User Guide
smartCOUNT

We make every effort to develop this product further. You will therefore appreciate that we reserve the right to change the scope of delivery at any time in respect to the layout, design and technology.

The manufacturer can only assume responsibility for the safety-related properties of the equipment in accordance with the statutory regulations, if the maintenance and service work as well as modifications are carried out by the manufacturer itself or by duly authorized persons who act in accordance with the manufacturer´s instructions.

The purpose of these statements in the installation instruction is to describe a technique of installing this product orderly. Tridelta Meidensha GmbH has no influence over the surrounding conditions that may have effect at the installation of this product. The client is responsible to ensure that the technique of installation is suitable for his surrounding conditions. The obligation of Tridelta Meidensha GmbH lies exclusively on the general terms and business conditions. Tridelta Meidensha GmbH would not take any responsibility of damages, which may occur through coincidence, direct or indirect application of this product.

This symbol indicates an important information inside the document. Please read this information carefully and make sure, that everything was understood correctly to avoid mistakes.

This symbol indicates a safety related instruction inside the document. This instruction has to be followed mandatory to avoid injuries and damages.

Content

Warning!

⚠ Any work on surge arresters must only be carried out after the relevant lines have been isolated and earthed. Always observe the currently valid international and national safety regulations.

When in operation, the surge arrester is connected to the high-voltage lines. It must therefore be ensured that only suitably trained and qualified personnel can access the surge arrester during the installation work.

1. Overview

The **smartCOUNT System** is a state-of-the-art monitoring system for diagnosis of high-voltage surge arresters by means of impulse- and leakage current analyzation.
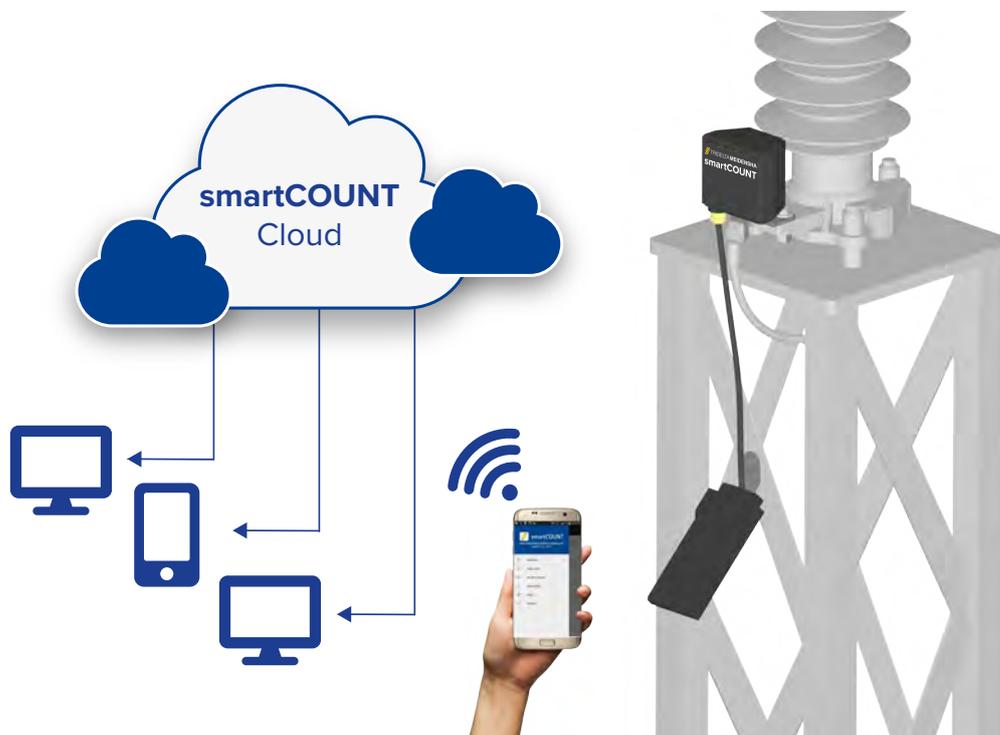
The **smartCOUNT System** is consists of:

- The **smartCOUNT Datalogger** for arrester data acquisition
- The **smartCOUNT Transponderpad** for downloading these data to a smartphone
- The **smartCOUNT Cloud** for calculation, visualization and evaluation of the measuring results.
- The **smartCOUNT App** to download the data via NFC with an Android smartphone

The downloaded data can be uploaded to the **smartCOUNT Cloud** and accessed by a browser. Alternatively, the data can be transmitted by USB cable from smartphone directly to a computer. Every **smartCOUNT Datalogger** contains a unique ID, which is forwarded together with each data record and which assigns the data records to the correct arrester.

- A **smartCOUNT Device** consists of 2 main hardware components:
   - **smartCOUNT Datalogger**
   - **smartCOUNT Transponderpad**
- The **smartCOUNT Transponderpad** comprises a data cable in available in different lengths.
- A smartphone with NFC is necessary to read out the arrester data.
- The **smartCOUNT Cloud** offers the best overview about the connected surge arresters and the according data

smartCOUNT Datalogger

smartCOUNT Transponderpad
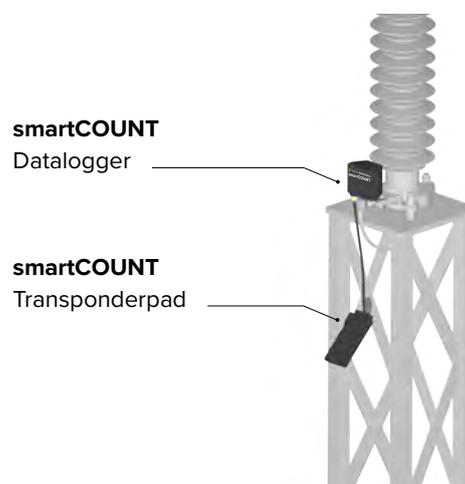
2. Installation Guide

The installation of the **smartCOUNT System** takes place in several steps which must be proceeded according to the following installation diagram. Please read the according sections of the User Guide to ensure that those steps are executed correctly.

```
        Start                                              Start
          │                                                  │
          ▼                                                  ▼
┌──────────────────────────┐                    ┌──────────────┐   no   ┌──────────────────────────┐
│ Install a smartCOUNT      │                    │ User Account  ├───────►│ Create user account      │
│ Datalogger                │                    │ existing?    │        │ Section 2.1.1            │
│ Section 2.3.2             │                    └──────┬───────┘        └──────────────────────────┘
└───────────┬──────────────┘                         yes │
            ▼                                             ▼
┌──────────────────────────┐                    ┌──────────────┐   no   ┌──────────────────────────┐
│ Install a smartCOUNT      │                    │ smartCOUNT    ├───────►│ Install the smartCOUNT   │
│ Transponderpad           │                    │ App installed?│        │ App                      │
│ Section 2.3.3             │                    └──────┬───────┘        │ Section 2.1.3            │
└───────────┬──────────────┘                         yes │              └──────────────────────────┘
            ▼                                             ▼
┌──────────────────────────┐                    ┌──────────────────────────┐
│ Install the data cable    │                    │ Login to smartCOUNT App   │
│ Section 2.3.4             │                    │ Section 2.2.2             │
└───────────┬──────────────┘                    └───────────┬──────────────┘
            ▼                                                 │
┌──────────────────────────┐                                 │
│ Charging the smartCOUNT   │                                 │
│ Datalogger                │                                 │
│ Section 2.3.5             │                                 │
└───────────┬──────────────┘                                 │
            └──────────────────────┬──────────────────────────┘
                                   ▼
                    ┌──────────────────────────────────────┐
                    │ Configure the smartCOUNT Datalogger   │
                    │ Section 2.2.3                         │
                    └───────────────────┬──────────────────┘
                                        ▼
                              ┌──────────────────┐
                              │ Upload Data       │
                              │ Section 2.2.6     │
                              └─────────┬────────┘
                                        ▼
```

→ smartCOUNT Device is configured and **ready to work**
→ A entry for smartCOUNT Device and the surge arrester was created in the smartCOUNT Cloud
It is recommended to check the correctness of the entry according to Section 2.2.3

Alternatively it is possible to connect the data cable of the **smartCOUNT Transponderpad** with the **smartCOUNT Datalogger** and to Charge and Configure the **smartCOUNT Datalogger** before installation on the surge arrester. This alternative installation procedure can be used, if the **smartCOUNT Datalogger** is not accessible after installation.
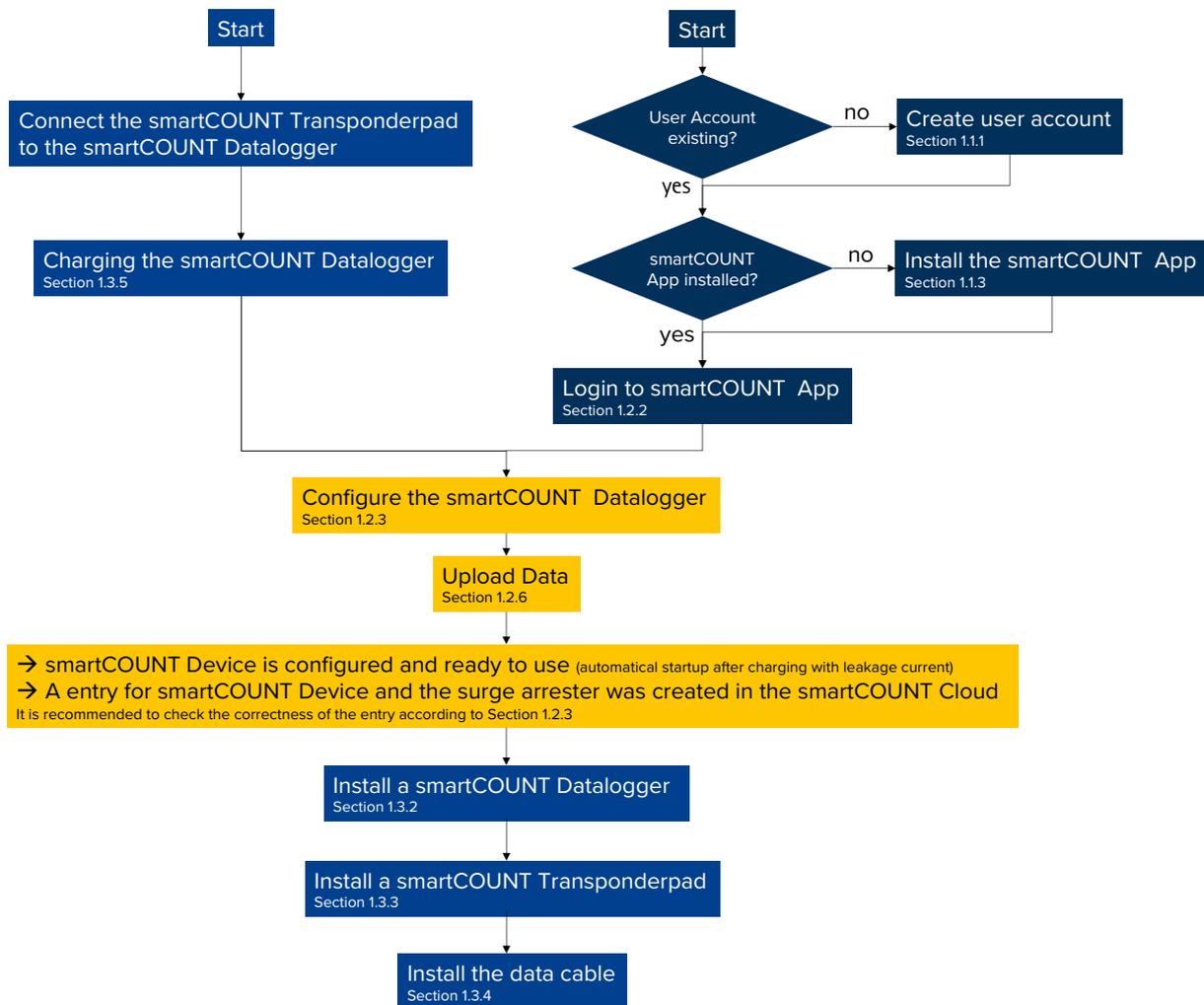
2.1. Preparations

2.1.1. Create a new user account

The **smartCOUNT System** offers the possibility of a secure, anonymous and flexible data management and simpli-fies the handling of arrester related data of the substation, a high-voltage line or of a whole fleet of surge arresters. It is necessary to create an online user account to use the full feature set of the **smartCOUNT System**.

Simply visit the **smartCOUNT Cloud**
https://smartcount.tridelta-meidensha.de
If the website is not available, read Troubleshooting code (A01).

If you haven't created a user account yet, click on "Register".

Login

User name	
Password	
	Login
	Send new password

In the following form, you have to enter your personal data. Username and password are necessary for the login in the smartphone App and to access the user account on the website later on. Your email address is mandatory to verify the authenticity of your user account. Therefor you will automatically receive an email with confirmation link. Your data will be encrypted and stored securely inside the **smartCOUNT Cloud**. At the end you will be asked for entering the "captcha", a random string of characters. The captcha is necessary for securing the website from spam and is mandatory for the registration process. If you can´t read the captcha clearly, refresh the page in your browser.

Registration

New User Name	Example
New Password	••••••••
Repeat Password	••••••••
New email Address	smartcount@tridelta-meidensha.de
Repeat email Address	smartcount@tridelta-meidensha.de
Enter following characters	npt9t
Privacy Policy	☑ I accept the terms of the privacy policy.
	Create account

All input fields are mandatory. Assign a personal user name at line „New User Name". It may happen, that your desired user name is already assigned to another user. In this case you have to choose another user name. Enter at least 6 symbols for a secure password at line "New Password" and repeat your input at "Repeat Password". Type in your desired email address at line "New email Address" and repeat your input at "Repeat email Address". Avoid copy and paste, enter your information manually to avoid mistakes. Click on "Create account" to submit your data. Always keep your registration data safely and easily retrievable. Your data will be submitted to the **smartCOUNT Cloud** and stored encrypted and secure.

You will now receive a confirmation email from the **smartCOUNT Cloud** within a few seconds. Open the email and click on the contained confirmation link. Don´t answer on this email. Your account will be activated immediately for usage. If you haven´t received a confirmation email, read Troubleshooting code (A02)

For more information about the smartCOUNT Cloud, read the 3.2 of the User Guide.

2.1.2. Selection of a suitable smartphone

The use of the **smartCOUNT System** requires a Smartphone for the purpose of data download, data management and data forwarding. The basic requirements for correct operation of the smartphone are:

- A smartphone with integrated NFC Module (the information can be found in the datasheet of the smartphone or can be asked from the manufacturer or dealer)
- Operating system Android 4.0 or later

2.1.3. Install the smartCOUNT App

Make sure to have the correct clock time set on your smartphone. The time from the smartphone is later used to set and correct the clock time on the **smartCOUNT Device**.

The **smartCOUNT App** is handling and transmitting the acquired arrester data. This App has to be installed on the smartphone previously.

a) Ensure there is enough free memory capacity on the smartphone. At least 100 Mbytes are required
b) Confirm the installation from unknown sources (if necessary) in your security configuration of the smartphone
c) Download App from **smartCOUNT** website
   1. Visit http://smartcount.tridelta-meidensha.de with your smartphone
   2. Login with your user account data (section 3.3.1).
   3. Click on "support" and click on the download link "**smartCOUNT App**"
d) Or Download the App by scanning the QR Code on the label of the **smartCOUNT Datalogger**
e) Or Download the App from Google Play Store by searching for "smartCOUNT"
f) Permit access to the required functions of your smartphone
g) Activate NFC in the communication settings of your smartphone

The app will be installed on your smartphone. It is recommended to create a shortcut on the main screen of the smartphone.

The installation of a new App version from other sources than the Play Store may require a deinstallation of the previous App version.

2.2. App handling

The **smartCOUNT App** will appear on a random place in your app screen of the smartphone or exactly there, where you drop the icon. Open the app by clicking on the **smartCOUNT** icon with Tridelta symbol.

smartCOUNT

2.2.1. Using the NFC Interface

The data exchange between the **smartCOUNT System** and the Smartphone takes place with Near Field Radio Communication which works over small distances of a few centimeters. Smartphones with NFC Function comprise an Antenna for the New Field Communication. This antenna is positioned inside on any spot of the backside of the Smartphone. The exact position of the antenna differs from Smartphone to Smartphone. Thus the positioning of the Smartphone on the **smartCOUNT Transponderpad** plays a role for a successful connection. Most Smartphones have a centric positioned NFC antenna; some might have it positioned eccentrically.

The **smartCOUNT Transponderpad** works with an approach mode, which generally works as follows:

    a)   Activate NFC data transmission on the **smartCOUNT App** (e.g. Single Shot)

    b)   Bring your Smartphone closer to the Transponderpad

    c)   NFC data transmission will be initiated between Transponderpad and Smartphone

Repeat this procedure to get a feeling of the sensitivity distance and the best positioning of the smartphone on the **smartCOUNT Transponderpad**.

a)   b)   c)

NFC data transmission will only be initiated by approaching the Transponderpad after activation of the NFC data transmission. It is recommended to position the Smartphone centric on the **smartCOUNT Transponderpad**, try to find the best positioning for your certain Smartphone. Do not deviate left, right, up or down during a connection, keep the Smartphone on the **smartCOUNT Transponderpad** until the data transmission is completed.

2.2.2. User Login

For full functionality of the data logging function and usage of the online data management, it is necessary to connect your smartphone to your user account. Proceed as follows:

- Open the main menu of the app (button top left ☰)
- Click on „Login“
- Enter your user name and password, which you have assigned before (section 2.1.1). Pay attention as the app distinguishes upper and lower case.
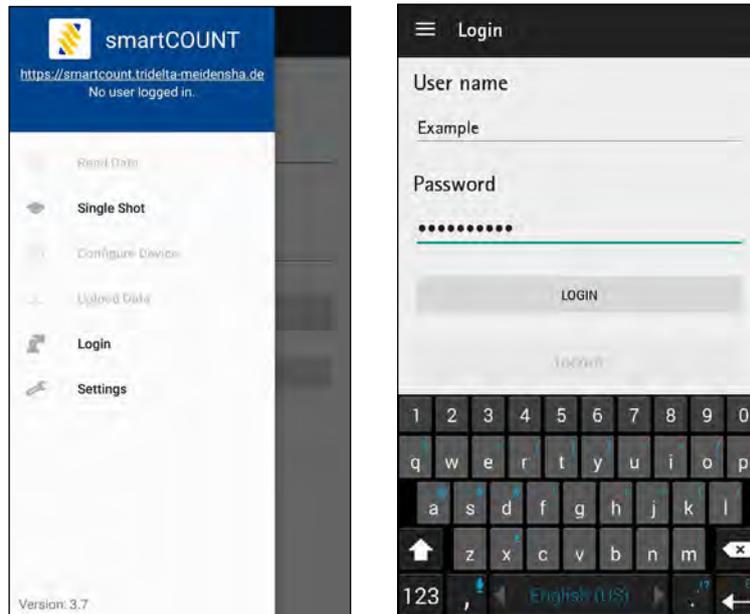
The **smartCOUNT App** will notify "Successfully logged in" if your smartphone has successfully been assigned to the account. The User Account will remain logged in after leaving the App but will be logged out by deinstalling the **smartCOUNT App** from the Smartphone.

If the App indicates an error, read Troubleshooting code (A03).

2.2.3. Configure the smartCOUNT Datalogger

After you have successfully logged in your user account to the smartphone, full functionality of the App is activated. The next fundamental step is to provide data about the surge arrester, where the particular **smartCOUNT System** is or will be mounted. Important measuring parameters are written in the **smartCOUNT Datalogger** as well. You can proceed this step in two different ways:

    a)   Before installation of the **smartCOUNT Device** on site

    b)   After installation of the **smartCOUNT** Device on site

In each case, the data cable must be connected (User Guide section 2.3.4) and the **smartCOUNT Datalogger** must be charged (User guide section 2.3.5)

Activate NFC, open the App and click on „Configure Device" in the main menu. Fill the form in the App as follows:

Choose manufacturer • Tridelta • Other Manufacturer	Choose manufacturer of the arrester, on which the **smartCOUNT Deviece** is installed Mandatory information
Site Berlin S/S 1	Type in the name of the city, area or substation (individual text and symbols) Optional information
Position Transf. 2	Type in the name of the transformer, bay or place (individual text and symbols) Optional information
Phase L1	Type in the name of the Phase (individual text and symbols) Optional information
Max. System Voltage Um (P-P) 420 kV	Choose maximum system voltage phase-phase (dropdown menu of IEC and ANSI voltages) Mandatory information
Tridelta Product Code 2313.6-0336.00	Type in the Product Code, if it is a Tridelta Arrester (numbers in fixed structure for example 2313.6-0336.00) Mandatory information in case of Tridelta Arrester
Type SBKC336	Type in the name of the Arrester (optional field - individual text and symbols) Optional information
Class	Choose the Arrester Class (dropdown menu of IEC Classes) Mandatory information in case of Non-Tridetla Arrester
Frequency 50 Hz	Choose the voltage frequency (dropdown menu 50Hz, 60Hz and 16,6Hz) Mandatory information
Uc [kV] 268,8	Type in the Continuous Operating Voltage of the Arrester (only Numbers – read from label) Mandatory information
Manufacturer Tridelta	Type in the Manufacturer (if different than Tridelta) (optional field - individual text and symbols) Optional information
Interval Options 1/week 11:00 AM Monday	Choose measurement interval - every hour - once a day at certain time (UTC) - once a week at certain day and time (UTC) Mandatory information
Set up	Confirm the filled form by pressing "SETUP" Afterwards put your smartphone on the **smartCOUNT Transponderpad** "successfully proceeded device setup" --> **smartCOUNT Device** is ready If the App indicates an error, read at Troubleshooting code (A04).

After configuring the **smartCOUNT Datalogger**, it starts recording cyclic leakage current measurements. The smartphone now contains the entered configuration data set of the according surge arrester. Now the configuration data set can be uploaded to the **smartCOUNT Cloud** by clicking on "Upload Data" in the main menu of the **smartCOUNT App**. Finally, a record in the Arrester Overview of the **smartCOUNT Cloud** is created. The configuration data set of a **smartCOUNT Datalogger** can be overwritten by repeating this process.

Arrester Overview

	ID	Site	Position	Phase	Max. System Voltage [kV]	Product Code	Type / Name	Uc [kV]	Class	Manufacturer	Date of Registration	Data available	Critical
🗑	394	Berlin S/S 1	Transf. 2	L1	242.4	2313.6-0366.00	SBKC336	268.8		Tridelta	04.09.2019	no	no

ⓘ The User Account which was used to configure the device will be the only User Account to which access via NFC will be provided subsequently. This feature allows highest data security of your **smartCOUNT Devices** in the field.

2.2.4. Read data

Depending on the chosen measuring interval, the **smartCOUNT Datalogger** will measure and permanently store leakage current data each hour / day / week. Impulse currents (lightning or switching overvoltages) will be recognized, measured and stored as well. Proceed as follows to read out these data sets:

    a)   Activate NFC transmission of Smartphone

    b)   Open **smartCOUNT App**

    c)   Click on „Read Data"

    d)   Put the Smartphone on the **smartCOUNT Transponderpad**

    e)   Wait until the App indicates a successful data download

If the App indicates an error, read at Troubleshooting code (A04).
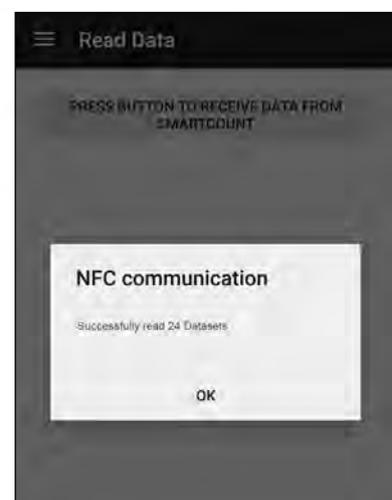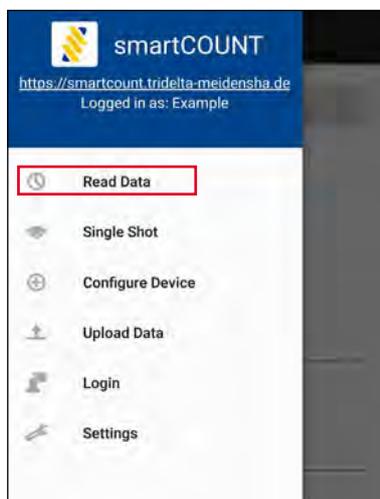
2.2.5. "Single Shot" function

The Single Shot function enables the user to perform an instant leakage current measurement with compensation of line voltage deviation. The input of the prevailing voltage reading (phase to earth) is required. Proceed as follows for performing a Single Shot:

    a)   Activate NFC transmission of smartphone

    b)   Open **smartCOUNT App**

    c)   Click on „Single Shot"

    d)   Input of Actual Voltage Phase-Ground

    e)   Select frequency

    f)   Put the Smartphone on the **smartCOUNT Transponderpad**

    g)   Wait until the App shows the measured current values

A prior login is not necessary for "Single Shot"

If the App indicates an error, read at Troubleshooting code (A04).

The Single Shot function also works, when the user is not logged in (without user account). The **smartCOUNT System** can now be used as classic surge counter, showing impulse count, peak/√2 current and additionally 3rd harmonic current.

2.2.6. Upload Data

As soon as data sets were stored in the Smartphone after a proceeded "Read Data" or a "Single Shot" measurement, the data sets can be uploaded to the **smartCOUNT Cloud**. The according user has to be logged in to the **smartCOUNT App**. Proceed as follows.

    a)   Activate WiFi or mobile data of the Smartphone. Check the internet connection.

    b)   Open **smartCOUNT App**

    c)   Click on „Upload Data"

    d)   Wait until the App indicates „Successfully uploaded Data"

If the App indicates an error, read at Troubleshooting code (A03).

The standard destination for the uploaded data is the **smartCOUNT Cloud**. The cloud address is preconfigured in the menu under "Settings". This address should only be changed in coordination with Tridelta Meidensha.

2.2.7. Reset Device

For certain purposes it might be necessary to restart or to erase all the data and configurations from the device. For instance:

- A new account shall be assigned to the **smartCOUNT Datalogger**
- The device shall be installed on another surge arrester
- A malfunction requires a reset of the device

To proceed a device reset:

a)   go to menu point "Settings"
b)   click on "Execute" under Factory Reset
c)   put the smartphone on the **smartCOUNT Transponderpad**
d)   wait until the App indicates a successful device reset
e)   if the App indicates an error, read at Troubleshooting code (A04).

ⓘ All data sets will be ultimately erased from the **smartCOUNT Datalogger**. Already uploaded datasets will remain on the Cloud.
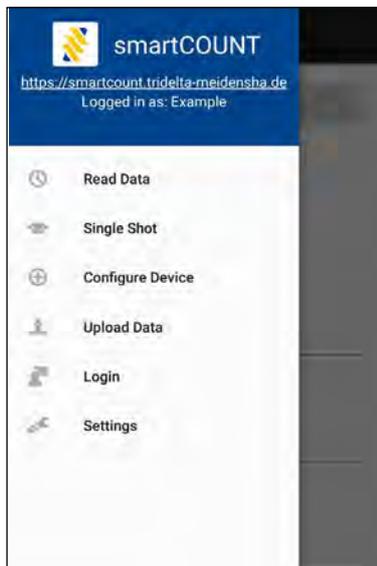
Wait until the App indicates a successful Device Reset. If the App indicates an error, read at Troubleshooting code (A03).

2.2.8. Logout and deinstallation

In seldom cases it might be necessary to logout from the **smartCOUNT App** or even to deinstall it. Therefore proceed as follows.

a) Open the **smartCOUNT App**

b) Use „Upload Data" to upload all remaining data sets on the smartphone.

c) Click on "Login" in the main menu and in the next page on "Logout"

d) Confirm that all still remaining data sets will be erased

The user account will be logged out from the **smartCOUNT App** and all recorded data sets will be erased from the Smartphone. Already uploaded datasets remain on the Cloud.

For deinstallation of the App, navigate to Android application manager. Click on the **smartCOUNT App** and choose "deinstall App". The App will be erased from the smartphone. The according structure of folders and system data will be kept.

For more information about the smartCOUNT App, read the section 3.2 of the User Guide.

2.3. Install a smartCOUNT Device on a surge arrester

Following tools are required for the installation of the **smartCOUNT System**.

- Open end spanner 19 mm
- Torque wrench 1, adjusted to 45 Nm
- Torque wrench 2, adjusted to 8 Nm
- 19mm socket spanner for torque wrench 1
- 17mm open end spanner attachment for torque wrench 2
- Kickstart set (Battery and clip are part of delivery)
- Continuity tester or multimeter

2.3.1. Safety rules

- Isolate and ground lines before installation, check de-energized parts for voltage!
- Wear personal protective equipment!
- Check all fittings after installation!
- Check correct earth connection on **smartCOUNT Datalogger** and **smartCOUNT Transponder-pad** with a continuity tester!

2.3.2. Install a smartCOUNT Datalogger

The **smartCOUNT System** is based on the evaluation of impulse and leakage currents, which flow through the arrester. For this reason the arrester has to be necessarily mounted on an insulating base.

Insulating base
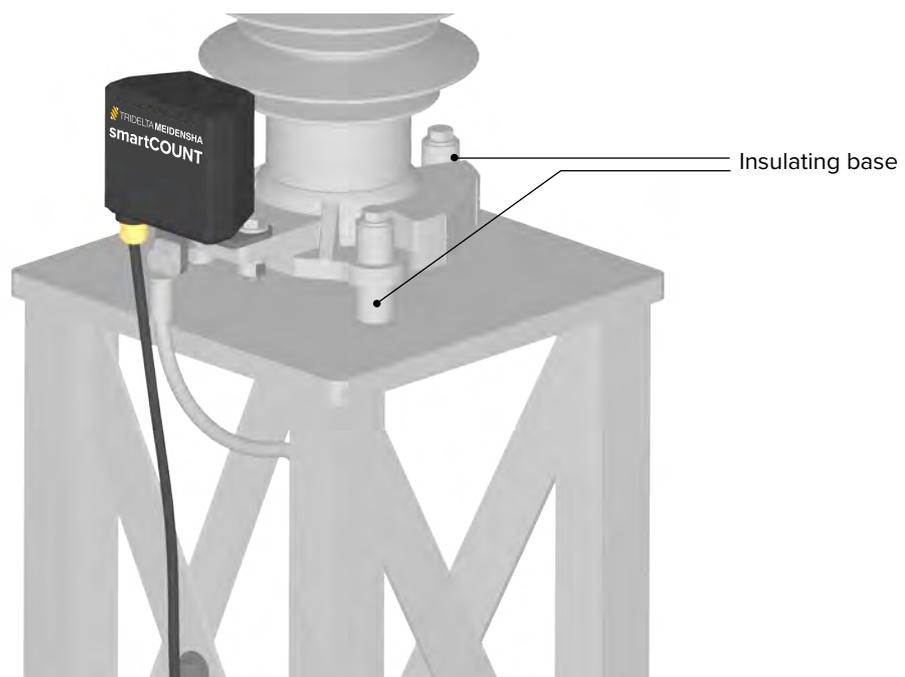
Installation procedure for smartCOUNT Datenloggers:

a) Fix the **smartCOUNT Datalogger** with its angled terminal on the lower terminal of the surge arrester with M12 bolt, washers, lock washer and M12 nut. Tighten the fitting with open end spanner 19mm and torque wrench 19mm with 45 Nm.

> ⚠️ Angled terminal must be connected to the surge arrester. Straight terminal should be connected to ground.
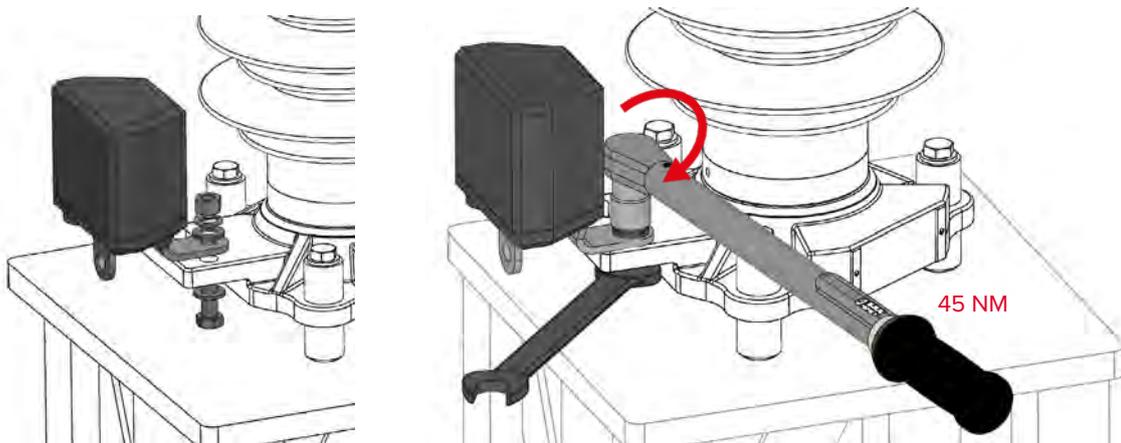
> ℹ️ Pay attention to ensure the following minimum clearances
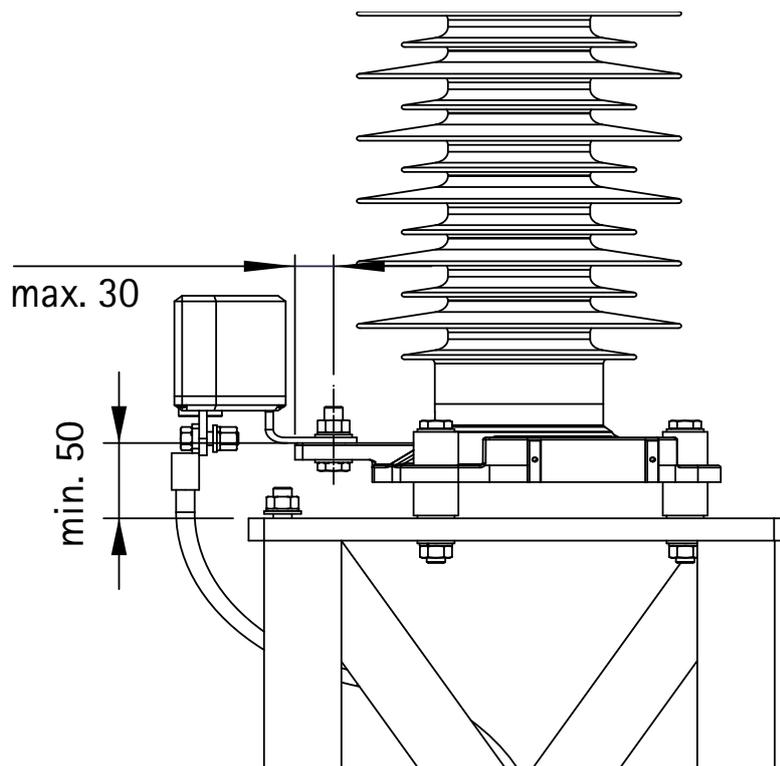
b) Connect the ground cable with M12 bolt, washers, lock washer and M12 nut (not included) to the straight terminal of the **smartCOUNT Datalogger**. Use an open end spanner 19 mm and a torque wrench 19 mm to tighten the fitting with 45 Nm.

45 Nm
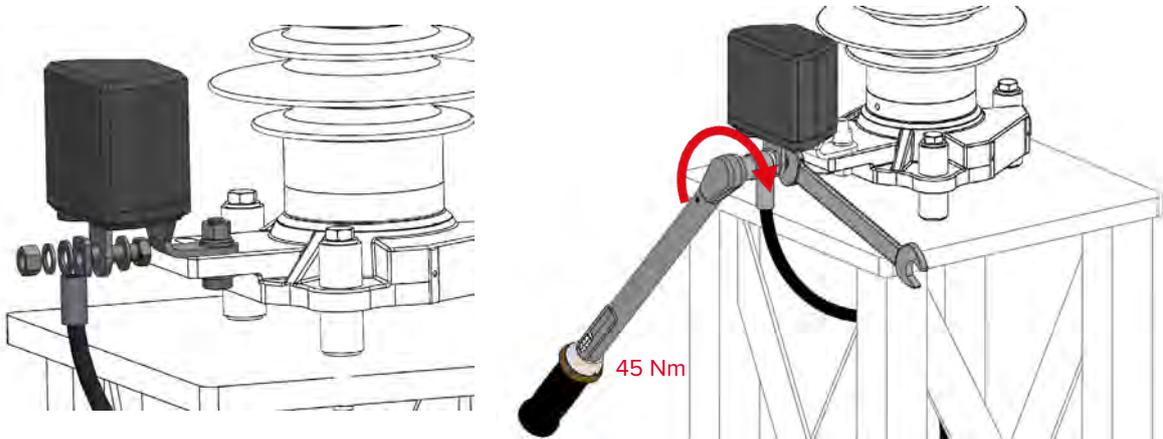
⚠️ The fittings are mechanical and electrical connections at the same time. The tightness and electrical conductivity of the connections has to be checked after installation.

2.3.3. Install a smartCOUNT Transponderpad

One of many possible solutions is to fix **smartCOUNT Transponderpad** on the base frame of the according surge arrester. A drill hole with a diameter of 13mm is necessary. Fix the **smartCOUNT Transponderpad** with M12 bolt, washers, lock washer and M12 nut on the metal base frame. Tighten the fitting with an open end spanner 19mm and a torque wrench 19mm with 45 Nm.

Ø13 mm

45 Nm
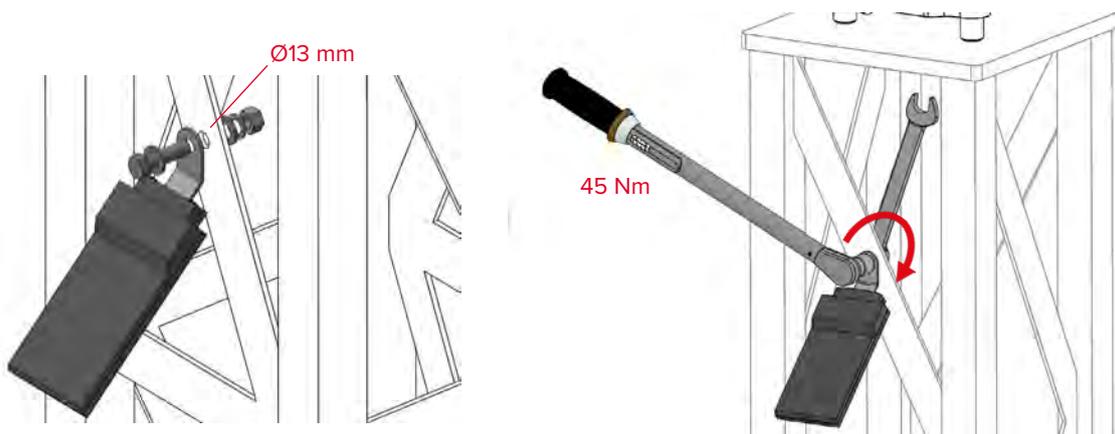
2.3.4. Install the data cable

ℹ️ Transponderpad and data cable are one unit. Order the Transponderpad with a sufficient cable length to provide enough cable for an easy installation.

The installation distance represents the clearance between the mounting surface of the lower arrester terminal and the drill hole for the Transponderpad.
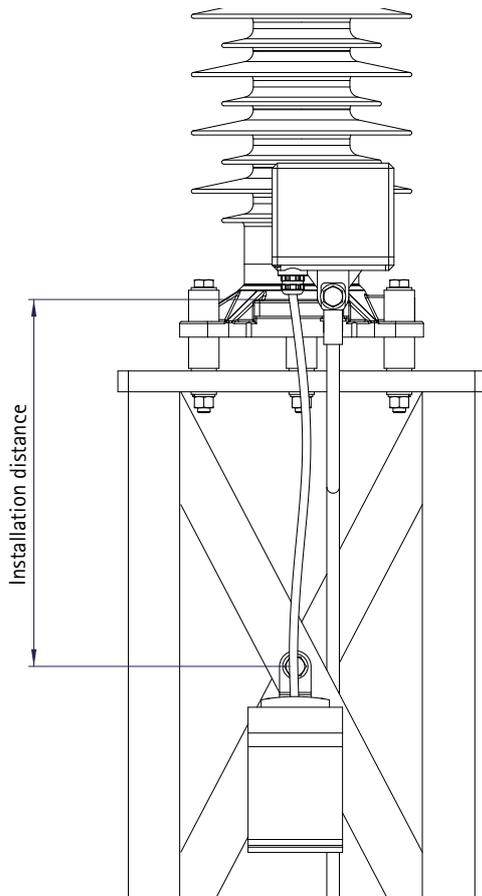
The data cable is weather- and UV-resistant and made for outdoor installation. We do not recommend to lead the cable through pipes or canals to prevent cable damages and influences to the data transmission.

Procedure for connecting the data cable to the smartCOUNT Datalogger.

a) Plug in the data cable in the RJ45 Jack of the **smartCOUNT Datalogger**. The plug "clicks", when it is connected correctly to the jack.
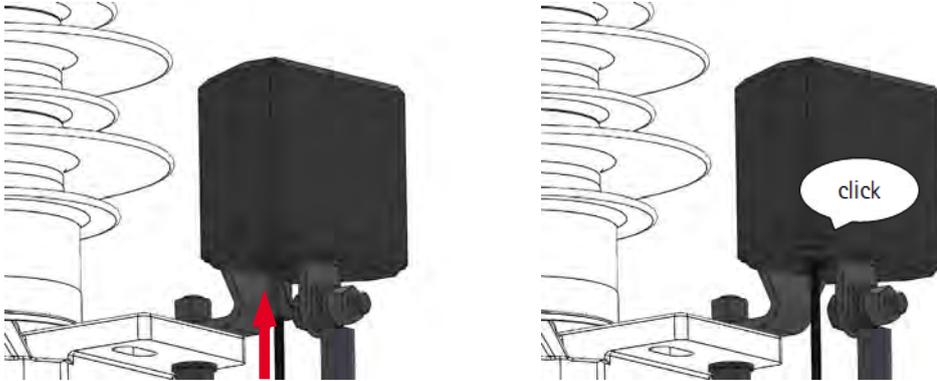
Unlatching the cable goes easy by pressing back the lever on the plug with a screwdriver. Don´t pull the cable with force, it will move out smoothly when the lever is pressed back.
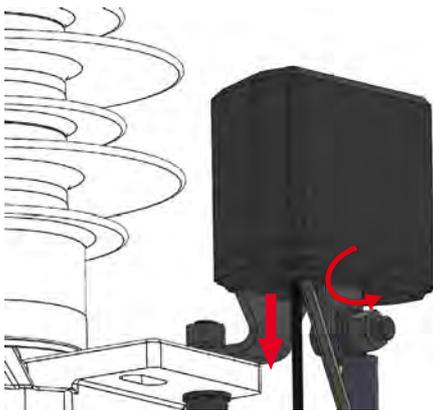
b) Screw in the cable gland with sealing insert (yellow) by hand until the ring seal (black) reaches the plastic dome of the **smartCOUNT Datalogger**. Apply the cap of the cable gland by hand and tighten it by using a torque wrench with 17mm open end spanner with 8 Nm. The cable gland is tight at 8 Nm. Do not apply more torque in order to protect the plastic dome against damages.
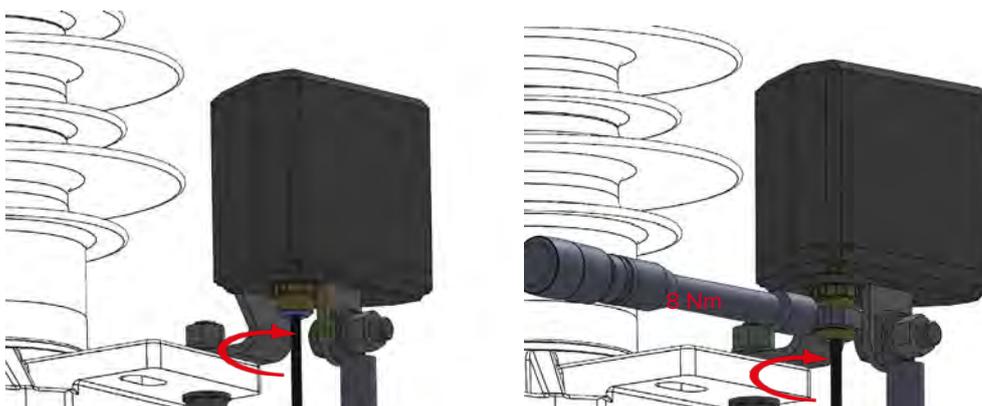
2.3.5. Charging the smartCOUNT Datalogger

After installation the internal energy storage is empty and needs to be charged, to proceed a configuration or even a Single Shot measurement. There are two options in this case:

a) Either use the Kick-start set (a part of delivery) to charge the **smartCOUNT Datalogger** quickly within 5 minutes.
   - High voltage must be switched off to prevent any damage or injury.
   - Polarity is irrelevant.
   - The Kickstart Set can be used several times until the battery is depleted.
   - Remove the Kickstart Set afterwards!
   - Do not short circuit the battery clamps.

b) Or switch High Voltage to the line and wait for the power to come up after a slow charge wit the surge arrester leakage current. This might take hours or days depending on the surge arrester specific leakage current.

It´s recommended to charge the device with the Kick-start set and to proceed a device setup directly after the installation and charging. The **smartCOUNT Datalogger** will automatically switch in operation, a while after the voltage is switched to the line.

⚠️ Never use the Kick-start set under high voltage to prevent injuries and damage to the equipment!
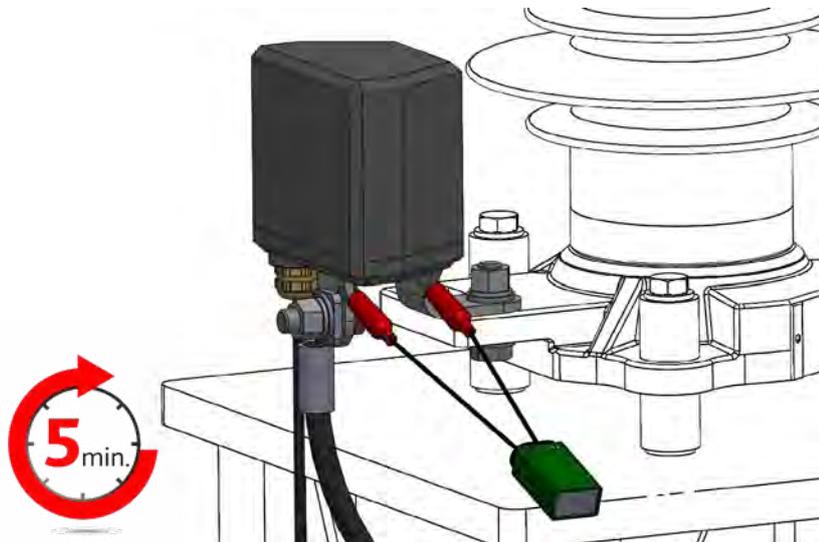
The smartCOUNT System is ready for use!

2.4. Troubleshooting

No.	Error	Possible reason	Approach
A01	Website not available	Website under maintenance	Try to reach the website another day
		No internet connection	Check your network and www access
		Outdated Browser	Try a recent browser (Chrome, Edge, Firefox)
		Typing error in URL	Check correct noting: https://smartcount.tridelta-meidensha.de
A02	No confirmation email received	Email moved to spam or trash folder	Open email or move it from spam or trash folder to main folder
		Email blocked by firewall or another safety related software	Contact your mailserver provider and ask for transmission of the email to your post box
		Wrong email address typed into registration form	Carry out a new registration
A03	Login failed or upload not possible	Typed in wrong username or password	Check username and password for typing mistakes. Check, if caps lock is activated.
		Server under maintenance	Try to login another time
		No Internet connection	Connect with the internet or mobile data
		Serveradress wrong	Check the server address in the App under „Settings". The correct address is: https://smartcount.tridelta-meidensha.de/appdata/
A04	App Error Code RTIMEOUT WTIMEOUT OINTERRUPT READFAIL OPENFAIL WRITEFAIL FORMATERROR BUFFERSIZE RETURNCODE UNKNOWN	**smartCOUNT Datalogger** discharged	Try it again later
		Smartphone incompatible	Check Smartphone compatibility (NFC, Android 4.0 or higher);
		App Version incompatible	Download newest App version
		NFC connection interrupted	Avoid deviating the Smartphone during NFC data transmission; Check Smartphone positioning; Approach Smartphone from distance
		Data cable defect or not correctly plugged in	Check datacable for defects Check the correct connection of the plug in the **smartCOUNT Datalogger**
		Any hardware damage	Report the Error Code to the Manufacturer
A05	Nothing applicable, problem not solved No solution found on Website under „FAQ"		Contact our support mailto: smartcount@tridelta-meidensha.de

2.5. Disposal

The **smartCOUNT Device** consists of lead-free and RoHS compliant materials and can be disposed in an environmentally-friendly way. The waste disposal contractor must observe the applicable local regulations.

Components of **smartCOUNT Device** are:

- Plastic and glass-fibre reinforced plastic
- Copper, Aluminium, tin, stainless steel and galvanized steel
- Silicon and Lithium for electronics and included battery
- Ceramics

3. smartCOUNT features and benefits

ℹ The values given in the following charts are only exemplary and should not be understood as minimum, maximum or typical values.

3.1. Automatical Data Acquisition and Leakage Current Trend

Every time, when a serious condition estimation shall be done on a surge arrester, it is not simply necessary to know the prevailing leakage current amplitudes or the impulse count. But it is very helpful to know how the condition of the surge arrester changes during its lifetime.

Therefore the **smartCOUNT Datalogger** performs an automatic data acquisition every hour, day or week – just like you prefer. The interval is defined in the **smartCOUNT App** during the device configuration. The data is permanently stored in the internal Datalogger memory. 1000 records can be stored before the data is downloaded from the **smartCOUNT Device**. If no download was carried out, the **smartCOUNT Datalogger** starts overwriting the oldest records.

The **smartCOUNT Datalogger**

- Performs cyclic data acquisition
- intervals hourly / daily / weekly are available
- Stores 1000 records (date, time, temperature, 3rd harmonic current, peak/√2 current)
- Overwrites the oldest records, if the internal memory is full
- Corrects the influence of harmonics from the voltage
- The leakage current trend can later be assessed within the **smartCOUNT Cloud**

3.2. smartCOUNT App and NFC Transponderpad

The data transmission between the **smartCOUNT Device** and the **smartCOUNT Cloud** is proceeded with a **smartCOUNT App** which requires a suitable smartphone (according to Chapter 2.1.2). The app is provided via Google Playstore or as direct download from the **smartCOUNT** website.

3.2.1. smartCOUNT App features

In the **smartCOUNT App**, all necessary functions for data transmission are provided, including:

- login/logout link the smartphone with the according user account
- configure device for configuring the measuring cycle and arrester properties
- read data to read out the automatically recorded data from the **smartCOUNT Datalogger**
- single shot to read the momentary impulse count and leakage current data
- upload data to upload
- device reset to make a factory reset of the **smartCOUNT Datalogger**

ℹ A registration on the **smartCOUNT Cloud** is necessary to get full access to these features. If no registration is done, the app will not be assigned to an account and for security purposes, the access to the **smartCOUNT Device** is prohibited. The functions configure device, read data, upload data and reset device are not available. Only the function single shot is usable.

3.2.2. NFC Communication

The communication between smartphone and the **smartCOUNT Device** is handled by the **smartCOUNT Transponderpad** which is an antenna for Near Field Communication (NFC). With NFC it is possible to exchange bidirectional data over a short distance of a few centimeter without plugging in a cable. The **smartCOUNT Transponderpad** does not require an extra power source. Depending on the amount of data, a data down- or upload can have a duration of a few seconds to about 2 minutes. The data transmission of the functions single shot, configure device and device reset take less than 5 seconds.

The **smartCOUNT Transponderpad** and Android App

- Allow Communication between smartCOUNT and smartphone
- Perform data exchange via Near Field Communication (NFC)
- provide different functions for user account handling, configuration and resetting of the **smartCOUNT Datalogger** and for data down- and upload
- Do not require an extra power source
- Require an Android smartphone with NFC

3.2.3. Using the smartCOUNT Device as conventional surge counter

With the "single shot" function, the operator is able to proceed a proactive measurement of the prevailing leakage current, regardless of the cyclically acquired records. This allows the operator to have a quick overview about:

- peak/√2 current
- 3rd harmonic current
- Temperature
- Impulse count

Moreover this function gives more than just the information of a conventional surge counter with leakage current meter.

3.2.4. Correction of voltage deviation

A Single Shot also enables the operator to indicate a prevailing phase-ground voltage, which might be deviating from the nominal phase-ground voltage and consequently influences the calculated resistive currents. This Single Shot data record will be uploaded to the **smartCOUNT Cloud**, if desired. There the previously entered phase-ground voltage will be updated for this single record and the calculated resistive current will be normalized accordingly.

3.2.5. Data Export in CSV and Excel

All the measurement data downloaded from the **smartCOUNT Device** is stored in the static app memory, which is not accessible from the user. But after each data download, the app creates 2 accessible CSV files per device, one for leakage current and one for impulse current in the path:
main internal storage directory\Download\Tridelta\...

Access this folder with your File Manager of the smartphone. You can also download those files via USB cable to a computer or send them to another destination. Each file is named with the unique ID of the **smartCOUNT Datalogger**.

Both CSV files are always created after a "Read data". A second "Read data" on the same **smartCOUNT Device** will overwrite the according CSV files. **Secure your CSV files before the next "Read data" on the same device.** Otherwise information might be lost.

The CSV file for leakage current data contains no resistive current but 3rd harmonic current. Resistive currents are only available in the **smartCOUNT Cloud**.

3.3. smartCOUNT Cloud

The **smartCOUNT Cloud** is an online data service, where all uploaded data from the **smartCOUNT App** is handled. It consists of a SQL database and is accessed through the webpage smartcount.tridelta-meidensha.de by a web browser. Only by using the **smartCOUNT Cloud** it is possible to have access to all features and benefits of the whole **smartCOUNT System**. These are:

- Leakage current trend curve and impulse current chart
- Comfortable data upload without cable to the **smartCOUNT Cloud**
- Access to all gathered data from computer, tablet or smartphone by web browser
- Full overview of the uploaded data of the corresponding account
- List of installed **smartCOUNT Devices** with
- Arrester details page
- Calculation of resistive currents acc. IEC 90066-5, Method B2
- Compensation of temperature influences
- Compensation of voltage deviation (for Single Shot)
- Automatical alert on the arrester overview page and via email, as soon as a surge arrester exceeds its critical current threshold
- List of cyclic leakage current measurements
- Support area with important links, downloads, news, videos and FAQ

A registration on the **smartCOUNT Cloud** and an authentication of the confirmation eMail is necessary to get access to these features.

3.3.1. Login page

Go to https://smartcount.tridelta-meidensha.de and click on "Login". Enter your previously registered User name and Password.

3.3.2. Arrester Overview page

After logging in, the browser directs to the "Arrester Overview" page, where all previously configured **smartCOUNT** Devices from this Account were uploaded.

The list shows furthermore all the information previously configured in the **smartCOUNT App**
- the device ID (unique, automatically created)
- the status of the connected surge arresters
- the date, site, position and phase of installation
- the arrester product code (only Tridelta arresters)
- type and continuous operating voltage
- the maximum system voltage (Phase-Phase) connected

The list also comprises the features
- sort all columns by pressing on ⇅ in the head row in each column
- filter columns by pressing on Filter above the table
- Download the list of entries as CSV by pressing on Export

ℹ️ It is possible to delete a complete entry by clicking on the corresponding recycle bin. The entry will be deleted permanently.

3.3.3. Arrester details page

By clicking on an entry in the "Arrester overview", the "Arrester details" page of the according **smartCOUNT Device** will open. On the top of the page, an information box will summarize the information about the corresponding surge arrester, like it has been configured in the **smartCOUNT App** during the installation/configuration procedure.

Inside the information box it is also possible to enter a Critical Peak/√2 Current Threshold. The surge arrester entry will be marked as "critical", if the peak/√2 current exceeds this value. This function mainly allows the user to specify the limit for the peak/√2 current based on own experiences for example concerning surface pollution induced peak/√2 currents. (note section 5.3)

To specify a Critical Peak/√2 Current Threshold, type in the maximum allowed peak/√2 current in µA and click on "Set".

Secondly the Arrester details page offers a chart, showing the arrester data visually including:

- Current curve of resistive and peak/√2 current
- Trend curves for resistive and peak/√2 current
- Critical current thresholds for resistive and peak/√2 current
- Impulse currents with amplitudes, date and time
- Everything together in one chart with date/time filter

The different curves can be hidden/shown by clicking on the according entry of the legend in the chart.
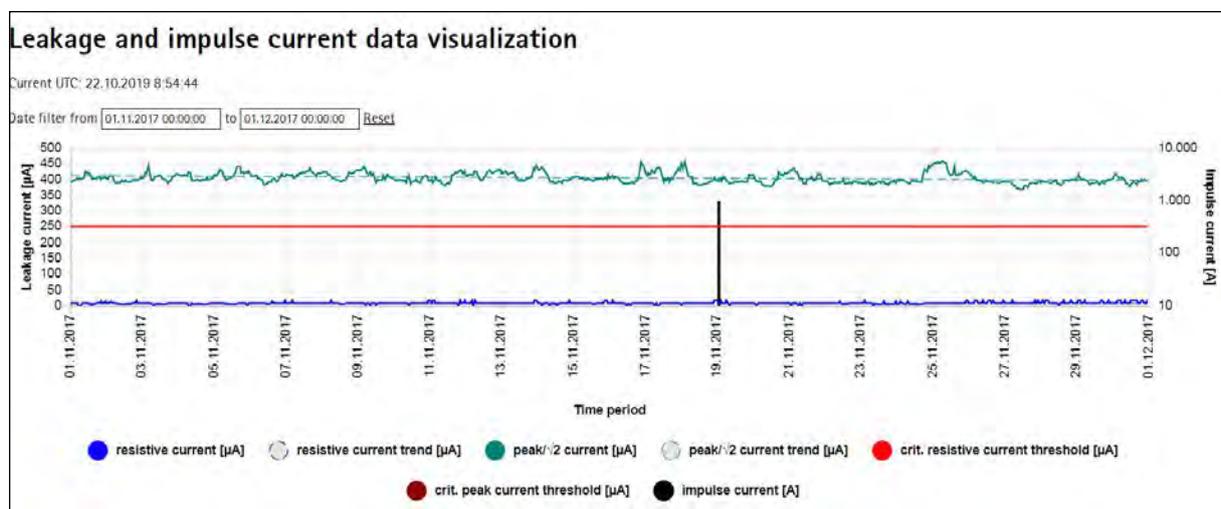
The Arrester details page loads the records of the past 12 months. Also the chart will initially show the last 12 months of records. In the Date Filter in the top left corner, the range of the date/time axis can be extended to get a better overview about the current trend of a bigger period or can be reduced to get a closer view to specific interesting dates/times.

To define the date/time range for the Arrester details page, enter date and time of begin and end of the desired range in the format DD.MM.YYYY hh:mm:ss Date filter from [01.11.2017 00:00:00] to [01.12.2017 00:00:00]
By pressing Reset

ℹ️   By defining a bigger period than 12 months the page will take more time for loading.

The loaded entries will be shown below in the lists for
- Cyclic Leakage current measurements
- Single shot measurements
- Impulse currents

All of those lists will be displayed reduced with maximum 50 entries and can be shown or hidden completely.

Leakage current measurements

Current UTC: 22.10.2019 8:56:47

| Export | Filter | Hide | | | | Delete all leakage current and single shot measurements |

ID	Date and Time (UTC)	Temperature [°C]	Actual Voltage Phase–Ground [kV]	3rd Harmonic Current [µA]	Resistive Current [µA]	Peak Current / √2 [µA]
0	26.10.2017 10:00:08	24	71.01	9	30	611
1	26.10.2017 11:57:56	17	71.01	10	38	610
2	26.10.2017 12:57:56	17	71.01	10	38	617
3	26.10.2017 13:57:56	16	71.01	10	38	609
4	26.10.2017 14:57:56	14	71.01	9	36	617
5	26.10.2017 15:57:56	11	71.01	10	41	591
6	26.10.2017 16:57:56	10	71.01	10	42	601
7	26.10.2017 17:57:56	10	71.01	11	46	599
8	26.10.2017 18:57:56	9	71.01	9	38	601
9	26.10.2017 19:57:56	10	71.01	9	38	621

The list for cyclic leakage current measurements shows the Record ID, which is already generated inside the **smart-COUNT Datalogger** and is unique for every Device. Furthermore following values are given per entry:
- Date and time (Coordinated unified time UTC)
- Measured ambient temperature
- 3rd harmonic current
- Resistive current
- Peak/√2 current

The list also comprises the features
- sort all columns by pressing on ⇅ in the head row in each column
- filter columns by pressing on Filter above the list
- Download the list of entries as CSV by pressing on Export
- Single records can be deleted by pressing 🗑
- All records can be deleted by pressing Delete all leakage current and single shot measurements

By clicking on the corresponding recycle bin, the entry will be deleted permanently. Greyed out values have been rated as invalid due to implausibility. Those values are shown in the list but not in the chart.

Single shot measurements

Current UTC: 22.10.2019 9:09:36

Export		Filter		Hide				Delete all leakage current and single shot measurements

	Date and Time (UTC)	Temperature [°C]	Actual Voltage Phase-Ground [kV]	3rd Harmonic Current [µA]	Resistive Current [µA]	Peak Current / √2 [µA]
🗑	16.11.2017 07:26:36	-3	71.10	7	35	569
🗑	15.12.2017 11:40:54	5	71.10	6	27	594
🗑	04.01.2018 09:29:12	4	71.10	7	32	588

In the list for Single shot measurements following values are given per entry:

- Date and time (Coordinated unified time UTC)
- Measured ambient temperature
- Actual Voltage Phase-Ground
- 3rd harmonic current
- Resistive current
- Peak/√2 current

The list also comprises the features

- sort all columns by pressing on ⇅ in the head row in each column
- filter columns by pressing on Filter above the list
- Download the list of entries as CSV by pressing on Export
- Single records can be deleted by pressing 🗑
- All records can be deleted by pressing Delete all leakage current and single shot measurements

By clicking on the corresponding recycle bin, the entry will be deleted permanently. Greyed out values have been rated as invalid due to implausibility. Those values are shown in the list but not in the chart.

The recorded impulse currents will be shown in the lists at the bottom of the page. The first list shows the number of impulse currents categorized in their magnitudes. The second list shows the impulse current entries, their unique ID, their date and time of occurrence and their magnitude.

Impulse current measurements

Current UTC: 22.10.2019 9:10:31

Impulse Current [A]	Count
100	0
1000	1
5000	0
10000	0
40000	0
100000	0

Export		Filter		Hide			Delete all impulse current measurements

	ID	Date and Time (UTC)	Impulse Current [A]
🗑	0	19.11.2017 01:11:44	1000

The second impulse current list also comprises the features

- sort all columns by pressing on ⇅ in the head row in each column
- filter columns by pressing on `Filter` above the list
- Download the list of entries as CSV by pressing on `Export`
- Single records can be deleted by pressing 🗑
- All records can be deleted by pressing `Delete all leakage current and single shot measurements`

ⓘ   By clicking on the corresponding recycle bin, the entry will be deleted permanently.

3.3.4. Account page

On the Account offers the possibility to:

a)   assign a new user name to your account

b)   assign a new password to your account

c)   assign a new email address to your account

One or multiple preferences can be changed at one time. Password and eMail Address must be entered twice to confirm the correct input.

3.3.5. Support page

The support page offers different useful information like

- News
- Videos/Animations for install procedure
- FAQ – Frequently Asked Questions and Answers
- Downloads for App, Manual, Installation guide
- Useful links to websites and publications
- Support request link
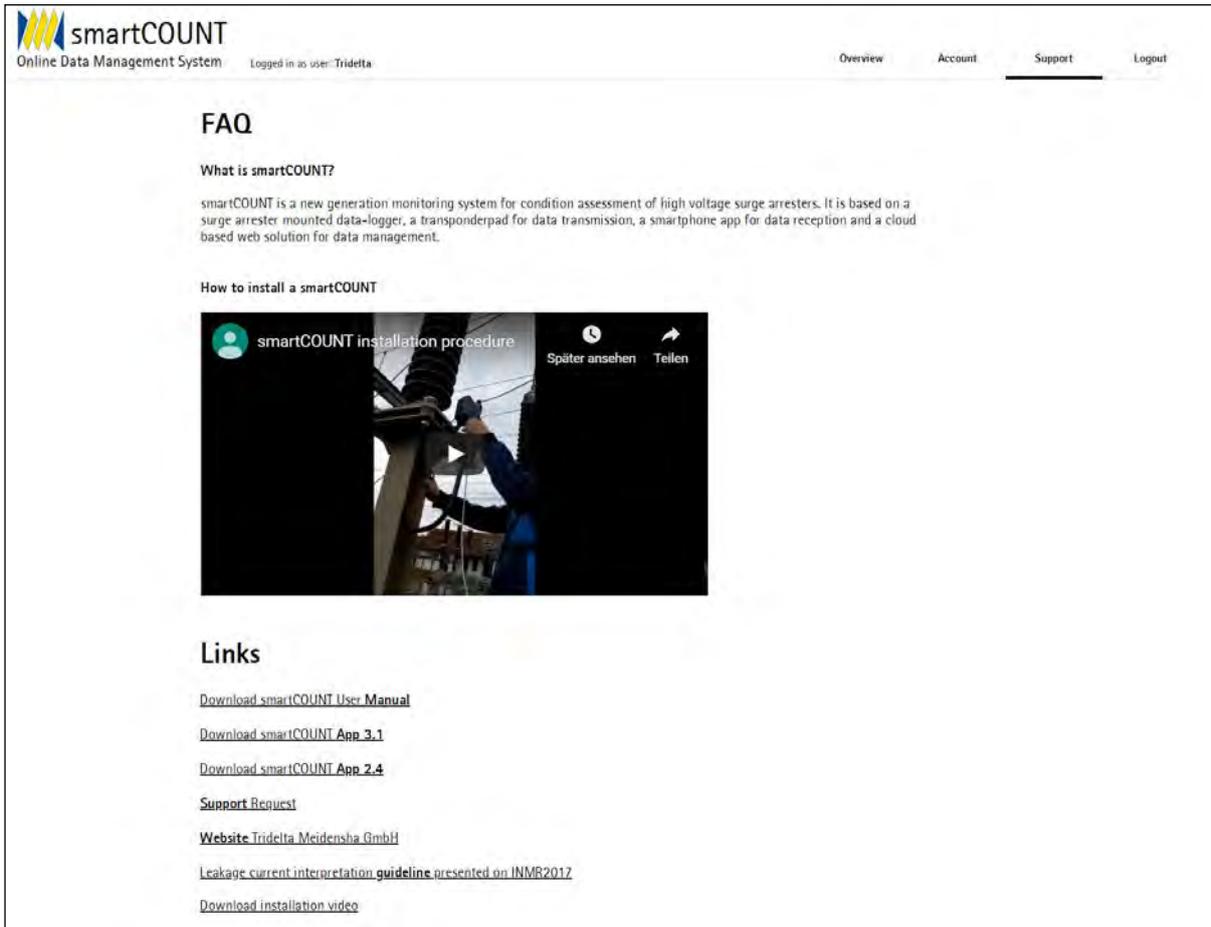
By pressing "Logout" in the top right page menu, the session will be ended and the account will be logged out on this browser. The page will redirect to the Login page.

3.4. Cloud based current calculation

The major benefit of the **smartCOUNT Cloud**, is the integrated calculation of 3rd harmonic leakage currents to temperature compensated resistive leakage currents. The **smartCOUNT Cloud** contains a database comprising all Tridelta surge arrester types, their Voltage-Current-characteristics as well as their Temperature-Current-Characteristics. For non Tridelta surge arrester types there are equivalent surge arrester class dependent models included.

The resistive current is calculated within the Cloud with the function

$$I_{resistive} = I_{3rd\ harmonic} \cdot \propto \cdot \vartheta$$

$\propto$ - is a function of U/Uc and the surge arrester class or the Tridelta surge arrester type
ϑ - is a function of temperature and the surge arrester class or the Tridelta surge arrester type

All resistive currents will be calculated involving the type//class of the surge arrester and will be normalized to the standard operating condition at **ambient temperature=20°C** inside the **smartCOUNT Cloud**.

This means that the smartCOUNT System can be applied on each gapless ZnO Surge Arrester!

3.5. Self-sufficient power supply

The **smartCOUNT Datalogger** powers itself by harvesting energy from a basically infinite energy source – **smartCOUNT** powers itself by the leakage current
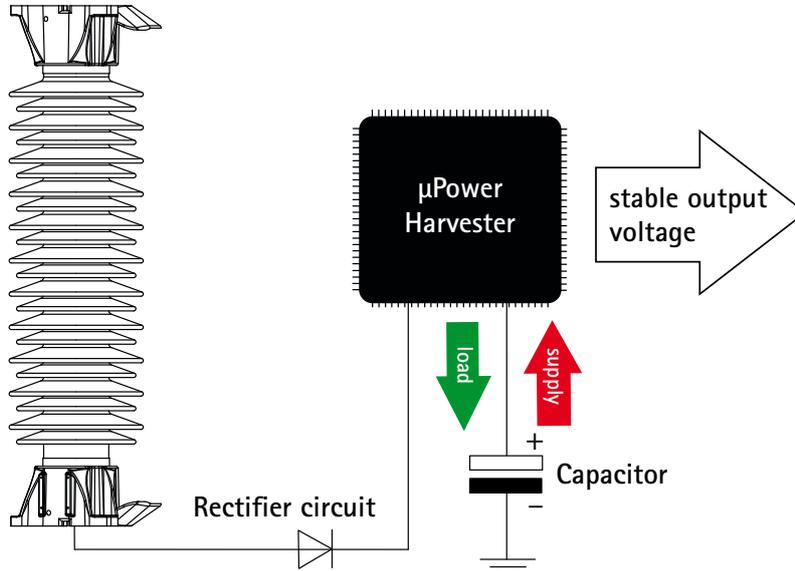
Figure 3.5.1 – **smartCOUNT** power supply schematic

When delivered, the **smartCOUNT Datalogger** comes in off-state but with a basic charge of the internal power supply unit. Depending on the charging current, a freshly installed **smartCOUNT Datalogger** will need more or less time to charge up and to change to working order.

Charging current r.m.s.	Latest operational after
2,0 mA	1 day
1,0 mA	2 days
0,4 mA	5 days
>10,0 mA (Charge with included 9V Kickstart-set)	5 minutes

Figure 3.5.2 – exemplary **smartCOUNT** Datalogger charge-up conditions

Once a **smartCOUNT Datalogger** is charged and has changed to working order, it will remain working until the system voltage is switched off. Even with switched off system voltage, the power supply unit retains energy for a few hours.

> ⓘ   The minimum required leakage current for a stable power supply is 200 µA r.m.s.

When a **smartCOUNT Datalogger** is out of energy it will:

- Ø Power down and will not be usable
- ✓ Retain all recorded datasets
  (max. 1000 leakage current datasets and 1000 impulse current datasets)
- ✓ Retain date and time

3.6. Durability under Environment

The **smartCOUNT Device** was designed to endure the most challenging environmental conditions on installation sites – just as a state-of-the-art surge arrester. Those conditions might be:

- Intense UV irradiation
- High temperatures up to +60°C
- Low temperatures down to -40°C
- Atmosphere with high salinity
- High air humidity, rain and fog
- Snow and icing
- High pollution areas
- Strong electromagnetic fields

To ensure the performance of the device, smartCOUNT System was intensively tested under all these environmental conditions in a 24 months field test.

Figure 3.6.1 – **smartCOUNT** under field test

3.7. Data Security

The whole **smartCOUNT System**, comprising **smartCOUNT Datalogger**, **smartCOUNT Transponderpad**, **smartCOUNT App** and **smartCOUNT Cloud** is a secure and highly available system. The complete data chain from the Datalogger up until the Cloud is secured against unauthorized access.
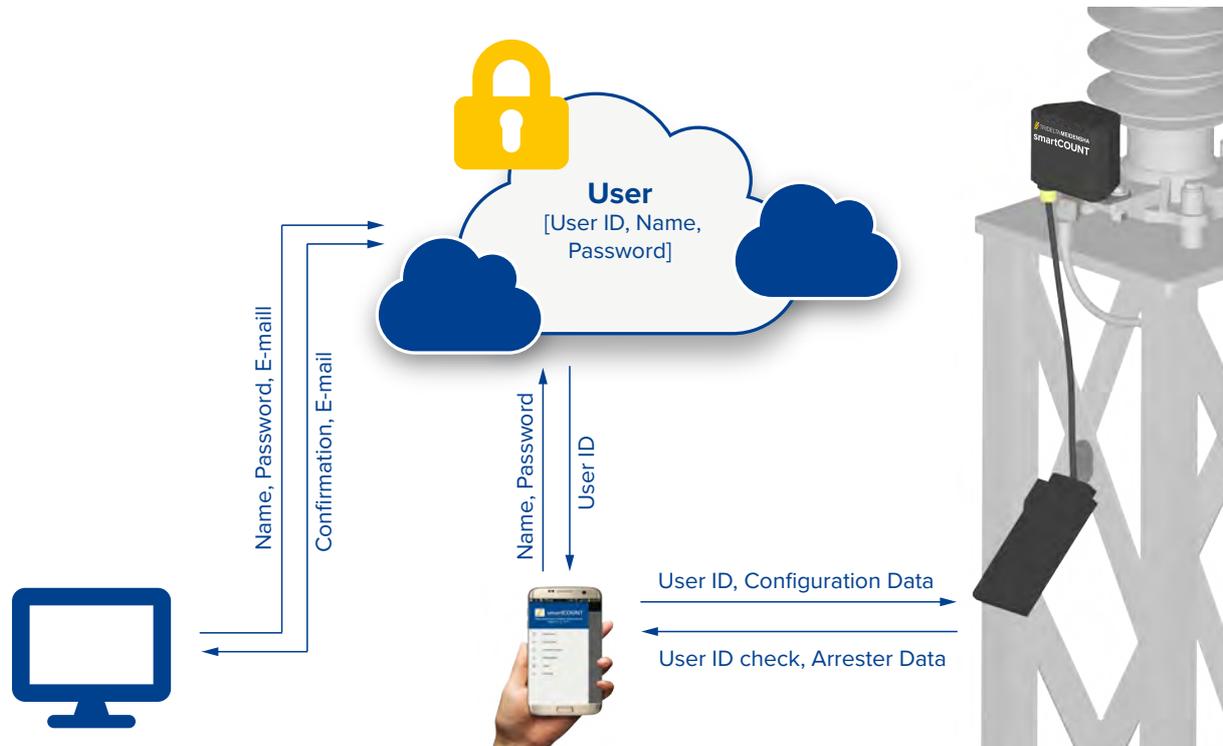
The main security key for the communication between the components of the **smartCOUNT System** is the unique user ID, which is assigned one single time, when an account is created in the registration form of the Website of the **smartCOUNT Cloud**.

The login on the **smartCOUNT App** with these account data will be verified according the correctness by dialing the **smartCOUNT Cloud**. The **smartCOUNT Cloud** will authenticate the dial with the correct account data by handing over the according unique user ID. The user ID will be kept statically on the **smartCOUNT App** until the user is logged out by logging out from or deleting the **smartCOUNT App**.

During the first Configuration of a **smartCOUNT Device** by using the "Configure Device" feature of the **smartCOUNT App**, the unique user ID will be assigned to the connected **smartCOUNT Datalogger**. Afterwards this certain **smartCOUNT Datalogger** will be solidly personalized with this user account. All following communication actions (except Single Shot) between the **smartCOUNT App** and the **smartCOUNT Device** will only be possible with the similar account login on the App. A **smartCOUNT App** with an account login different from the account that was personalized on the **smartCOUNT Datalogger** will have no access to the functions

- Read Data
- Configure Device
- Reset Device

This principle ensures that no unauthorized person is able to have influence the Data of the configured **smartCOUNT Device**.

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ⓘ The Single Shot function represents an exception. By performing a Single Shot measurement on a **smartCOUNT Device**, no sensible data can be changed or accessed. A Single Shot enables the operator to use the **smartCOUNT Device** with its basic function of leakage current measurement and impulse count notification, just like a conventional surge counter.

All account related data stored in the **smartCOUNT Cloud** will be securely encrypted and stored as a 60-symbol-cipher. A backup server guarantees high data availability, even in case of Data loss on the main server. A backup is created daily for the last 7 days, every week for the last 4 weeks and every month for the last 12 months. The latest valid backup will be recovered automatically. The backup server is encrypted accordingly to the main server. The server is located on 3 Datacenters in Germany and Finland. It is a redundant managed server type with SSL encryption, integrated security concept, Anti-Virus, integrity test and permanent self-monitoring. The provider of the **smartCOUNT Cloud** server is an independent, professional and certified german hoster and server provider.

4. Arrester Condition Monitoring Theory

The main purpose of a surge arrester is to protect the primary equipment like transformers from dangerous overvoltages. A surge arrester breakdown will directly lead to an outage of the connected transformer or the complete substation. To prevent scenarios like this, it is necessary to detect a defect surge arrester before any major incident. A surge arrester monitoring device like **smartCOUNT** is the right choice to discover and signalize defect surge arresters by monitoring the surge arrester leakage current permanently.

> (i) The values given in the following charts are only exemplary and should not be understood as minimum, maximum or typical values.

4.1. Surge Arrester Discharge Current

For many years, condition monitoring of surge arresters meant to count the number or to estimate the amplitude of discharged currents in the surge arrester due to overvoltages. Today, a proper signal analysis of the surge arrester leakage current is much more meaningful, than just impulse counting. Especially because todays surge arresters consist of MOV blocks which are not essentially ageing due to the number of discharged surge currents. Nevertheless, the recognition of a surge current together with information about its amplitude and its date and time of occurrence might be helpful by the assessment of the surge arrester leakage current behavior.

4.2. Surge Arrester Leakage Current

ZnO Surge Arresters have a complex impedance, which consists of a resistive and a capacitive component due to the material structure of Zinc Oxide. Under AC-Voltage, this results in two currents: One sinusoidal capacitive current phase shifted -90° to the voltage signal and one resistive current which is in phase with the voltage and is not sinusoidal but rather shaped as a periodic pulse signal. Both components are superimposed to the total leakage current (Figure 4.2.1)
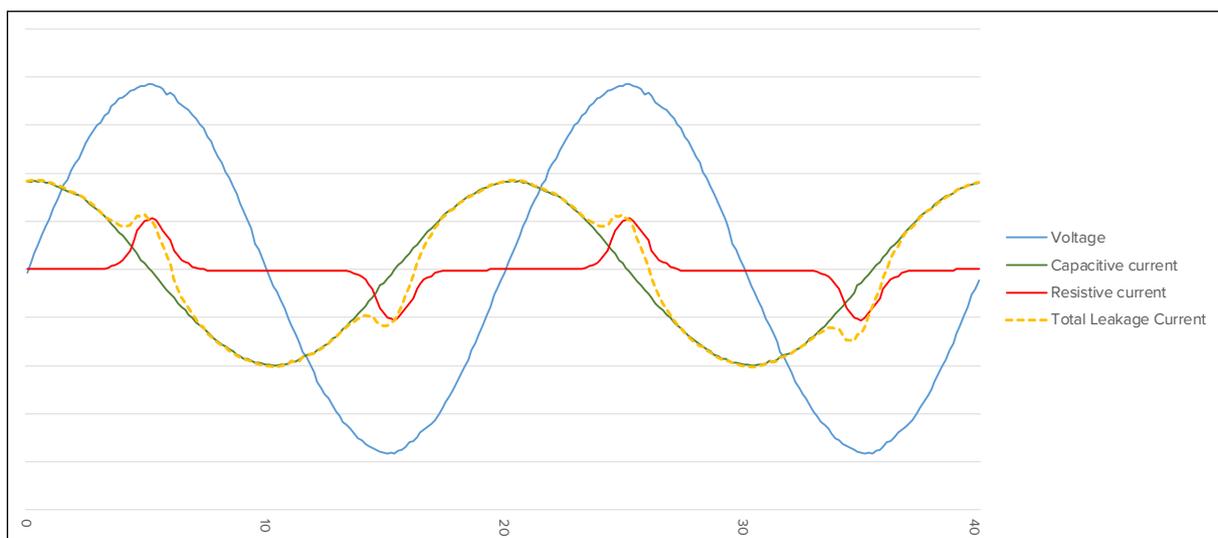
Figure 4.2.1 – Total leakage current, capacitive and resistive current component

The capacitive current component I $_{cap}$ (r.m.s.) of the surge arrester leakage current is approximately shifted by -90° to the voltage phase and has an almost proportional dependency from the amplitude of the system voltage. It is not influenced by temperature and is negligibly impacted by the grade of degradation of the surge arrester metal oxide resistors.

The resistive current component I $_{res}$ (r.m.s.) of the surge arrester leakage current is in phase with the voltage and shows pulse shaped current spikes at the highest points of the voltage amplitude. It is exponentially dependent from the voltage and sensitive to temperature and to the grade of degradation of the surge arrester metal oxide resistors. (Figure 4.2.2) The resistive current is nearly proportional the real power loss in the surge arrester.
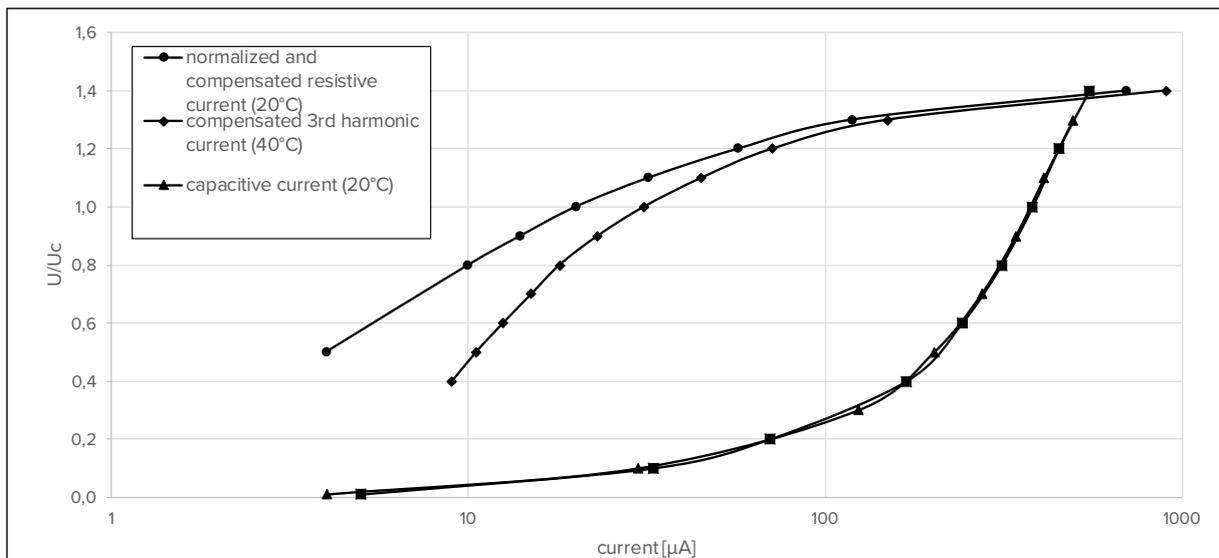
Figure 4.2.2 – Capacitive and resistive current component

Two further important values for the condition assessment of the surge arrester play a role: Capacitive and resistive current are superimposed to a total leakage current signal which contains the peak/√2 current and harmonic currents. (Figure 4.2.3)
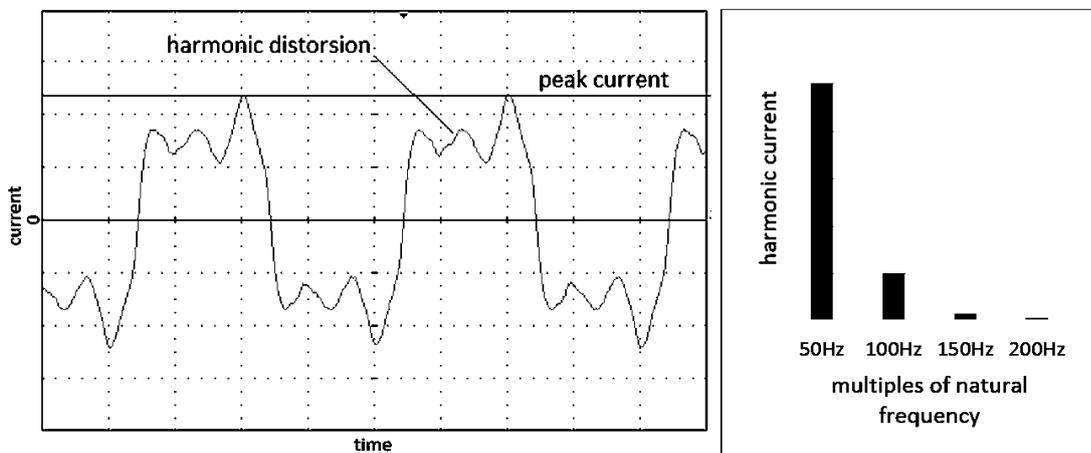
Figure 4.2.3 – peak current and 3rd harmonic current in the total leakage current

The peak/√2 value I_peak (peak/√2) of the surge arrester current is the maximum point of the total leakage current divided by √2 and always orientated on the predominating component (capacitive or resistive) of the current. At low voltage levels (approx. <U_c), the peak/√2 current orients itself on the value of the capacitive component. At higher voltage stresses, primarily in a range above Ur (rated voltage), the peak/√2 current orients itself on the value of the resistive component.

The 3rd harmonic current I_3rd (r.m.s.) is the current value of next odd multiple frequency of the natural current frequency and shows a very similar behavior to the resistive current which qualifies the 3rd harmonic current as a physical equivalent of the resistive current which is easy to measure, exemplary shown in Figure 4.2.4.
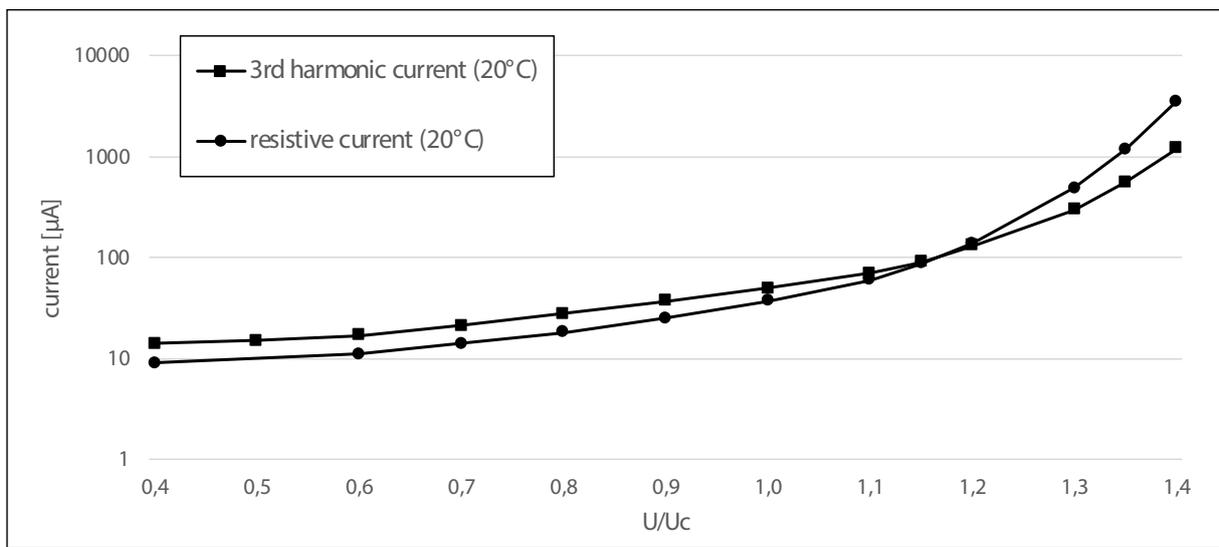
Figure 4.2.4 – 3rd harmonic current related to resistive current

4.3.   IEC 60099-5 method B2

The surge arrester IEC standard for selection and application of surge arresters (IEC 60099-5) describes different diagnostic methods for surge arresters. The most common measurement method B2 is described as third order harmonic analysis with compensation for harmonics in the system voltage.

Method B2 assumes that harmonics in the surge arrester leakage current arise from the impact of the resistive current component to the total leakage current. The 3rd harmonic current is considered as the harmonic current which is most equivalent to the resistive current and thus the 3rd harmonic shall be measured and related to the resistive component.

Method B2 also explains that harmonics in the system voltage have an influence on the harmonic content of the total leakage current of a surge arrester and thus produce measuring errors in the determination of the 3rd harmonic leakage current. According to the standard, Method B2 requires a compensation function to minimize the influence of voltage harmonics to the measured 3rd harmonic current. (Figure 4.3.1)
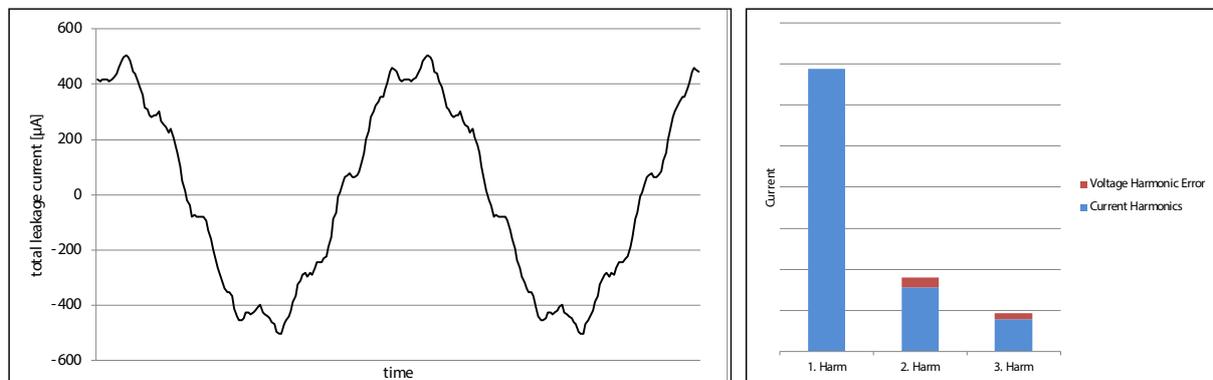
Figure 4.3.1 – typical surge arrester leakage current and harmonic error induced by voltage noise

4.4.   Application of measurement method B2

The resistive current is a good representative value for the surge arrester condition due to its high sensitivity and logarithmic growth over the whole leakage current area of the V-I-Curve. Unfortunately it can´t be measured directly but can be determined as proposed in the measurement method B2. Then the resistive current is based on the third harmonic content of the leakage current, which is extracted from the leakage current spectrum by using a digital Fast Fourier Transformation algorithm, short "FFT". The ratio between 3rd harmonic current and resistive current depends from the voltage ratio U/Uc, the temperature of the MOV blocks and the type of the according MOV block. (Figure 4.4.1)

The measurement procedure in particular:

a)   Digital sampling of the total current signal using a high performance 32 Bit Microcontroller

b)   Creation of the total current spectrum by means of a Fast Fourier Transformation algorithm

c)   Compensation of the 3rd harmonic error amount due to the influence of harmonics in the system voltage using an integrated electric field probe

d)   Conversion of the compensated 3rd harmonic current to a resistive current with a voltage ratio dependent factor corresponding to the type of MOV block

e)   Normalization of the resistive current to standard condition: 20°C and U/Uc = 0,8
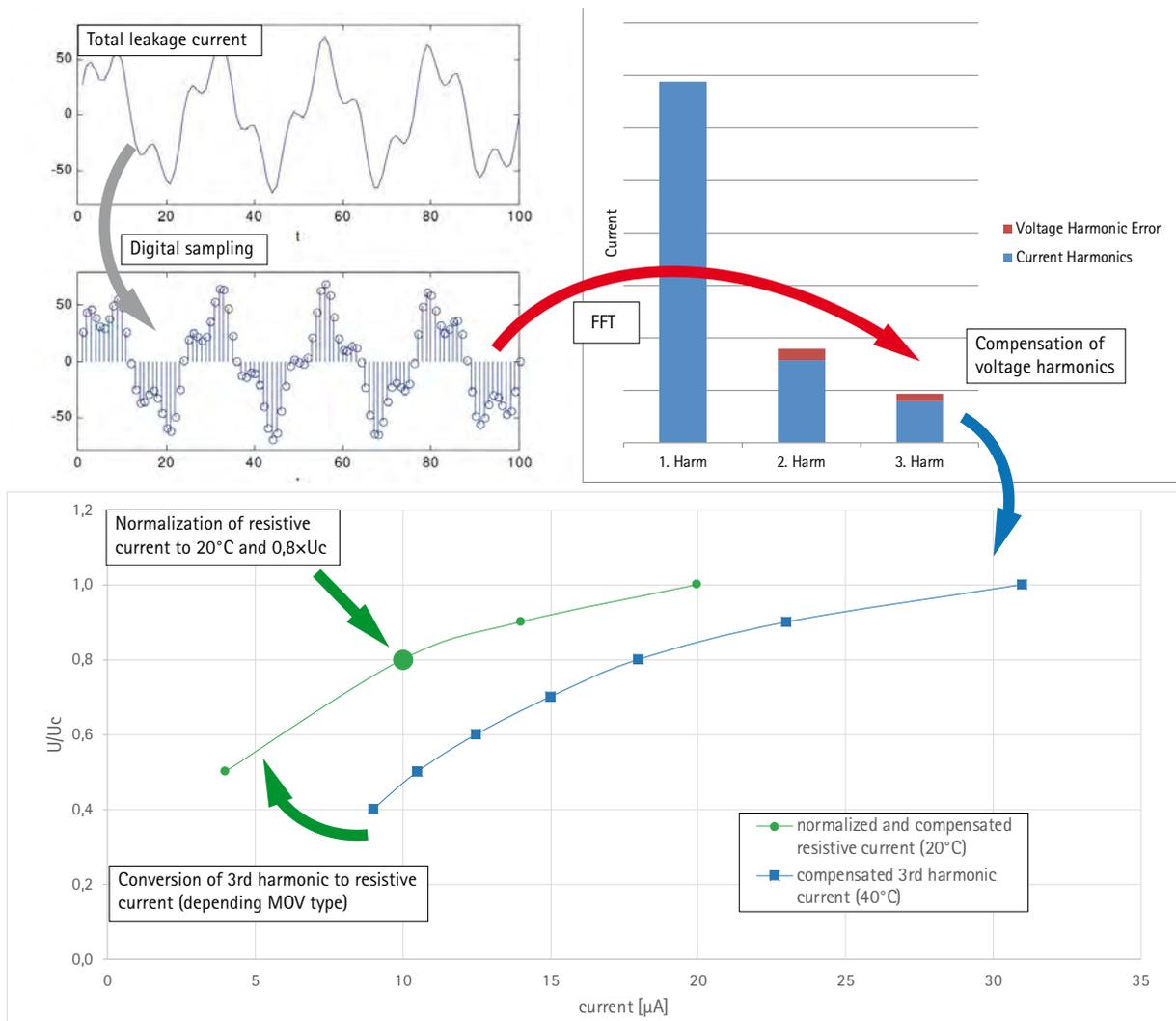
Figure 4.4.1 – Principle procedure for determination of the resistive leakage current component

smartCOUNT determines the resistive current according to IEC 60099-5 Annex D, Method B2

5. Guideline for leakage current assessment

The following chapter describes special cases which may lead to misunderstanding of the measured data. Temperature and grid related influences like harmonics in the system voltage play a minor role since there are existing methods for rough compensation of them. Weather and pollution still influence the arrester current by adding surface currents and hence errors to the measured values. A humidity ingress or successive degradation of MOV blocks are the most common reasons for surge arrester failure and need to be detected early. Only proper understanding of measured leakage current values, preferably available as periodically logged long term data, guarantees early failure recognition and the making of a correct decision for replacing a surge arrester. Thus, the most frequent cases of leakage current behavior are explained and set in relation to the according practical scenario. Side effects and their impact on the measurement results are discussed and recommendations for a proper condition assessment of surge arrester are given.

5.1. Temperature influences and compensation

Usually temperature impacts on the resistive leakage current from the ambient temperature is compensated by measuring the ambient temperature and by multiplying the measured raw value with a correction factor based on a temperature compensation model. Of course temperature models also differ between varistor types but can be approximated for all varistor types or roughly linearized for one specific ratio U/Uc in order to simplify the compensation procedure.

But there is another influence on the temperature compensation algorithm that arises from the temperature measurement itself. Usually the temperature sensor is built inside the monitoring device and the measured temperature differs from the ambient temperature due to the temperature constant of the monitoring device and how long it takes until the ambient temperature has been conducted to the temperature sensor. The temperature constant of the monitoring device and surge arrester should be roughly the same in order to replicate the same temperature impact on both. Furthermore the influence on the temperature sensor and the varistor will be mismatched due to differences in the capability of the arrester housing and shell of the monitoring device to reflect sunlight. Varying sunlight radiation angles and partial shading will influence temperature calculations. These factors lead to an effect that has been observed on surge arresters in the field, called over-compensation, where a compensation value is subtracted, that is larger than the nominal temperature deviation. Finally with rising ambient temperature, the resistive leakage current neither rises, nor stays stable, it sinks. This leads to a ripple in the resistive leakage current, due to night and daytime temperature fluctuations, outlined in Figure 5.1.1.
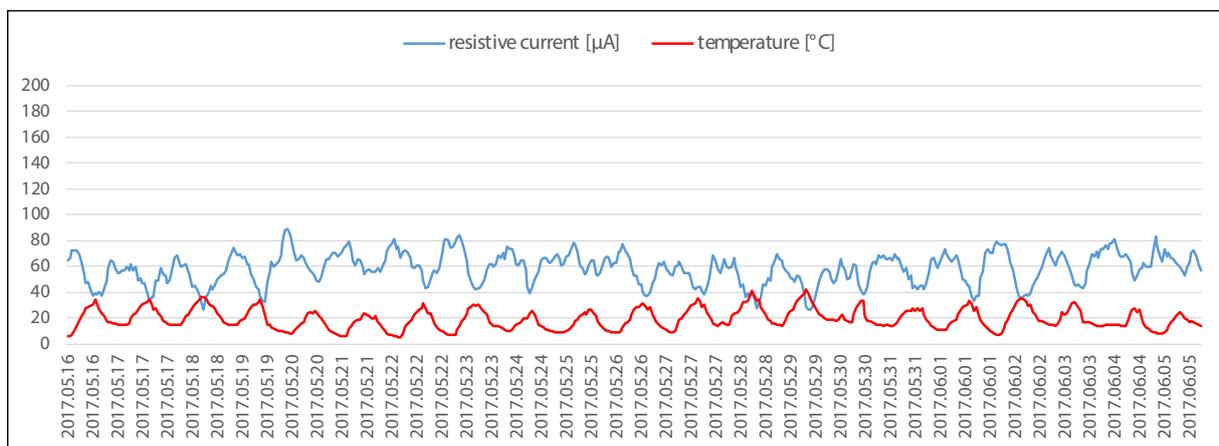
Figure 51.1 - ripple effect due to temperature over-compensation

This problem can be handled most effectively by measuring at night to mainly eliminate the influence from sunlight. It might also be necessary to check, if the correct arrester type has been assigned during the configuration process of the monitoring device.

5.2. Humidity and rain effects

As high voltage surge arresters are usually installed outside, they are affected by rain and humidity or fog. Effects on the leakage current, caused by these conditions can be figured out by means of meteorological data. High peak/√2 currents correlate directly with very heavy rain and storm (area marked in blue). Fluctuating peak/√2 values with low changes in the amplitude can be related to continuous, steady rain, heavy fog and high humidity (area marked in green). Humidity and rain produce only marginally fluctuating values on the resistive current trend.
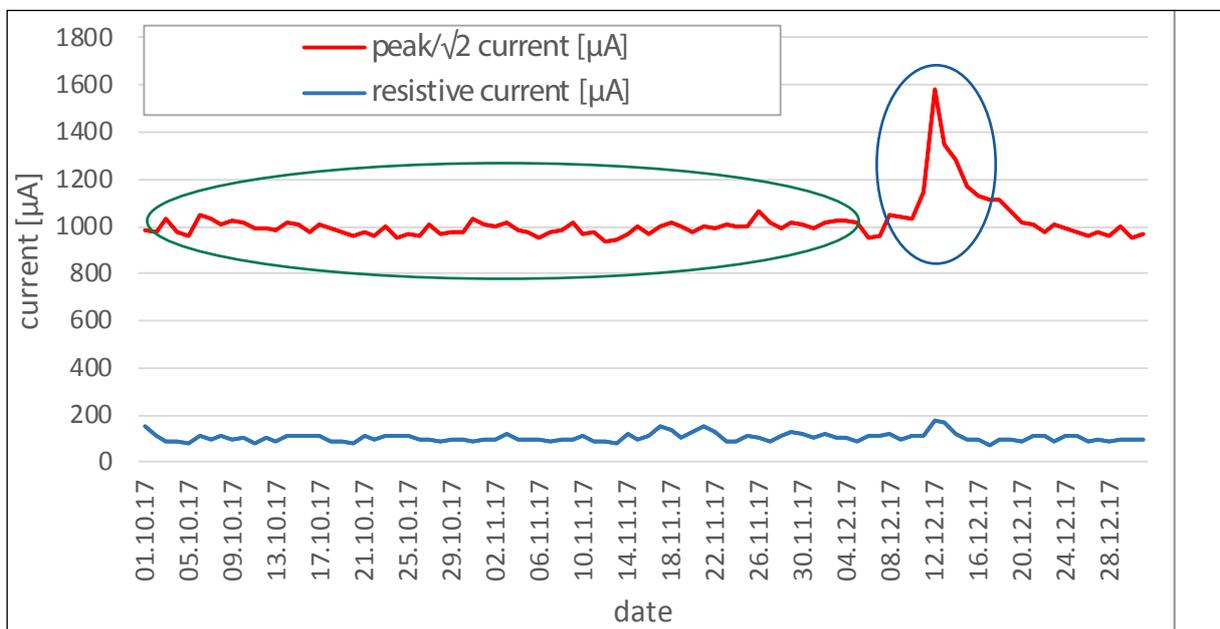
Figure 5.2.1 – Influences rain and humidity to the peak/√2 current

Humidity and rain induced peak/√2 current values always fall back to their nominal value under dry conditions. The resistive current is influenced only marginally.

5.3. Polluted arresters

In heavily polluted areas, like deserts, industrial parks and coastal areas, exposed surge arresters often show deposits of conductive sediments on their housing after a certain time period. Figure 4.3.1 shows the behavior of the surge arrester leakage current in a coastal desert climate with salt fog as well as humidity in the morning followed by hot and dry ambient conditions. Under dry air the peak/√2 current and the resistive current are stable on their nominal value. In the morning hours, where salty water vapor condenses on the surge arrester housing surface, the measured peak/√2 current will start rising. During hot and dry daytime, the peak/√2 current falls back to a level that is lower than the maximum value but still higher than the nominal current of a clean housing. This behavior repeats with every daily cycle with gradual rise in the daily maximum value as well as the subsequent nominal value to which the peak/√2 current falls back, when the arrester housing is drying. This behavior is due to the continuous growth of a pollution layer with high salinity and humidity during salt fog exposition.
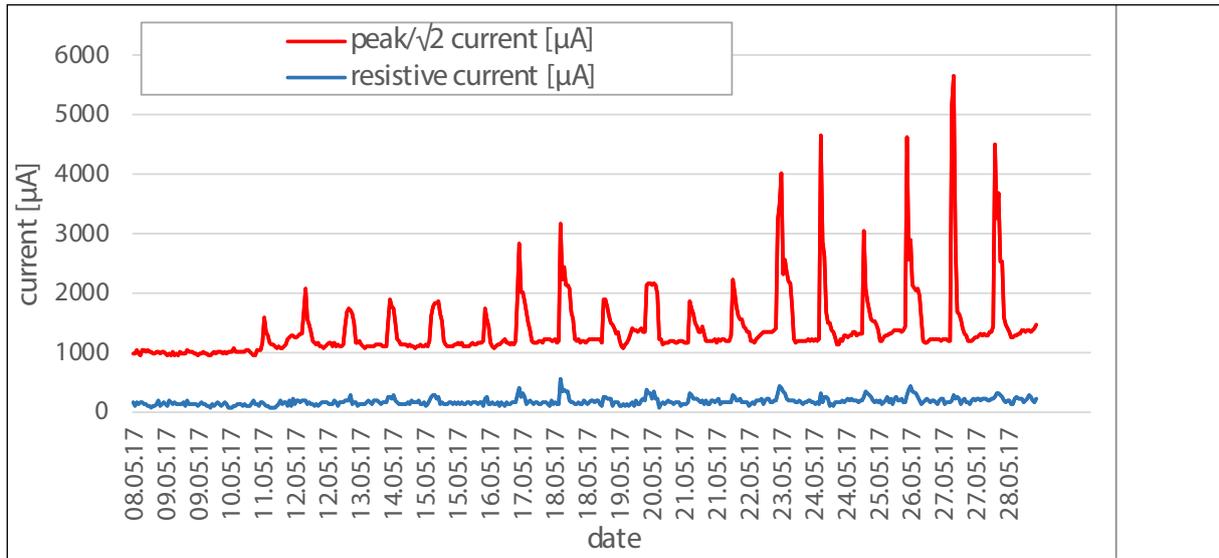
Figure 5.3.1 - high leakage current due to accumulating pollution

Especially wet salt layers have a high conductivity, thus the prevailing capacitive current is superimposed by very high sinusoidal currents that are in phase with the voltage. The nominal value rises and the dried off surface pollution layer remains partially conductive. The conductivity of the pollution layer rises with the cross section of the salty layer. The resistive current is marginally affected because the total current is approximately sinusoidal and primary contains a predominant 1st harmonic, a small 3rd harmonic from the ZnO current and high frequent distortion.

Cleaning the polluted surge arresters eliminates surface currents and brings the leakage current back to its normal value (Figure 5.3.2)
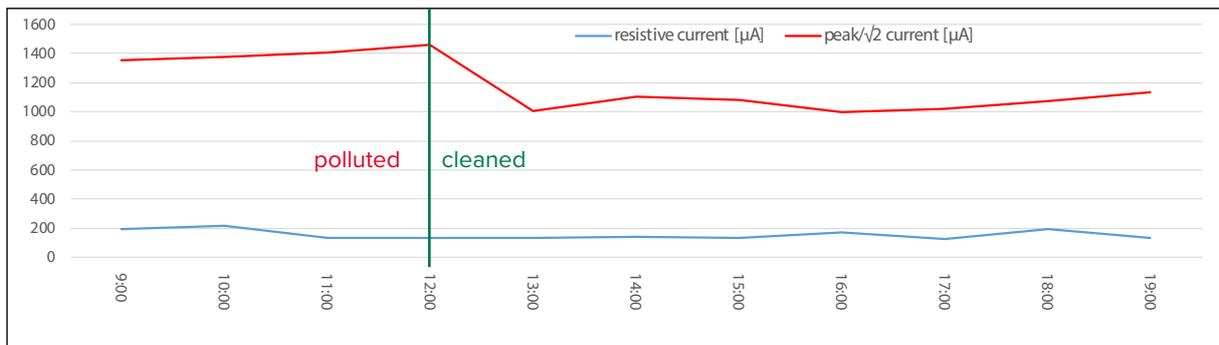
Figure 5.3.2 – recorded leakage current with polluted porcelain housing and after cleaning

5.4.   Detect humidity ingress

Humidity ingress is the most common reason for surge arrester breakdowns mostly induced by a tightness issue on the sealing system. When humidity has entered to a surge arrester with enclosed gas volume, the air humidity inside the arrester rises and consequently, a conductive water film will condense on the internal surfaces. A creepage current will establish along the inner insulator surface and along the stack of MOV blocks. Single MOV blocks or complete sections are short-circuited. The non-short-circuited sections of the MOV block stack are overloaded which finally leads to a thermal runaway.

The peak/√2 current will show stochastically rising and falling amplitudes due to the moistening, drying-off and remoistening of certain conductive creepage current paths. An impact to the resistive current will show up, if single MOV Blocks or complete MOV sections are humid and thus short-circuited. This scenario is alarming. A surge arrester exchange is absolute necessary (Figure 5.4.1).
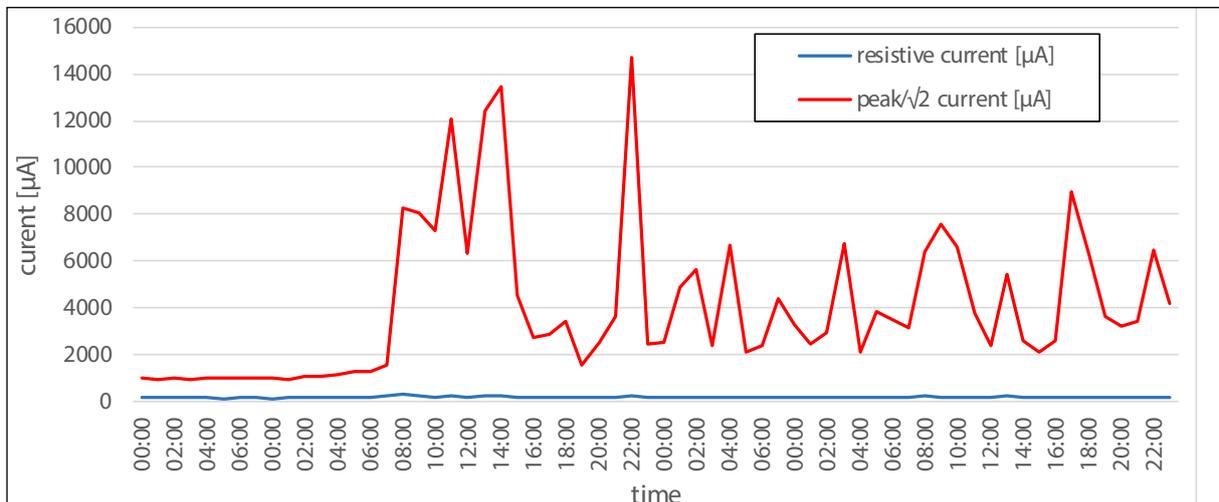
Figure 5.4.1 – recorded leakage current under humidity ingress

5.5. Discover degrading surge arresters

Degradation takes place, when the power loss in the stack of MOV blocks in a surge arrester is rising due to a change in its V-I-characteristic after an energy overload or as a result of aging. This case of a surge arrester fault manifests in a continuously rising resistive current. This scenario is alarming as well because rising resistive currents lead to rising surge arrester temperatures and finally to a thermal runaway. A surge arrester exchange might be necessary. For Tridelta Surge Arresters, the **smartCOUNT Cloud** system provides a critical resistive current threshold and gives a notification that this surge arrester is considered as critical (Figure 5.5.1).
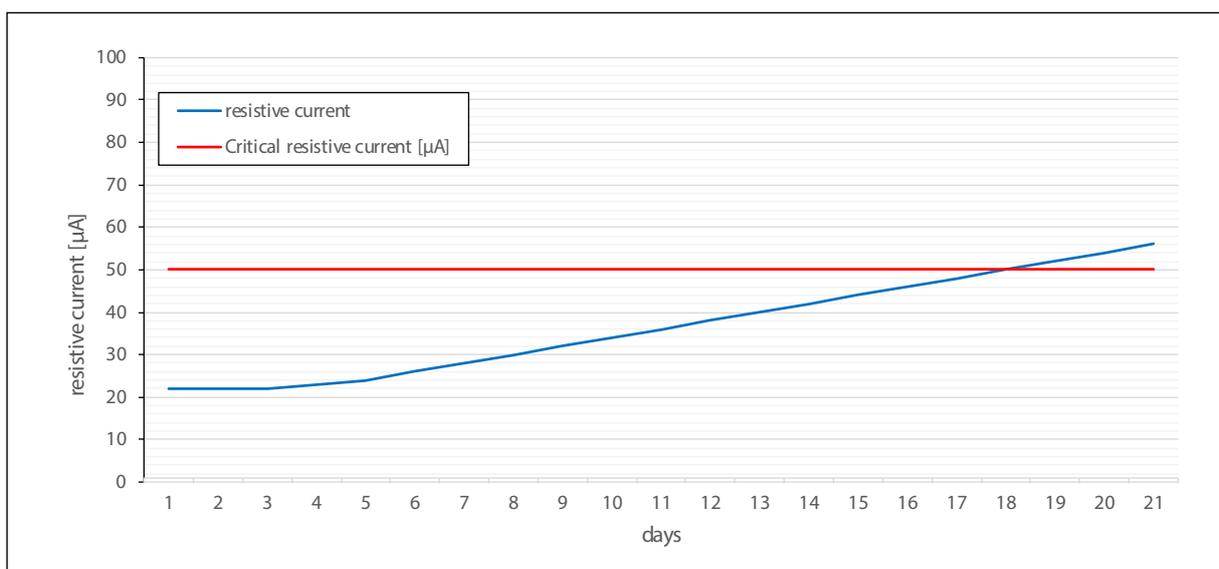
Figure 5.5.1 – rising resistive current due to degradation

5.6. Taking impulse currents into account

Previously surge counters (and monitoring spark gaps) have been used to estimate the condition of a surge arrester. The essential information about the arrester condition was derived from the number (and amplitude) of the discharges, the arrester has handled in its lifetime. Of course, the estimation of the arrester condition based on the change of the V-I-characteristic is rather precise. But it might be necessary to take the discharged currents into account and to relate them to the behavior of the temporal leakage current as well.

One possible case might be the overload of a surge arrester due to discharges with an amplitude or energy higher than specified. Subsequently, the resistive current will show a successive rise and no recovery, which is critical and requires an immediate arrester replacement. (Figure 5.6.1).
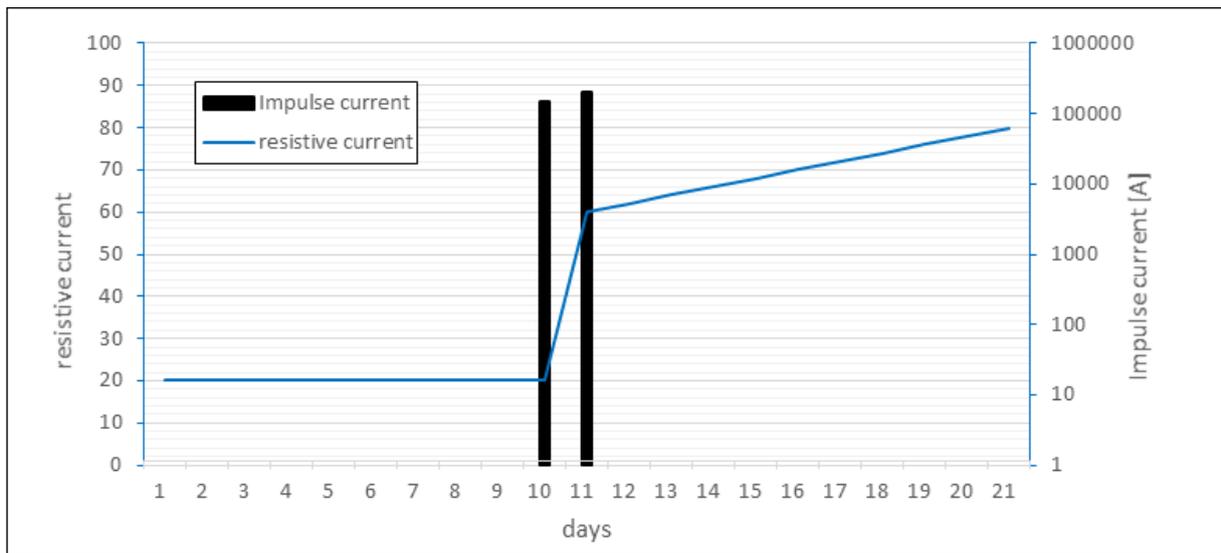
Figure 5.6.1 – rising resistive current caused by sudden degradation due to impulse overload

Another possible case is the occurrence of discharges, followed by a heating of the MOV blocks and consequently a step up of the resistive current and slow recovery to the nominal value afterwards while cooling down (Figure 5.6.2).
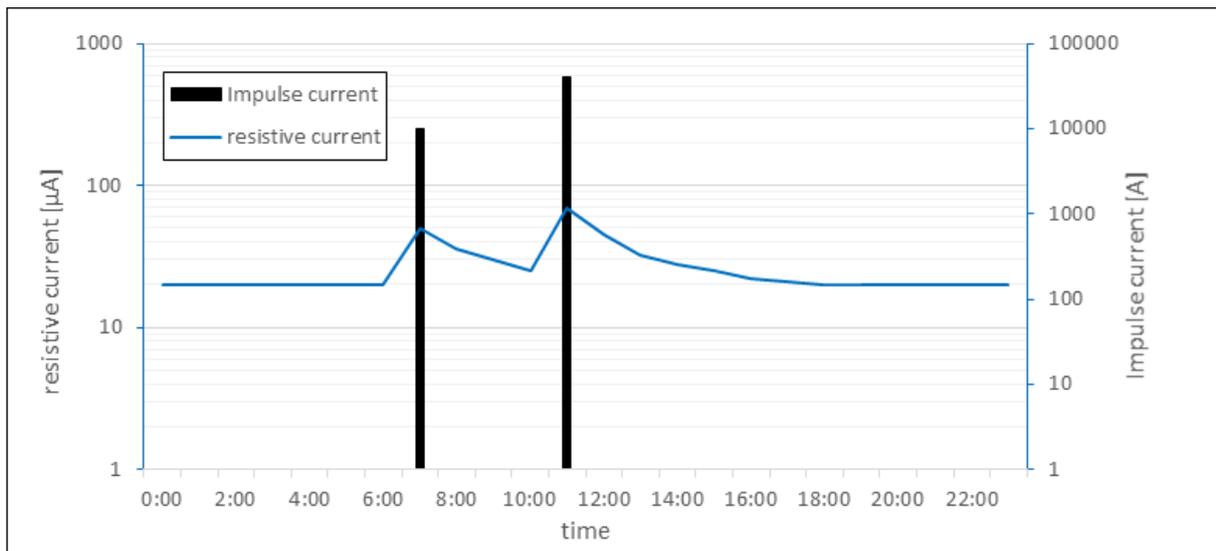
Figure 5.6.2 – rising and recovering resistive current caused by temporary heating of the MOV blocks due to discharges

5.7. Cases and recommendations

The following pictograms show the most common cases of leakage current behavior. The corresponding background information and recommendations are summarized accordingly.
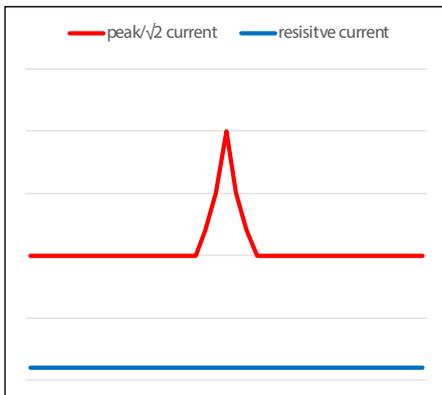
CASE A

Sudden spike in peak/√2 current
Later recovery of the nominal value
Reason: Current affected by heavy rain, humidity

➡ Arrester is ok
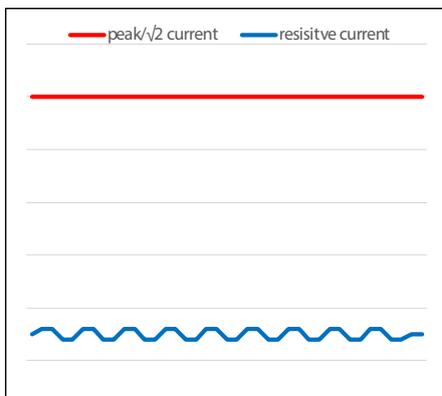
CASE B

Cyclic resistive current swing
Reason:Temperature or voltage fluctuation, wrong configuration

➡ Check the monitoring device configuration
➡ Configure automatic measurements at night
➡ Arrester is ok
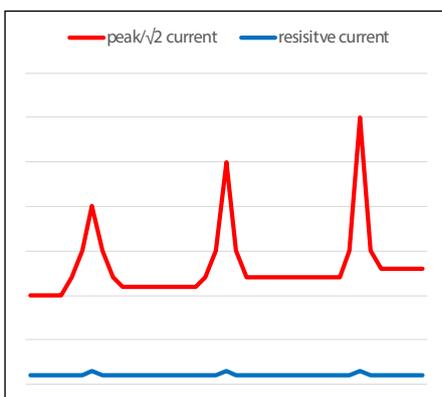
CASE C

Periodic spiking and peak/√2 current, rising nominal value
Reason: Surface pollution

➡ Check and clean the arrester to prevent outer flashover
➡ Recovery of nominal value
➡ Arrester is ok
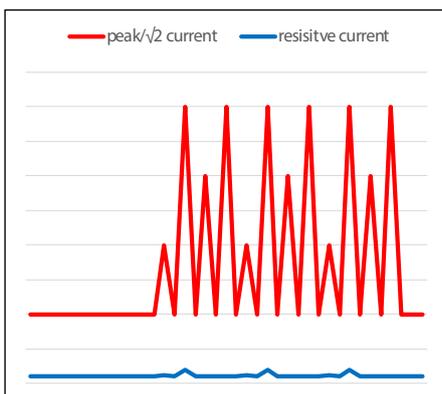
CASE D

Very high fluctuating peak/√2 currents and low change in resistive current
Arrester surface is clean (and dry)
Reason: Humidity ingress

➡ immediately replace the surge arrester
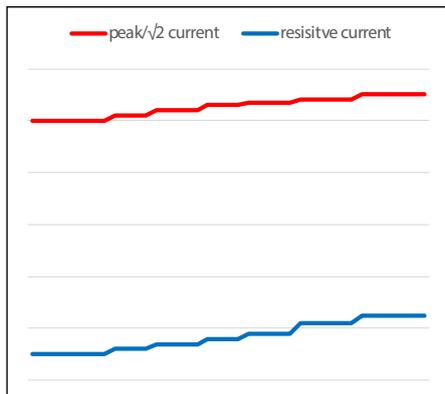
CASE E

Rising values of resistive (and peak/√2) current; successively over life-time or immediately after impulse current

Reason: MOV degradation

➡ Check more frequent and call the Manufacturer
➡ replace surge arrester preemtively

It is recommended to configure the **smartCOUNT Datalogger** for **daily measurement** at night. Consequently an effect according to CASE B is eliminated. Furthermore over 2 years of memory capacity for leakage current datasets can be used before overwriting the oldest entries.

It is recommended to configure the **smartCOUNT Datalogger** for **hourly measurement** to receive a highly resolved leakage current trend. This is necessary if a surge arrester shall be monitored with regards to surface pollution (CASE C) or humidity ingress (CASE D) or if the surge arrester has shown resistive current anomalies according to CASE E.

6. Technical Data and dimensions

Measuring range	
total leakage current	0 µA to 50 mA peak/√2
3rd harmonic leakage current	0 µA to 5 mA r.m.s.
resistive leakage current	0 µA to 5 mA r.m.s.
Leakage current resolution	1 µA
frequency	16,6 Hz 50 Hz 60 Hz
measurement cycle	1/hour 1/day 1/week
surge counting classification (8/20 µs)	x ≤ 100 A 100A < x ≤ 1000 A 1000A < x ≤ 5000 A 5000A < x ≤ 10.000 A 10.000A < x ≤ 40.000 A 40.000A < x ≤ 100.000 A
memory (cyclic buffer)	1000 leakage current entries 1000 impulse current entries
time stamp format	YYYY-MM-DD hh:mm:ss
operating temperature	-40 to +60 °C
data cable length	1 to 30 m

Seitenansicht / Sideview

Frontansicht / Frontview

Ansicht von unten /
View from below