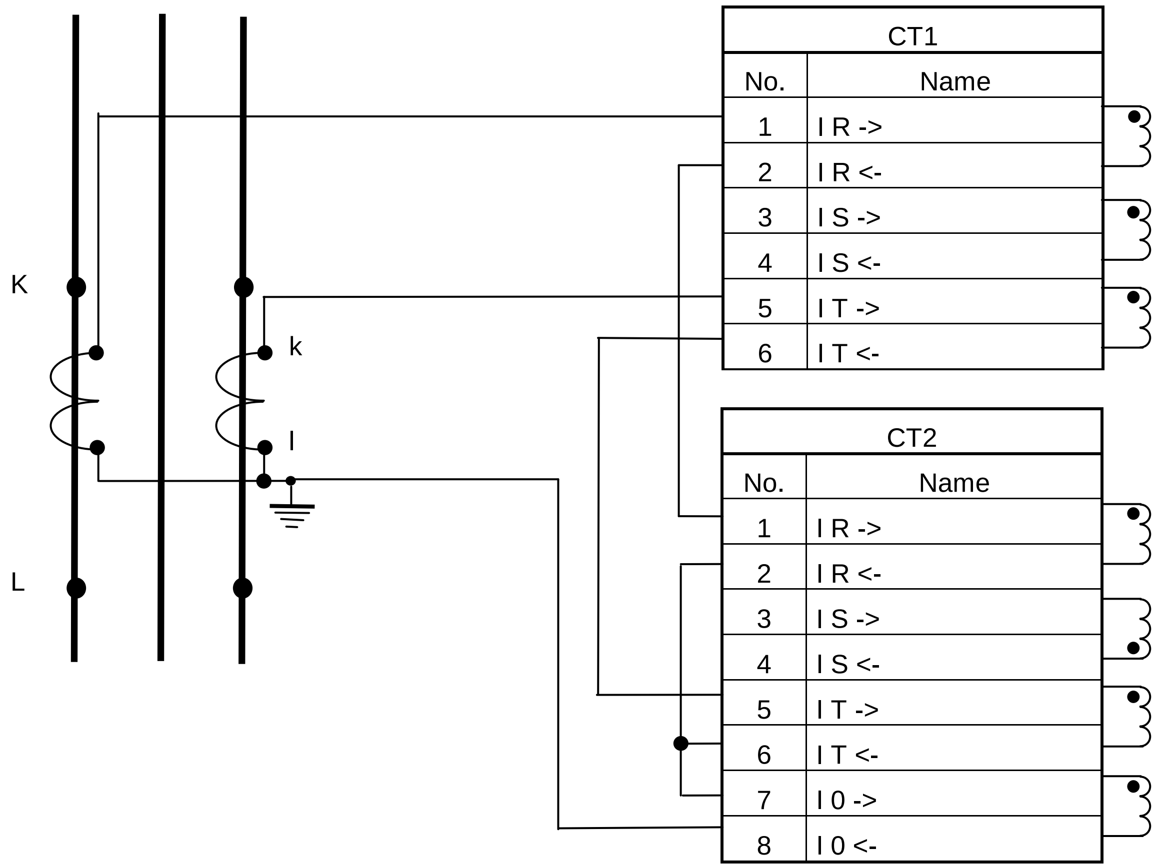


Figure 3-8: CT power supply in application as phase overcurrent back-up protection with two available CTs

3.3 Connection of the currents to the measuring element

The device can be energized with currents connected to the set of CT1 inputs. These can be:

- three phase currents,
- two phase currents,
- the residual current.

3.3.1 Operation with three phase currents

3.3.1.1 Power supply: VTs and CTs

Figure 3-1 shows the “Basic connection”, when all three phase currents are connected. The internal electronic circuits of the device selects the largest one and this is considered as the energizing quantity of the overcurrent function. This is the normal operating mode of the device.

Figure 3-9 shows the characteristic when the device has dual power supply, parallel from CTs and VTs. The characteristic does not depend on the fault type: single phase, two phase and three phase fault results the same operating time. The horizontal axis is scaled in per unit. The current base is the setting value. *Figure 3-9* shows also that in case of dual power supply the shape of the characteristic does not depend on the setting value (on the Figure this is the parameter 1 I_N, 2 I_N, 3 I_N, 4 I_N). This special current dependent characteristic is considered in this document as the basic characteristic:

$$to = fo(I)$$

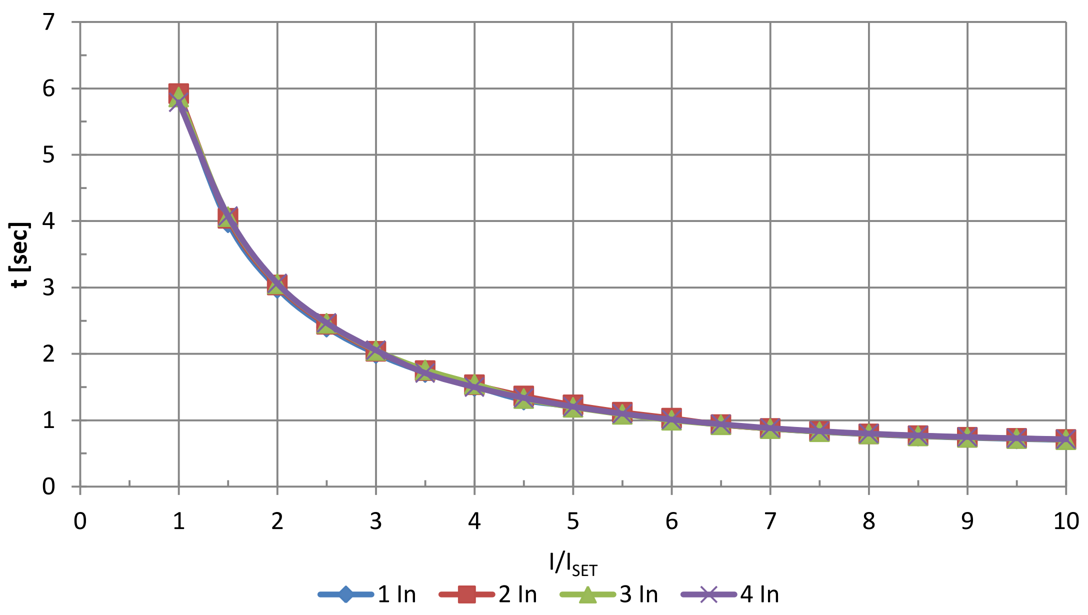


Figure 3-9: AZT+ basic operating characteristic, phase current measurement, supplies from VTs and CTs (Parameter: I_{SET})

Figure 3-10 demonstrates the effect of time delay setting. The figure shows the basic setting, with no additional time delay (to), the setting of additional 2,5 s and additional 4,5 s. In case of dual power supply, the additional delay can be measured practically along the whole characteristic.

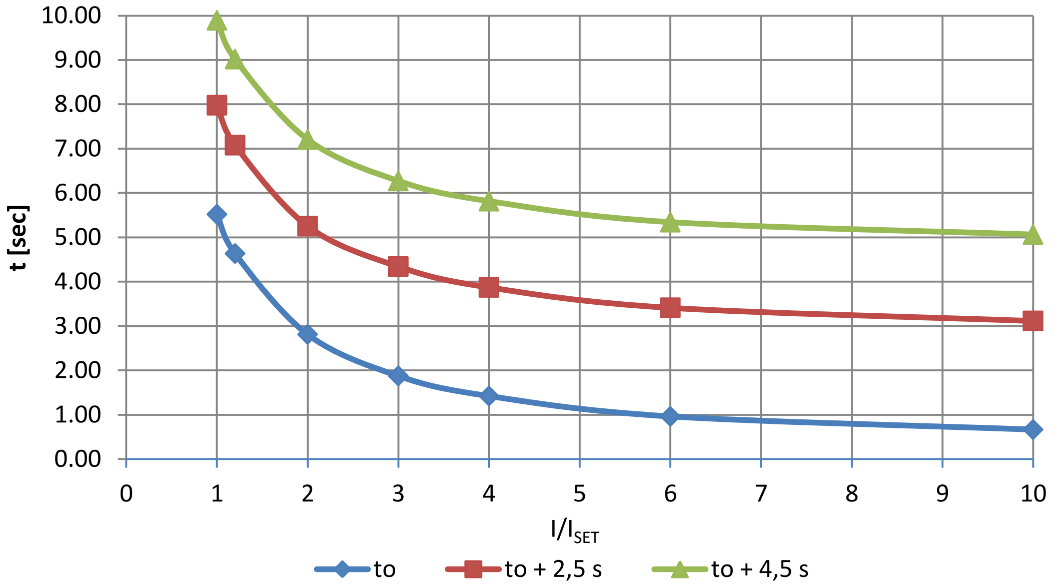


Figure 3-10: AZT+ operating characteristic, time delay setting, supplied from VTs and CTs (Parameter: time delay)

3.3.1.2 Power supply: CTs only

Figure 3-11 below shows the operating characteristics for 3 phase fault, if the power is supplied by CT only, VT power supply is not applied.

In absence of VT supply the normal load current of the network is not sufficient to keep the capacitors charged. At the moment of fault inception the capacitors need to be charged first, the measurement of the currents starts only after that. The trip command is generated if the capacitors are fully charged. This results an additional time delay, if the setting current is low (1 I_N) and the fault current is relatively low (in the range of 1 I_N – 2 I_N). When applying higher current setting (2 I_N and above), this additional time delay cannot be measured. If the operating times are compared with those with VT and CT supplied modes (*Figure 3-9*), the additional time delay is obvious if the setting current is low.

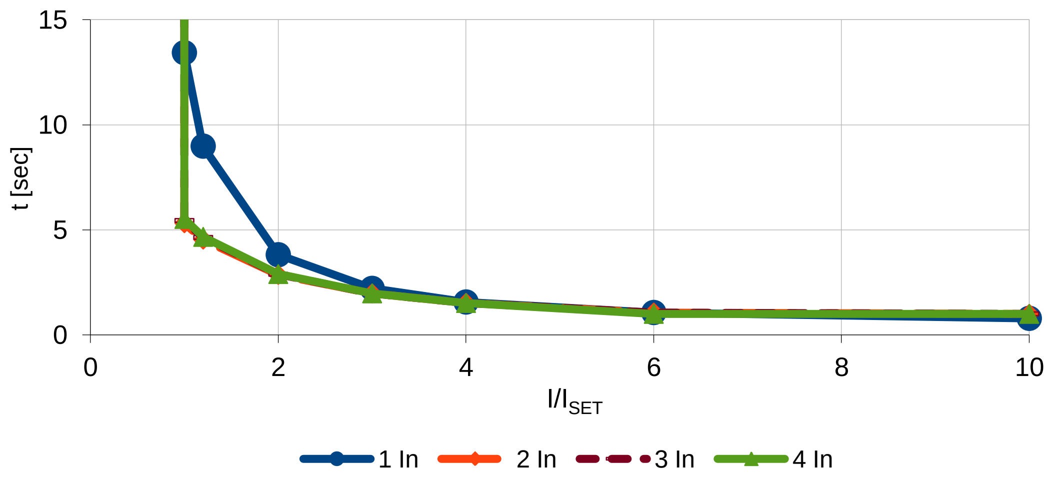


Figure 3-11: AZT+ operating characteristics, 3 phase current measurement, supplied from CTs only (Parameter: I_{SET})

Additionally, in case of single phase fault, the single current charges the capacitors slower than three currents with the same values. As a consequence, single phase and two phase faults are cleared with longer time delay than three phase faults, if the VT supply mode is not applied. *Figure 3-12* shows the changed characteristics. Do not forget however, that the function of the device is the last backup protection; this delay can be tolerated.

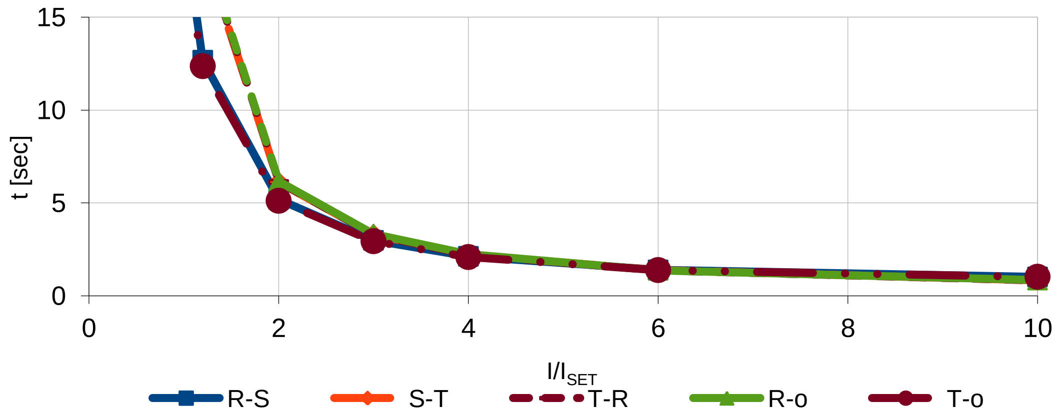


Figure 3-12 AZT+ operating characteristics, 2 phase and 1 phase current measurements, supplied from CTs only, I_{SET}= 1 I_N (Parameter: fault type)

Figure 3-13 demonstrates the effect of time delay setting. The figure shows the characteristic, without additional time delay (to), the setting of additional 2 s, 3 s and 4 s. In case of CT power supply only, the additional delay can be measured at higher fault currents only. This is due to the slow charging of the capacitors in case of low fault currents.

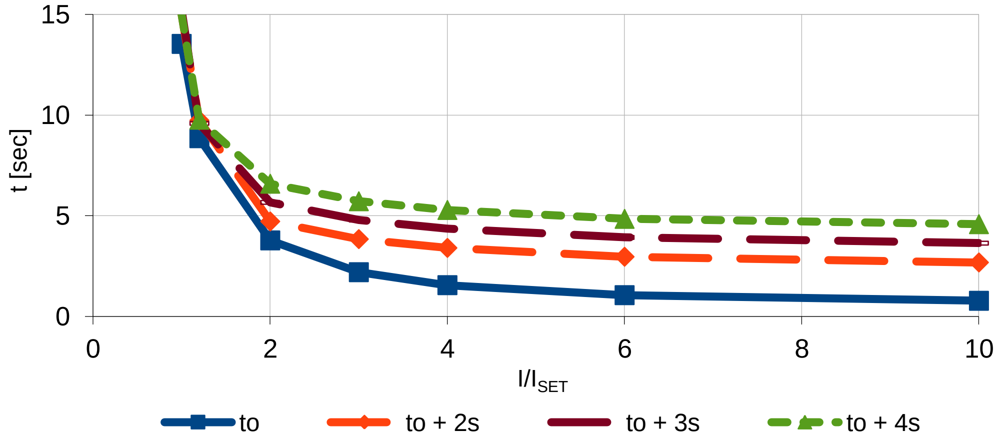


Figure 3-13: AZT+ operating characteristic, time delay setting, supplied from CTs only (Parameter: time delay)

3.3.1.3 Influence of the fault current magnitude if the power is supplied by CTs only

Figure 3-14 shows the operating characteristic measured for 3 phase fault, when the current setting is 0.5 I_N, 1 I_N, 1.5 I_N, 2 I_N. In case of low current setting (0.5 I_N) the operation starts only at 2*I_{SET} current value. As the interval below 2*I_{SET} cannot be used with settings (0.5 I_N) if only CT power supply is available, so this low setting is not recommended in this case.

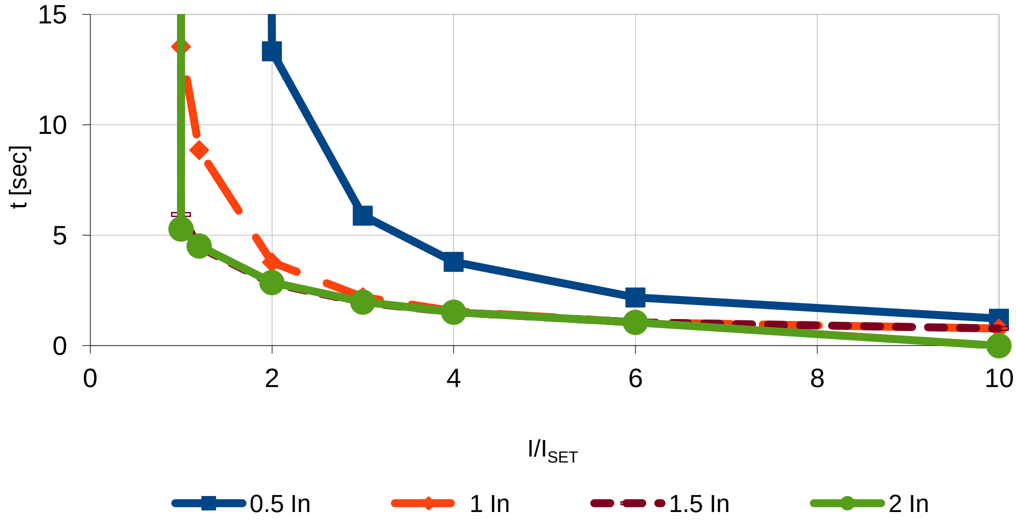


Figure 3-14: AZT+ operating characteristics, current measurement, supplied from CTs only (Parameter: I_{SET})

Figure 3-15 shows the operating characteristic measured for two phase and single phase fault, when the currents setting is 0.5 I_N. The basic characteristic is also shown.

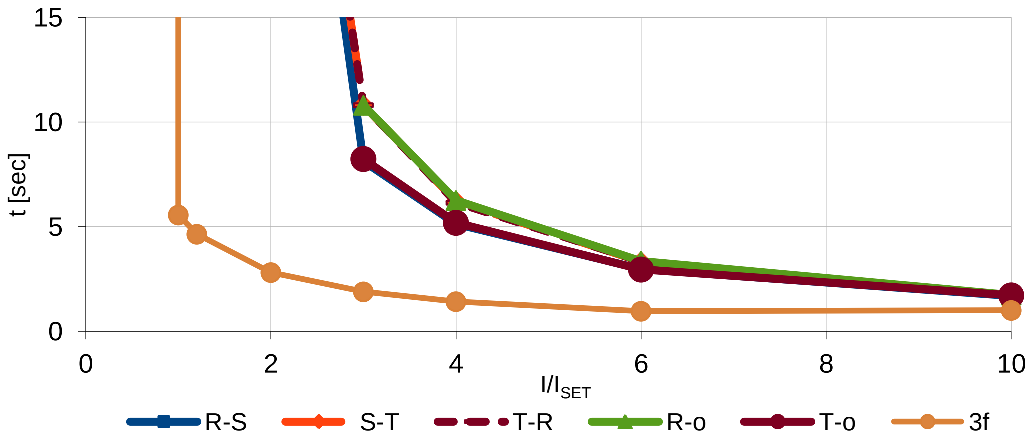


Figure 3-15: AZT+ operating characteristics, 2 phase and 1 phase current measurements, supplied from CTs only, I_{SET}= 0.5 I_N (Parameter: fault type)

In this case the small single phase fault current is not sufficient to charge the capacitors; the device can not generate the trip command. Consequently, if no VT supply is available, then current setting below 1 I_N is not recommended.

To avoid the problem, connect the VTs to the power supply input if possible. For the recommended setting see chapter *Setting*.

3.3.2 Operation with two phase currents

If the CT power supply is connected with two phase currents and also the VT power supply is applied also then there is no difference in the characteristics measured in case of asymmetrical faults. This is demonstrated in *Figure 3-16*.

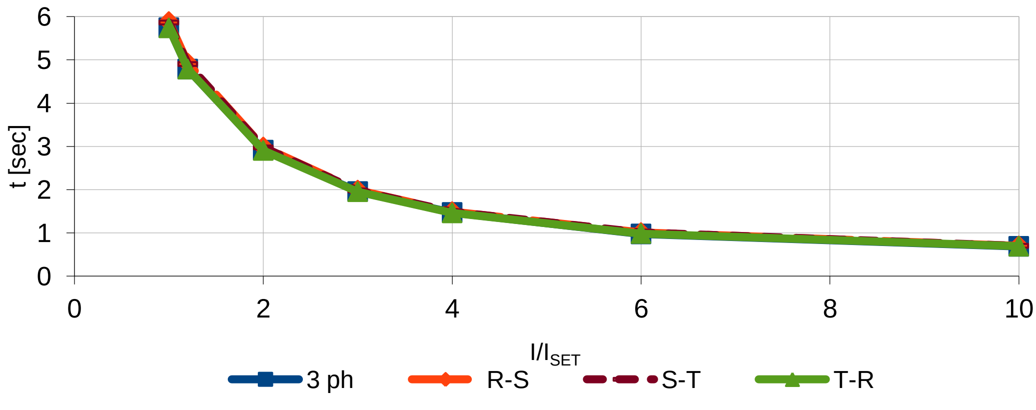


Figure 3-16: AZT+ operating characteristics, operation with two CTs, supplied also from VTs, I_{SET} = 1 I_N (Parameter: fault type)

If however, no supply from VTs is available, there are slight changes in the characteristics for asymmetrical faults. This is demonstrated in *Figure 3-17*. In case of T-R phase fault, there are two CT inputs to supply the charging of the capacitors. Accordingly the characteristic is the same as that in case of 3ph fault. For two-phase faults involving the S phase only one phase supplies the capacitors, the characteristics show a longer time delay due to the slower charging of the capacitors.

NOTE: Single phase faults are not considered here. In not solidly earthed networks, where only two CTs may be applied, the single phase faults do not result in high fault currents.

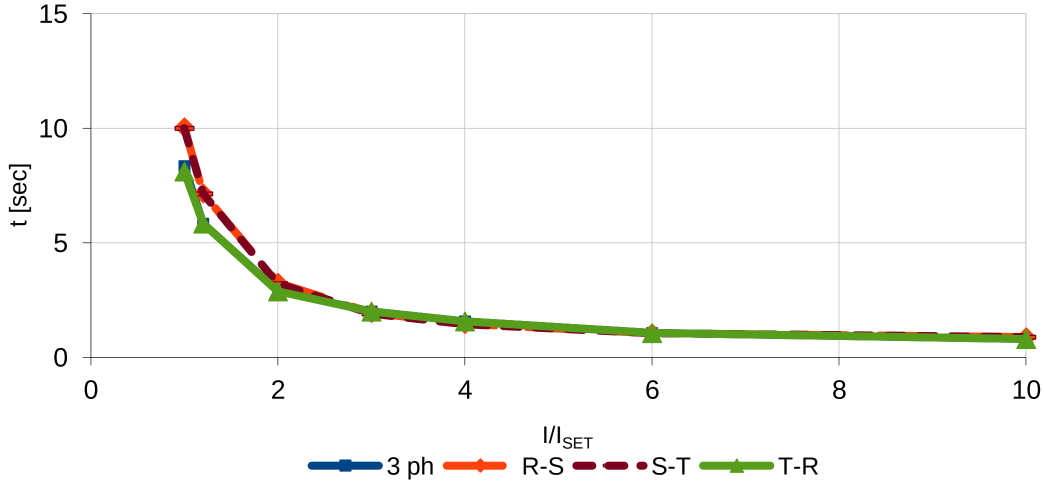


Figure 3-17: AZT+ operating characteristics, current measurement, operation with two CTs, supplied from CTs only, I_{SET} = 1 I_N (Parameter: fault type)

3.3.3 Operation with the residual current

3.3.3.1 The basic characteristics

The diagram of *Figure 3-2* shows the connection, when the residual current is connected to the device. This is considered as the energizing quantity of the overcurrent function.

Figure 3-18 shows the characteristic when the device has dual power supply, parallel from CTs and VTs.

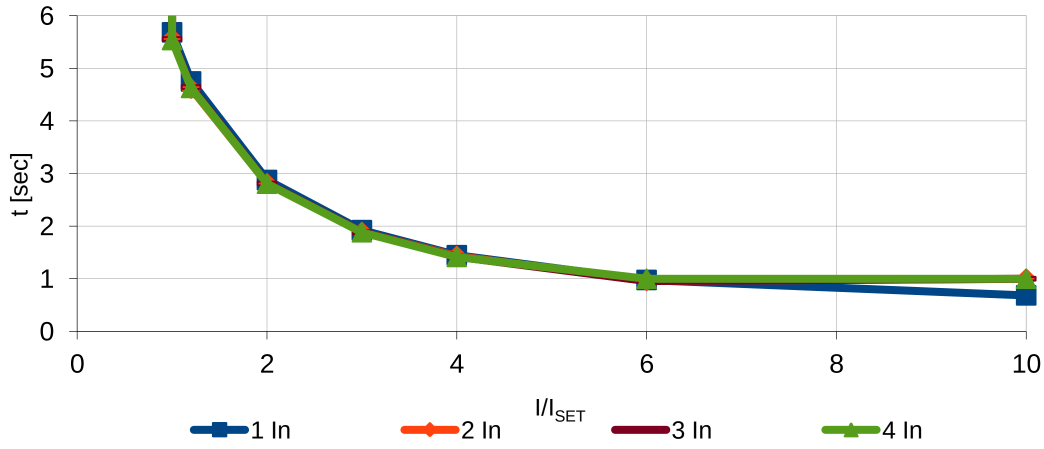


Figure 3-18: AZT+ operating characteristic, residual current measurement, supplied from VTs and CTs (Parameter: I_{SET})

Figure 3-18 demonstrates that the current threshold setting (1 I_N, 2 I_N, 3 I_N or 4 I_N as examples) does not change the characteristic, if also VT supply is connected.

Figure 3-19 below shows the operating characteristics, if the power is supplied by CT-only, VT power supply is not applied.

Under 1.5 I_N range the current is not sufficient to keep the capacitors charged, and cannot operate. When the current is higher than 1.5 I_N, first the capacitors need to be charged, the measurement of the currents starts only after that. The trip command is generated if the capacitors are fully charged. This results an additional time delay. If the operating times are compared with those with VT and CT supplied modes (*Figure 3-18*), the additional time delay is clearly visible.

Additionally the smaller single phase current charges the capacitors slower than the larger residual current. As a consequence, in the smaller current setting range the characteristic has longer time delay, if the VT supply mode is not applied. Do not forget however, that the function of the device is the last backup protection; this delay can be tolerated.

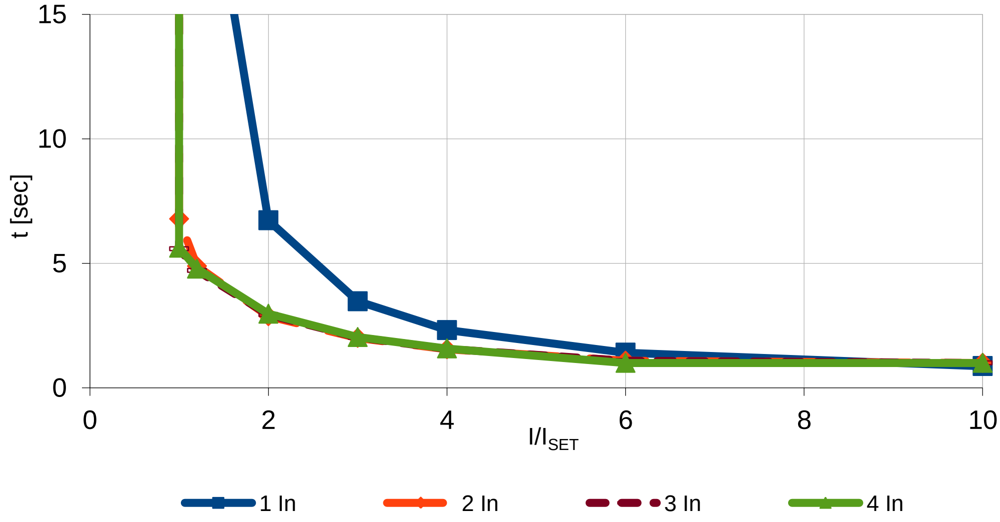


Figure 3-19: AZT+ operating characteristic, residual current measurement, supplied from CTs only (Parameter: I_{SET})

The distortion of the characteristic is more emphasized in case of extreme low current setting. *Figure 3-20* demonstrates the distortion also for I_{SET} = 0.5 I_N.

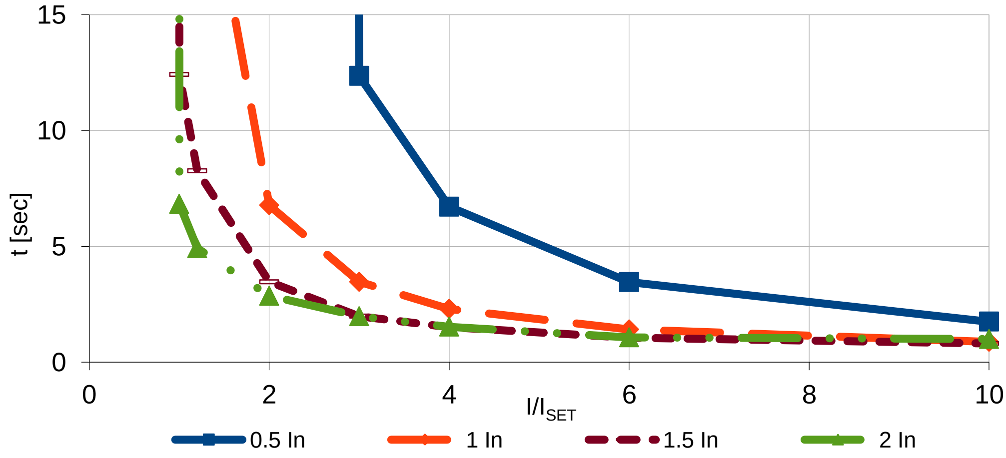


Figure 3-20: AZT+ operating characteristic, residual current measurement, supplied from CTs only (Parameter: I_{SET})

Because of the changes in the characteristics, the setting of low starting current values is not recommended if no VT supply is applied.

4 Setting

All the parameter setting operations must be carried out by suitably qualified personnel with adequate knowledge of the protected object and the device.

To perform setting of the IDMT characteristic, DIP switches are applied. For setting, open the top side of the box by screwing off the four screws at the corners of the lid.

Figure 4-1 shows the opened state of the box.

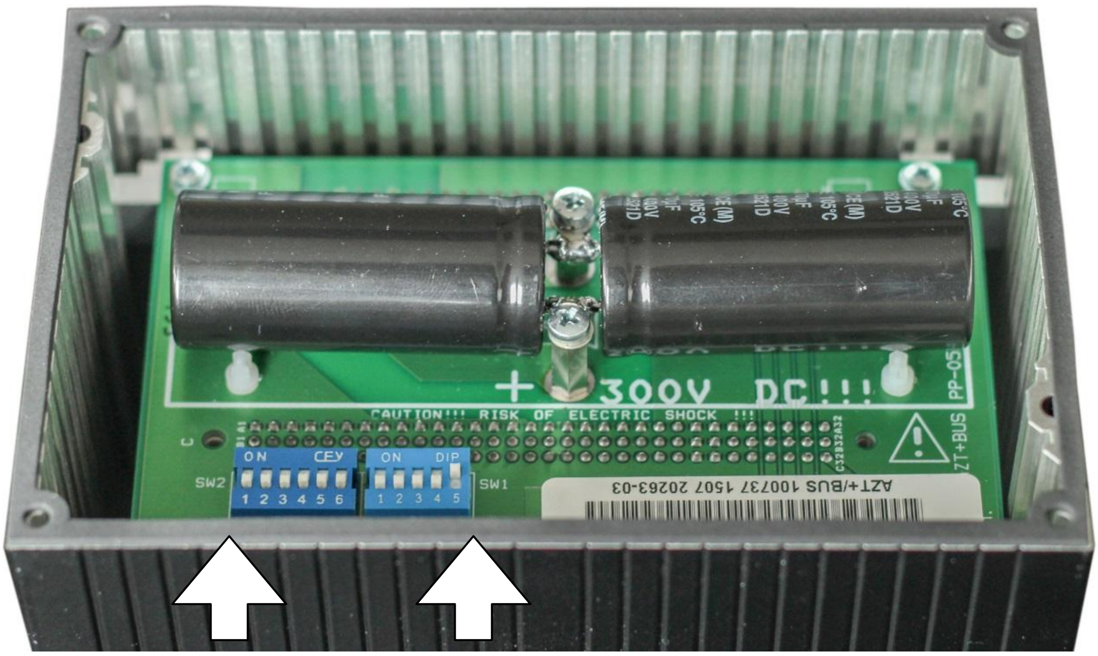
Hazardous voltages can occur during interruptions of secondary circuits of current transformers.
Interrupting the CT secondary circuits can resulting death, severe personal injury or substantial property damage.
Short-circuit the current transformer secondary circuits before current connections to the device are opened.

Caution!

Mind electrostatic discharges:
Non-observance can resulting minor personal injury or property damage.
In order to avoid electrostatic discharges when handling with plug connectors use antistatic wrist strap.
Do not plug or unplug interface connectors under voltage!

After de-energizing the device, the capacitors near to the DIP switches need some minutes to discharge.

The switches are marked on the PCB by SW1 and SW2. For the setting values see the setting table: *Table 4-1*.



SW2 SW1

Figure 4-1: AZT+ setting with DIP switches

The switch SW1 provides setting the additional time delay. Based on the settings of levers of SW1 DIP switch, the delay time as the function of the RMS value of the current "I" can be calculated with the formula below:

$$t = to(I) + \sum_{j=1}^{5} Sj$$

Where

to(I) is the time, according to the characteristics in 3.3.
I is the RMS value of the current,
j indicates the lever numbers of SW1
Sj is the value according to the *Table 4-1* for SW1 below.

The lever #5 of SW1 has a special role:

- In OFF position additional 0.5 s is added to the time,
- In ON position it changes the total added time to 0. This means that in its ON position the time delay is defined by the basic characteristic $to(I)$.

The switch SW2 provides setting the starting current I_{SET}. Based on the levers of SW2 DIP switch, the starting current can be calculated with the formula below:

$$I_{SET} = I_N + \sum_{j=1}^{5} Qj$$

Here

I_{SET} is the starting current RMS value
I_N is the nominal current of the device
j indicates the lever numbers of SW2
Qj is the value according to the *Table 4-1* for SW2 below.

The lever #6 of SW2 has a special role:

- In ON position the I_{SET} value calculated by the formula above is halved.

SW1 "j"		At values in "OFF" position "Sj"
1		0.5 s
2		1.0 s
3		2.0 s
4		4.0 s
5	OFF	0.5 s
	ON	$\sum = 0\ s$

SW2 "j"	At values in "ON" position "Qj"
1	$0.1\ I_N$
2	$0.2\ I_N$
3	$0.4\ I_N$
4	$0.8\ I_N$
5	$1.6\ I_N$
6	$\Sigma\ I_{SET} = ½ * I_{SET}$

Table 4-1: Setting table

The default values for the delivered device is set to its nominal current, furthermore the additional delay is set to zero.

Table 4-2 summarizes the lowest setting currents for different power supply modes with which the protection can operate on the whole current interval for all type of faults.

AZT basic connection:

Power supply mode	Allowed lowest setting I_{SET} min
CT + VT	0.5 In
CT only	1.5 In

AZT $3I_O$ connection:

Power supply mode	Allowed lowest setting I_{SET} min
CT + VT	0.5 In
CT only	0.5 In

AZT $3I_O$ reduced load current circuit connection:

Power supply mode	Allowed lowest setting I_{SET} min
CT + VT	0.5 In
CT only	1.0 In

Table 4-2: Allowed minimum setting (I_{SET} min) for the power supply modes

The effect of time delay setting is shown in *Figure 4-2*. The horizontal axis is scaled in p.u. where the reference value is the "I_{SET}" current setting value. It can be seen that the time delay value is an additional value, added to the un-delayed characteristic.

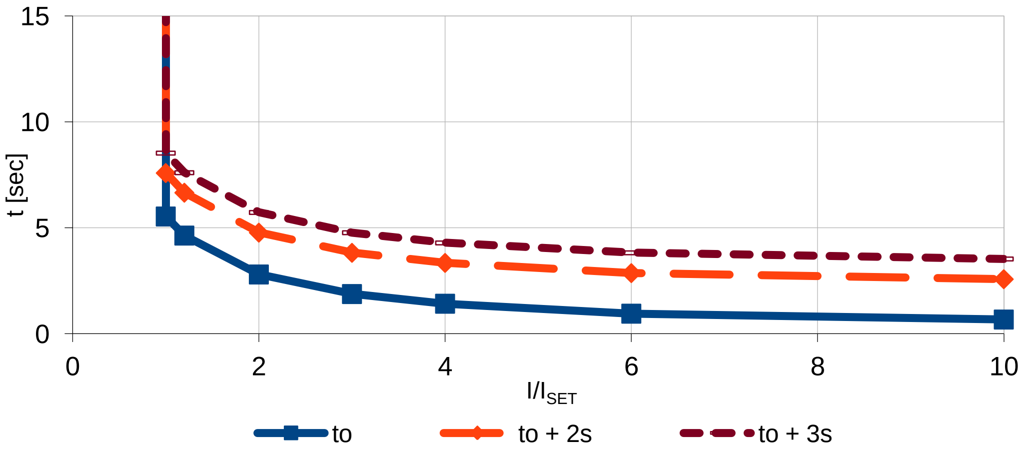


Figure 4-2: AZT+ time delay setting in CT+VT power supply mode (Parameter: time delay)

NOTE: If the power is supplied by the CTs only, for small fault current value the characteristics are slightly distorted, the additional time delay is applied to correct the distortion caused by slow capacitor charging. This is shown in *Figure 4-3* below.

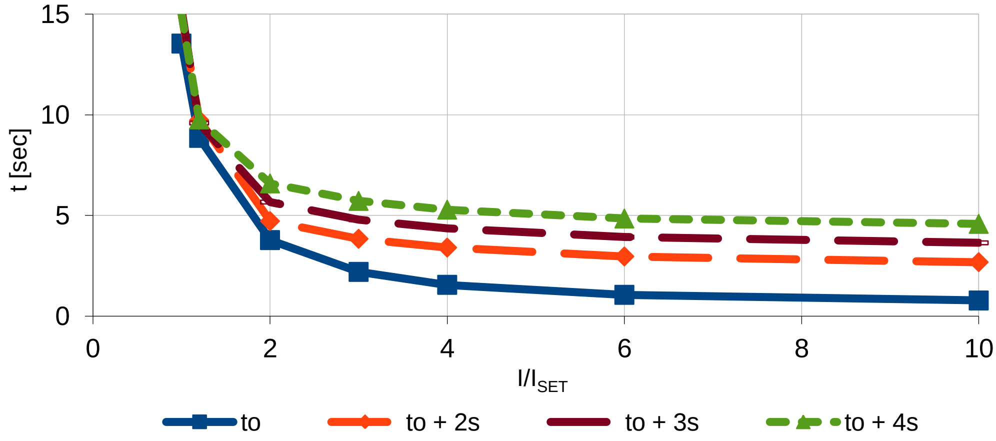


Figure 4-3: AZT+ time delay setting in CT power supply mode (Parameter: time delay)

Table 4-3 shows the typical test points for checking the compliance of the product for the full range of operation in CT+VT power supply mode.

Test points:	Tripping time [sec]:
1 I_N	6,00
2 I_N	3,06
4 I_N	1,57
6 I_N	1,07
10 I_N	0,75

Table 4-3: Typical test points

5 Application of the ancillary functions

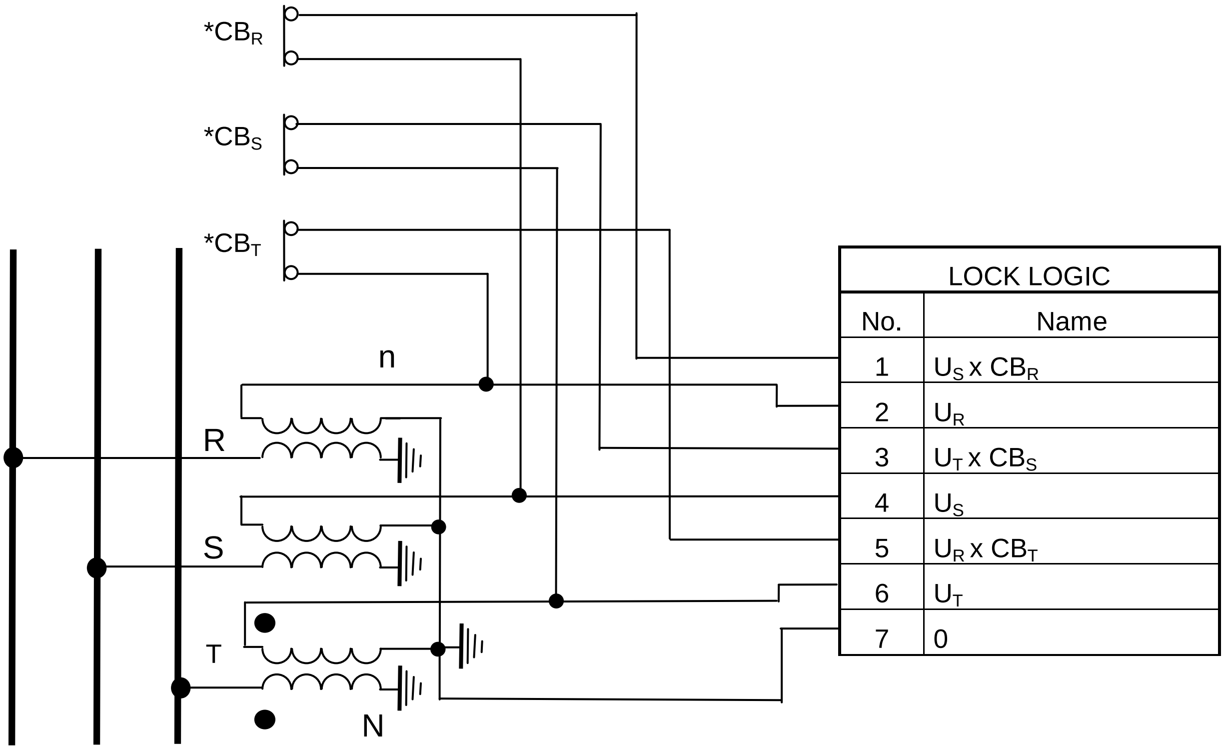
The AZT+ device provides some useful ancillary functions connecting to the backup IDMT overcurrent protection function. The application of these functions is described in this chapter.

5.1 Blocking in single-phase open mode of the protected power network

If the AZT+ device is energized with the residual current (See *Figure 3-2*) then this function supports selectivity of the protection.

In some emergency situations, if the solidly grounded three-phase network operates with one phase of the circuit breaker open, or during the dead time of the single phase reclosing, the parallel (Holmgren) connection of the CTs delivers residual current. This measured current may cause protection function operation and the result would be an unwanted trip command.

To prevent this unwanted trip command a special logic is applied. This needs the connection drawn in *Figure 3-2*, and this is repeated in *Figure 5-1*.



** Auxiliary contact belongs to open state of the CB.*

Figure 5-1: Blocking connection

In normal operation, i.e. if all the three phase voltages are present, the logic blocks the operation of the protection function. If a single phase to earth fault cause one phase voltage to break down, the logic enable the protection function. When the circuit breaker opens its contact in that phase, its normally open auxiliary contact connects one of the healthy phase voltages to the blocking system and the protection function is blocked again. In case of fault in another phase, that phase voltage will be broken down as well, and the logic enables the protection function.

The SPECIAL LOGIC BLOCK status is also indicated by the dedicated LED on the front panel of the device “LOCK LOGIC”.

NOTE: In healthy 3 phase symmetrical voltage state the LED on the front panel is going to be active.

5.2 Checking the state of the capacitors

The operation of the device is highly dependent on the state of the internal capacitors. If their capacitance decreases, the stored energy also decreases, and it can get insufficient to operate the circuit breakers. To prevent this, the state of the capacitors is continuously (practically in every 3.5 - 4 s) checked by internal electronic circuits. The capacitor is partly discharged through a resistor and the time-constant of the decaying process is measured. The aged capacitor is characterized by a decreased time constant. If this is detected then a warning LED “C<” indicates the error state on the front panel of the device and the fault relay drops. The electrolytic capacitors, which can dry out causing this problem, can be substituted by an external capacitor unit, described in chapter *5.4* below.

NOTE: The LED “C<” signal has about 10 s time delay. After that time, if the internal capacitors are not fully charged, the signal indicates this “not ready” state.

NOTE: In CT power mode the normal load current is not sufficient to charge the capacitors. In this case the warning LED “C<” will indicate the error.

5.3 Trip circuit supervision

The operation of the device is highly dependent on the health of the trip circuits. If any of the trip circuits is broken, the trip cannot be performed. To prevent this, the trip circuits are continuously monitored by injecting a small current into the circuit. In case of lack of this current, the device is inoperable. This state is indicated by the missing “READY” LED light and by triggering the fault contact.

5.4 Capacitor options

In the basic configuration the device operates with external long life film capacitors. This unit is housed in a separate box. These external capacitors are connected to the main unit as it is shown in *Figure 5-2*.

The device can be ordered with electrolyte capacitors instead of the long life film capacitors. The benefit of this layout is that the electrolyte capacitors take place inside the device, but these their aging effect has to be taken into consideration. The aging is monitored by the capacitor supervisor, as chapter *Checking the state of the capacitors* shows.

Caution!

The connectors of the internal and external capacitors may never be interconnected with each other, if the device is connected to CTs and/or VTs.

After disconnection of the device from all of the power sources, the capacitors remain in charged state for a few minutes. Be sure to leave enough time for the capacitor to discharge before any operation is performed on the device. For discharge time see *Table 7-3*.

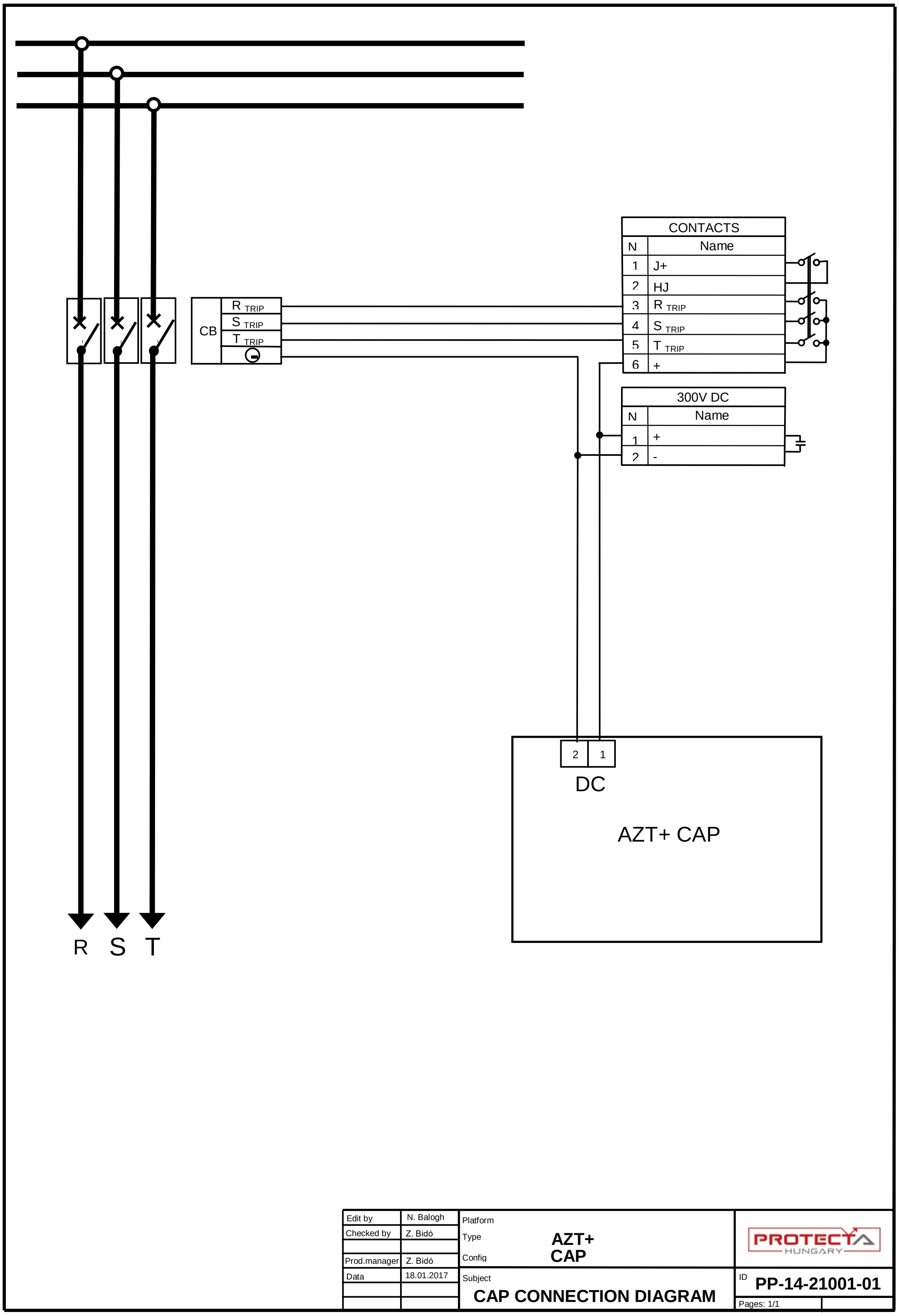
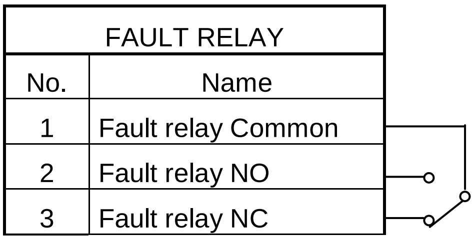


Figure 5-2: Connecting the external capacitor unit

5.5 Signaling the healthy/faulty state of the device

The internal fault relay is energized only if the self-supervision detects healthy state.



FAULT RELAY	
No.	Name
1	Fault relay Common
2	Fault relay NO
3	Fault relay NC

Figure 5-3: Connecting the healthy/faulty state indication

The internal fault relay is drops at any of the following conditions:

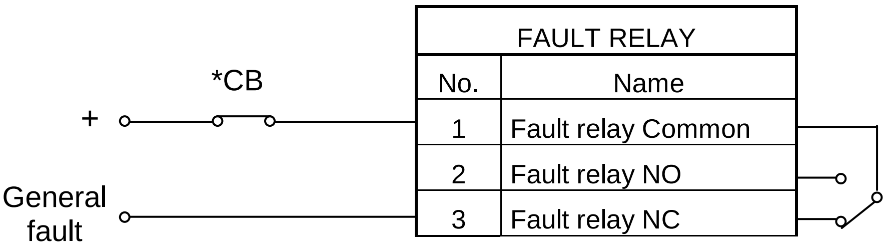
- The device is not connected to live power source.
- The voltage of the internal capacitor is below the level required to trip the circuit breaker.
- The CB circuit supervision logic detects broken trip circuit.
- The capacitor supervision logic detects capacitance failure.

In this faulty state the protection is not operable. The control system should generate an alarm state in the substation, and the cause of the error should be repaired by the service personal.

If the bay protected by the device switched off, the device is not supplied. Thus, the fault relay drops despite the device being healthy.

5.5.1 Alternative connection of fault relay

If the fault relay is wanted not to drop when the bay is switched off, we recommend the alternative connection of the fault relay. In this connection mode the “+” is connected to the fault relays common through the circuit breaker normally close auxiliary contact. This connection is shown in **Auxiliary* contact belongs to closed state of the CB.
Figure 5-4.



FAULT RELAY	
No.	Name
1	Fault relay Common
2	Fault relay NO
3	Fault relay NC

**Auxiliary contact belongs to closed state of the CB.*

Figure 5-4: Alternative connection of fault relay

5.6 Signaling the trip commands

If the AZT+ device generates a trip command, this indicates that the main protection system is not operable. The control system should generate an alarm signal in the substation, and the cause of the problem should be fixed by the service personal. The connection of the signal relay is shown in *Figure 5-5*. The applied contacts are 1-2.

CONTACTS	
No.	Name
1	J+
2	HJ
3	R_{TRIP}
4	S_{TRIP}
5	T_{RIP}
6	+

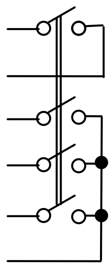


Figure 5-5: Trip command signaling with contacts 1-2

5.7 Counters

The device is configured with two counters in the front panel.

- START counter: counts the started states of the device.
- TRIP counter: counts the trip commands of the device.

5.8 LED indications

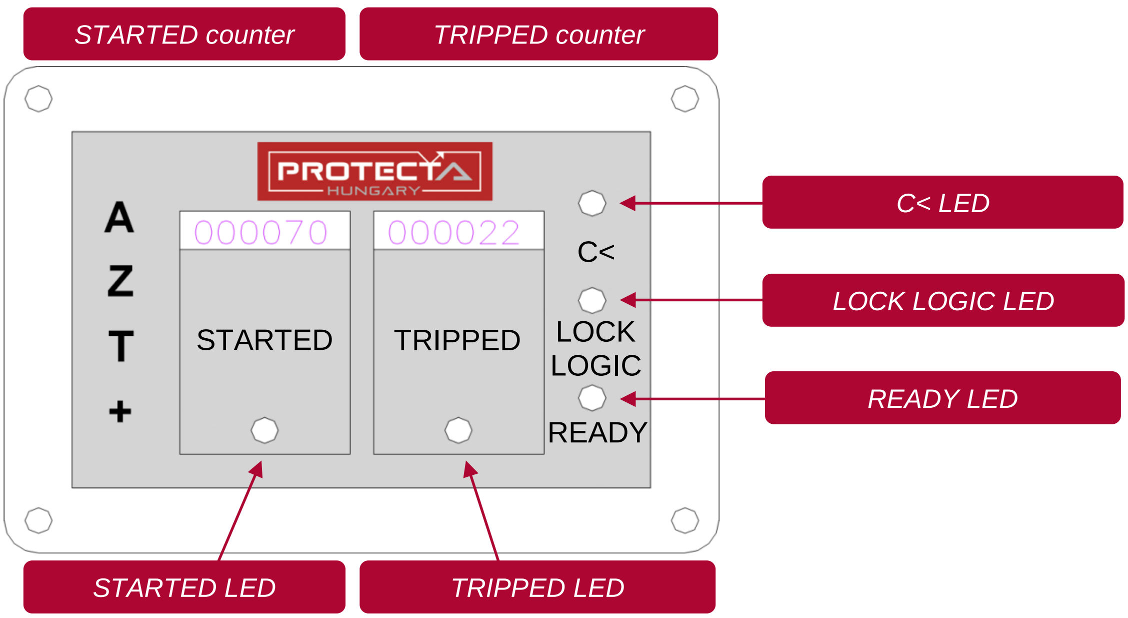


Figure 5-6: LED-s on the front panel of the device

Table 5-1 lists the explanation of the LED signals.

LED	Meaning
LED C<	The self-diagnosis of the device detected aged capacitors, the charge may not be sufficient to trip the circuit breaker. Replace capacitors.
LED LOCK LOGIC	In zero sequence overcurrent protection application, the function can be blocked (See ** Auxiliary* contact belongs to open state of the CB. Figure 5-1 and the related explanation).
LED READY	The capacitor is charged, the device is ready for operation.
LED STARTED	This LED indicates started state of the protection function.
LED TRIPPED	This LED indicates the trip command of the protection function.

Table 5-1: LED-s on the front panel of the device

6 Sizes, mounting

6.1 Sizes

Figure 6-1 shows the sizes of the device. The external capacitor bank has the same external dimensions as the AZT+ device.

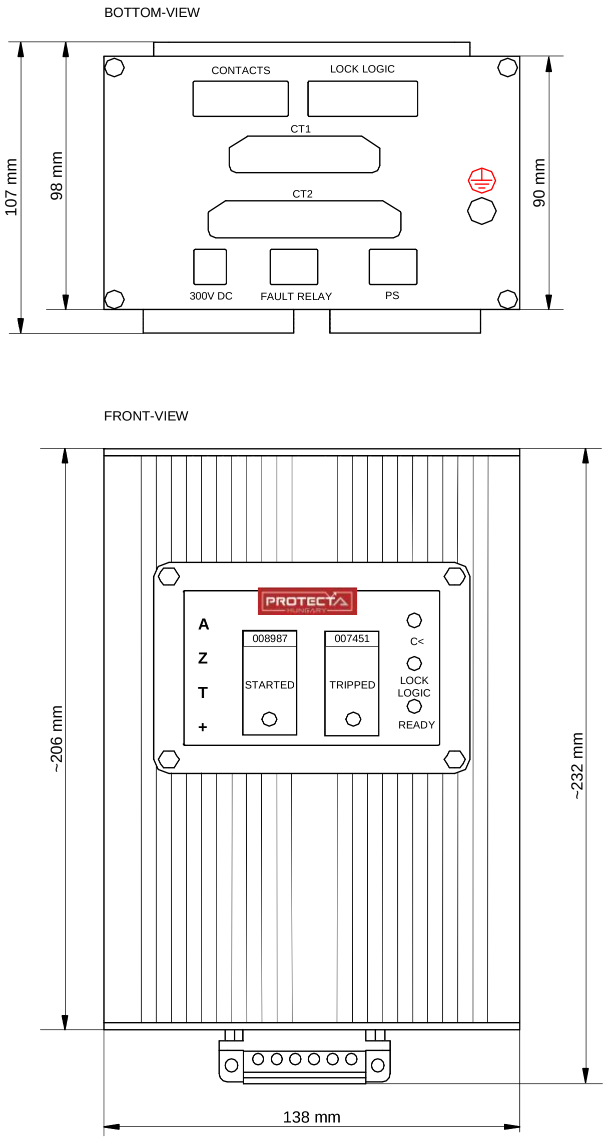


Figure 6-1: Sizes of the device

6.2 Information for safety

Non-observance of the proposed transport, storage, installation, and application of the device can resulting in death, personal injury or substantial property damage.

Trouble free and safe use of this device depends on proper transport, storage, installation, and application of the device according to the warnings in this instruction manual.

Particular importance has to be given to the general installation and safety regulations for work in a high-voltage environment (for example, VDE, IEC, EN, DIN, or other national and international regulations). These regulations must be observed.

- Check that the installation spaces, segregations and ambient conditions are suitable for the device.
- Make sure that all the installation, commissioning and maintenance operations are carried out by suitably qualified personnel with adequate knowledge of the apparatus.
- Make sure that the requirements are followed during installation, service and maintenance.
- Check that the rated performance of the apparatus is not exceeded during service.
- Check that the personnel operating the apparatus have this instruction manual to hand, as well as the necessary information for correct intervention.

Consult the documentation to establish the nature of any potential hazard and any actions which need to be taken to eliminate or minimize this hazard.

On the site, the integrity of any protective conductor connections shall be checked before carrying out any other actions.

In the configuration manual identify the applied hardware elements, and in this description, find the requirements for the substation environments, e.g.

- ability to withstand transient overvoltage,
- the supply voltage or voltage range, the permitted fluctuation,
- frequency or frequency range,
- voltage and current rating of the equipment.

6.3 Instructions for commissioning

This chapter is intended for experienced commissioning staff. The staff must be familiar with the commissioning of protection and control systems, with the management of power systems and with the relevant safety rules and guidelines.

6.3.1 Packing and transport

There is standard packing for each device. This guarantees protection under normal transport and storage ambient conditions. For special transport or storage requirements, please contact PROTECTA.

There is no standard to cover the transportation of equipment between the manufacturer and the customer. However, PROTECTA ensures that the equipment is suitably packaged to withstand, without damage, reasonable handling and environmental conditions appropriate to the method(s) of transportation to the customer’s delivery address. The factory-packed device can be delivered in covered vehicles.

A visual inspection should be made by the customer to check that the equipment has not been damaged during transportation.

6.3.2 Checking on receipt

Upon receipt check that the apparatus is complete and that the nameplate data on the side of the device corresponds with the data specified in the order acknowledgement sent by PROTECTA.

Should any damage or irregularity be noted in the supply on unpacking, notify PROTECTA (directly or through the agent or supplier) as soon as possible and in any case within five days of receipt.

For any communication regarding the unit, always quote the SERIAL No. which can be found on the nameplate at the side of the device.

In each shipment the following documents are attached:

- DECLARATION OF CONFORMITY

This document declares that, based on the EU directives 2006/95/EC and 2004/108/EC, the electrical product is in conformity with the safety requirements listed in the directives above, and is complying with the following standards:

EN 60255-1,
EN 60255-26
EN 60255-27
IEC 60255-21-1,2,3,

- QUALITY CONTROL CERTIFICATE

This document declares that the delivered device is in full compliance with the following:

- Final tests according to the PROTECTA quality control instructions,
- Insulation test according to the EN 60255-27.

6.4 Storage

If the installation is not carried out immediately, the apparatus must be repacked using the original packing material. Should the original packing material no longer be available, store the apparatus in a dry, dust-free, covered area which is noncorrosive and has a temperature range between the temperatures for storage, declared in the technical data.

6.5 Installation

The equipment ratings, operating instructions and installation instructions shall be checked before commissioning.

Correct installation is of primary importance. The manufacturer's instructions must be carefully studied and followed. All the installation operations must be carried out by suitably qualified personnel with adequate knowledge of the apparatus.

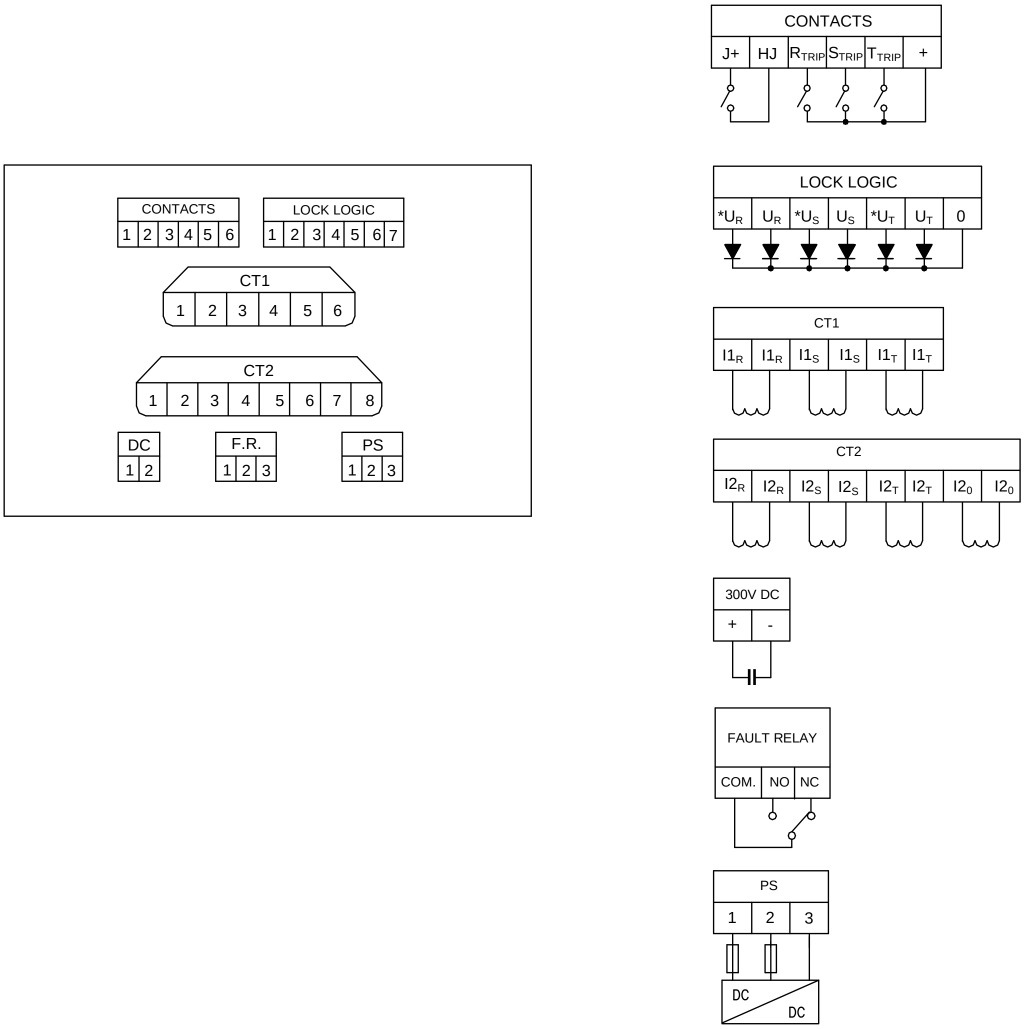
The box is designed to be mounted on OMEGA rail.

Figure 6-2: Back of the device

When mounting the device, please mind that the DIP switches for the setting are located inside the box. For changing the setting values, the top cover of the device must be opened. Leave enough clearance for this operation.

If it is not possible, after disconnecting the voltage- and current supply, the changing of the settings becomes available. Wait until the capacitor bank became discharged, than the setting can be made.

The connectors are located at the bottom of the device (*Figure 6-3*). When mounting the device, please mind that the wiring needs some clearance.



* *Signs the phase voltages connected through the* auxiliary contacts belong to open state of the CB.

Figure 6-3: Connector arrangement

6.5.1 Ventilation requirements

Do not mount heat dissipating equipment below the device. In case of doubt please contact PROTECTA.

6.5.2 Instructions relating to the protective earthing of the equipment

The grounding wire should be as short as possible, between the grounding connector of the device and the solid metal frame.

Recommended size of the grounding wire is at least 6 mm^2, made of copper.

The frame, especially the swinging parts should be carefully grounded.

Protective earth connections should not be removed when the equipment is energized.

6.5.3 Wire type, size and rating necessary for correct installation of the equipment

The applicable wire cross-sections for different types of modules (power supply, CT input, VT input, Trip relays, signal contacts, etc. are described in *Table 6-1*.

Connector type	**Stripping length [mm]**	**Conductor cross-section[mm^2]**	**Conductor diameter [mm]**	**Tightening torque [Nm]**	**Minimum bend radius***
VT Bin. output	7	0.2 – 1.5 solid: 0.2 – 2.5	0.5 – 1.4 solid: 0.5 – 1.8	0.4 – 0.5	3 × OD**
CT	9	2.5 – 4	1.8 – 2.3	0.5 – 0.6	3 × OD**

** Bend radius is measured along the inside curve of the wire or wire bundles.*
*** OD is the outer diameter of the wire or cable, including insulation.*

Table 6-1: Wiring

The tightening torque of the screw for protective earth connection and the wall mounting must be approx. 5 Nm. The tightening torque of the screw for fastening the STVS connector must be approx. 1 Nm.

When arranging the wires, at least 30 mm space shall be left between the wires and the device. The configuration manual, related to the device also includes the wiring diagram.

6.6 Parameter setting

The method of parameter setting is described in chapter *Setting*.

6.7 Commissioning

During the commissioning procedure switching operations must be carried out. The tests prescribed require that they can be done without danger. They are accordingly not meant for operational checks.

Check that all the operations for commissioning are carried out by suitably qualified personnel with adequate knowledge of the apparatus.
Before commissioning, at least the test prescribed in the manuals of the user must be carried out.

6.8 Testing

Primary tests may only be carried out by qualified persons who are familiar with commissioning protection systems, with managing power systems and the relevant safety rules and guidelines (switching, earthing etc.). Non-observance of the measures can result in death, personal injury or substantial property damage.

For tests with a secondary test equipment ensure that no other measurement voltages are connected and the trip and close commands to the circuit breakers are blocked, unless otherwise specified.

NOTE: If parameters were changed for this test, they must be returned to their original state after completion of the test!

6.9 Instructions for use

It is the responsibility of the user to ensure that the equipment is installed, operated and used for its intended function in the manner specified in the manuals.

6.9.1 Operating instructions for the equipment

Before working on CT circuits, they must be short-circuited.

Warning of dangerous voltages when operating an electrical device

Non-observance of the following measures can result in death, personal injury or substantial property damage.

Only qualified people shall work on and around this device. They must be thoroughly familiar with all warnings and safety notices in this instruction manual as well as with the applicable safety steps, safety regulations, and precautionary measures.

Before making any connections, the device must be earthed at the protective conductor terminal.

Hazardous voltages can exist in the power supply and at the connections to current transformers, voltage transformers, and test circuits.

Hazardous voltages can be present in the device even after the power supply voltage has been removed (capacitors can still be charged).

After removing voltage from the power supply, wait a minimum of 10 seconds before re-energizing the power supply. This wait allows the initial conditions to be firmly established before the device is re-energized.

The limit values given in Technical Data must not be exceeded, neither during testing nor during commissioning.

6.9.2 Calibration

The AZT devices are factory calibrated. During their lifetime they do not need any further calibration unless otherwise specified.

6.9.3 Maintenance

The equipment ratings, operating instructions and installation instructions shall be checked before maintenance.

Hazardous voltages during interruptions in secondary circuits of current transformers
Non-observance of the following measure will result in death, severe personal injury or substantial property damage.

Short-circuit the current transformer secondary circuits before current connections to the device are opened.

To ensure the safety of the preventative maintenance and inspection procedures please observe all measures described in operating instructions, especially recommendations relating to safety earthing and de-energization of the equipment, where applicable.

6.9.3.1 Maintenance of the capacitor

The capacity supervisor continuously checks the state of the capacitors, and if the capacity falls below a value, the “C<” LED will indicate it, and also the fault relay will drop, see chapter *5.2*. If the device supplied only by CTs, at the next maintenance event connect nominal voltage to the 1-2 connection of the PS voltage input for at least 5 minutes. This amount of time will be enough for the capacitor supervisor to check the state of the capacitors, and let the leakage current drop to its stationary value, so as not to disturb the measurement. If the “C<” LED is still active after 5 minutes of supply, the capacitor bank’s capacity is under the factory limit, and it is recommended to replace it.

The nominal voltage must be connected to the PS input.

6.9.3.2 Maintenance of the long life film capacitor

This is the default version for ordering. This type of capacitor bank normally doesn’t need any maintenance.

6.9.3.3 Maintenance of the electrolyte capacitor

The device has a version, in which the capacitor bank made of electrolyte capacitors instead of long life film capacitors (ordering option). These capacitors need periodic control after every 4 years. It is recommended to replace the electrolyte capacitor bank after 12 years. For replacement contact Protecta Ltd.

6.9.4 Troubleshooting

LEDS					CONNECTIONS		Explanation
C<	LOCK LOGIC	READY	STARTED	TRIPPED	300V DC	Voltage transformer circuit	
Active							In case of external capacitor unit, please check the connection between the device and the capacitor unit. If the connection is proper, the capacitor unit is aged, and it has to be replaced. In case of internal capacitor unit, the unit is aged, and it has to be replaced.
	Not Active					Connected, and the voltages are healthy.	If the Lock Logic is properly connected, then one of the phase voltage is not healthy, and the circuit breaker is switched off in another phase.
		Not Active			Charged	Connected, and the voltages are healthy.	Check the continuity of the trip circuit. If it is healthy, the device has broken, please contact Protecta Ltd.
		Not Active			Not charged	Connected, and the voltages are healthy.	The device has broken, please contact Protecta Ltd.
		Not Active			Not charged	Not connected	There is no enough current in the CT circuit to operate the device.
		Active			Not charged	Connected, and the voltages are healthy.	The device has broken, please contact Protecta Ltd.
			Active		Charged	Connected, and the voltages are healthy.	The current is higher than the starting current. If the device does not trip within 10 seconds, the device has broken, please contact Protecta Ltd.
			Active		Not charged	Connected, and the voltages are healthy.	The device has broken, please contact Protecta Ltd.
			Active		Not charged	Not connected	The current is higher than the starting current. If the device does not trip within 30 seconds, the device has broken, please contact Protecta Ltd.
			Active		There is voltage, but less than 300V		The current is higher than the starting current. If the device does not trip within 30 seconds, the device has broken, please contact Protecta Ltd.
		Not Active	Active	Active	Charged		The current is higher than the starting current and the device is tripping. Check the continuity of trip circuit continuity. If it is healthy, the device has broken, please contact Protecta Ltd.

If you find an error what is not in the previous table, please contact Protecta Ltd.
https://buy.protecta.hu/support/

6.9.5 Subsequent safe decommissioning and disposal

It is assumed that access to the equipment during decommissioning is restricted to users aware of working procedures necessary to ensure safety.

6.10 Documentation related to equipment type tests and routine testing

Documentation relating to equipment type tests and routine testing are available at Protecta at request.

7 Technical specification

7.1 Technical data

Rated current, In	1 A / 5 A (ordering option)
Rated voltage, Un	100 V AC / 200 V AC (ordering option)
Rated frequency	50 Hz (60 Hz for special ordering)
Thermal overload capacity Current circuits, thermal — Continuous 1 s Dynamic limit for 20 ms	 1.2 In 50 In 100 In
Overload capacity Voltage circuits	 1.2 Un
Overcurrent relay (I>) setting range (preferred for power supply from CTs only)	(0.5 … 4.1 I_N) (1.5 … 4.1 I_N)
Overcurrent relay reset ratio	< 0.85
Overcurrent relay accuracy (using VT power supply)	± 5 %
Power consumption in current transformer circuits	See chapter 7.2
Rated voltage of the circuit breaker operating coil	220 V DC
Output relay contacts Maximum switching voltage Continuous load current Rated making current Breaking capacity, at 220 V DC At conductive load L/R= 40 ms load Mechanical endurance	 400 V 8 A 15 A 0.25 A 0,1 A 10×10^6 cycles
Rated operating temperature range	-40 °C … +65 °C
Rated storage temperature range	-40 °C … +65 °C
Insulation tests	IEC60255-27
Electromagnetic compability tests	IEC60255-26 Zone A
Rated trip output voltage	300 V DC ± 5 %
Capacitance of the storage capacitor banks Electrolyte capacitor bank Long-life capacitor bank	 640 µF ± 10 % 550 µF ± 10 %

Table 7-1: Technical data

Weight:	AZT+ External capacitor unit	2.3 kg 1.7 kg
IP protection	From top and sides: From bottom:	IP54 IP2x

Table 7-2: Mechanical data

Discharge times of electrolyte capacitors* to 50 V to 30 V	 110s 150s
Discharge times of long-life capacitors* to 50 V to 30 V	 80s 100s

** Data valid for fully connected state of the device*

Table 7-3: Capacitor discharge times

7.2 Current transformer burden

The highest current transformer burden values are showed in the following table. These values can be measured in residual overcurrent application (see *Figure 3-5*).

7.2.1 1 A rated current

Supplied from CTs only		
I [A]	U [V]	Z [Ohm]
0.5	17.87	35.73
0.6	17.75	29.58
0.7	18.09	25.85
0.8	18.50	23.12
0.9	18.85	20.94
1	19.14	19.14
2	22.49	11.25
3	24.70	8.23
4	27.04	6.76
5	28.03	5.61

Supplied from VTs and CTs		
I [A]	U [V]	Z [Ohm]
0.5	2.08	4.16
0.6	2.43	4.05
0.7	2.77	3.96
0.8	3.12	3.90
0.9	3.53	3.92
1	4.05	4.05
2	7.75	3.87
3	12.02	4.01
4	15.78	3.95
5	19.54	3.91

7.2.2 5 A rated current

Supplied from CTs only		
I [A]	U [V]	Z [Ohm]
2.5	3.79	1.52
3	4.08	1.36
3.5	4.23	1.21
4	4.29	1.07
4.5	4.30	0.96
5	4.46	0.89
10	5.33	0.53
15	6.03	0.40
20	6.24	0.31
25	6.65	0.27

Supplied from VTs and CTs		
I [A]	U [V]	Z [Ohm]
2.5	0.46	0.18
3	0.55	0.18
3.5	0.65	0.18
4	0.75	0.19
4.5	0.85	0.19
5	0.91	0.18
10	1.85	0.18
15	2.87	0.19
20	3.71	0.19
25	4.68	0.19

8 Ordering options

8.1.1 Rated current

The nominal value of the current transformers. 1A and 5 A options are available. It is recommended to order the device with the same ratings.

8.1.2 Rated voltage

The nominal value of the voltage transformers. 100 V and 200 V options are available. It is recommended to order the device with the same ratings.

8.1.3 Capacitor bank

Internal or external bank options are available. For more information, see chapter *5.4*

8.1.4 Ordering

Protecta products can be ordered by using an Order Code. This code specifies the hardware configuration. Please **always** refer to a valid Order Code when placing an order.

The Order Code page available at https://buy.protecta.hu/ordercode/