

Documentation | EN

SCT5xxx

Ring-type current transformer for differential current 0...2 A, type B/B+ (all-current sensitive), ISO62020-1 conform



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1 Foreword

1.1 Notes on the documentation

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Patent Pending

The EtherCAT Technology is covered, including but not limited to the following patent applications and patents: EP1590927, EP1789857, EP1456722, EP2137893, DE102015105702 with corresponding applications or registrations in various other countries.

Intended audience

This description is only intended for the use of trained specialists in control and automation engineering who are familiar with the applicable national standards.

It is essential that the documentation and the following notes and explanations are followed when installing and commissioning these components.

The qualified personnel is obliged to always use the currently valid documentation.

The responsible staff must ensure that the application or use of the products described satisfy all the requirements for safety, including all the relevant laws, regulations, guidelines and standards.

1.2 Safety instructions

Description of instructions

In this documentation the following instructions are used.
These instructions must be read carefully and followed without fail!

DANGER

Serious risk of injury!

Failure to follow this safety instruction directly endangers the life and health of persons.

WARNING

Risk of injury!

Failure to follow this safety instruction endangers the life and health of persons.

CAUTION

Personal injuries!

Failure to follow this safety instruction can lead to injuries to persons.

NOTICE

Damage to environment/equipment or data loss

Failure to follow this instruction can lead to environmental damage, equipment damage or data loss.



Tip or pointer

This symbol indicates information that contributes to better understanding.

Exclusion of liability

All the components are supplied in particular hardware and software configurations appropriate for the application. Modifications to hardware or software configurations other than those described in the documentation are not permitted, and nullify the liability of Beckhoff Automation GmbH & Co. KG.

Personnel qualification

This description is only intended for trained specialists in control, automation and drive engineering who are familiar with the applicable national standards.

WARNING

Intended use

If the equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.

Safety regulations

Please note the following safety instructions and explanations!
Product-specific safety instructions can be found on following pages or in the areas mounting, wiring, commissioning etc.

Current transformer safety instructions

The following points must be noted:

- The applicable laws, standards and regulations.
- The state of the art at the time of installation.
- The technical rules.
- The operating instructions.

- The fact that operating instructions can only list general regulations and that these regulations must be followed.
- Check the device carefully for transport damage prior to commissioning. The device must not be put into operation if it is mechanically damaged.
- The devices described are intended for installation by qualified electricians and may only be installed in electrical plant rooms or in closed housings. Any other use or the disregard of these application notes will result in the loss of the warranty/guarantee.
- The devices may only be installed in dry indoor rooms.
- Do not mount on highly flammable materials.
- Operation with a higher current than the rated current specified on the name plate can lead to overheating of the current transformer and thus to burns.

2 Product overview

2.1 Introduction

SCTxxxx | Current transformers for power measurement



Fig. 1: SCT current transformers

The SCT current transformers allow reliable power sensor technology to be implemented directly in the field as an integral part of the PC-based control system. Users can choose between two concepts, which are highly scalable thanks to various designs and performance classes and are thus suitable for any application. The SCT series portfolio is extremely diversified, ranging from the low-cost 3-phase transformer sets for properties and standard industrial transformers for mechanical engineering, through to solutions for test benches with particularly high requirements for accuracy.

The choice of the right product category [► 14] depends on the type of usage:

Whilst the data acquisition can be implemented cost-efficiently and with high measurement accuracy using the ring-type current transformers, particularly in new systems, the split-core current transformers are suitable as an uncomplicated retrofit solution due to the simplicity of their attachment.

The SCT5xxx transformers occupy a special position. These are not intended for energy measurement, but are specially designed for highly accurate detection of differential currents. In addition, unlike the other SCT transformers, they are also suitable for DC currents and thus meet the differential current detection according to the Type B definition. Therefore, AC as well as DC currents up to 100 kHz can be measured by a fluxgate measuring principle.

2.2 Basics current transformers

Basic information on the technology area of current transformers is given in the following. The information is of general nature; so it is imperative to check the extent to which these notes apply to your specific application.

Function and design

A current transformer is a transforming device that transforms an input current into a processable current signal at the output. A current transformer is mainly used to transform currents of large magnitudes to directly measurable, smaller values in the milliampere or small ampere range. With a classic current transformer, the input current is proportional to the output current. Due to the physical principle and the mechanical construction, the current signal is transmitted galvanically isolated to the evaluation electronics.

A current transformer basically consists of a small number of windings on the primary side and a larger number of windings on the secondary side. The current to be converted flows through the primary side. The windings are usually wound on an alternating magnetic ferrite ring core.

A typical transformer type is the ring core or ring-type current transformer. The current rail or current-carrying cable is often used as the primary winding, which is guided through the toroidal core of the transformer. Thus, the rail or line forms the primary winding with one turn. The secondary winding is located on the ring core. The transformation is determined by the ratio of the number of primary and secondary windings. The classic structure of a ring-type current transformer is shown in the following figure.

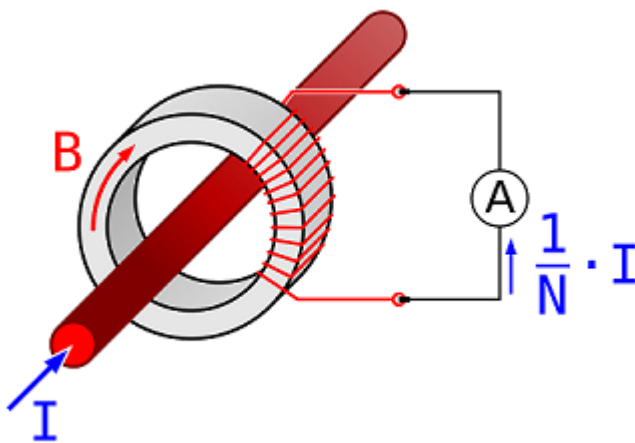


Fig. 2: Principle ring-type current transformer

Another classic type is the coiled current transformer. In this type of transformer, the primary winding is a current-carrying wire which is wound around the ring core on the primary side. In this case, the primary winding number is > 1 , but smaller than the secondary winding number. The principle is shown in the following figure

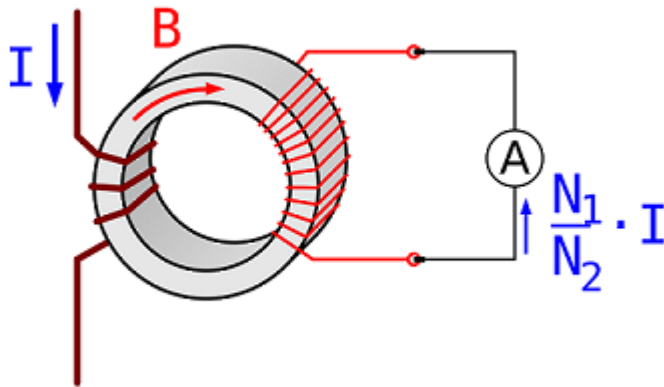


Fig. 3: Principle coil current transformer

⚠ WARNING

Dangerous voltages with secondary side not connected

The secondary winding must be connected to a current measuring device or short-circuited, otherwise high core losses or dangerous voltages may occur on the secondary side. Before replacing the measuring electronics in the secondary circuit, the current transformer must therefore be short-circuited at its secondary terminals.



Grounding of secondary terminals

According to DIN VDE 0141 (01/2000) paragraph 5.3.4, current and voltage transformers for nominal voltages from $U_m = 3.6 \text{ kV}$ must be grounded on the secondary side. For low voltages ($U_m \leq 1.2 \text{ kV}$), grounding is not required if the transformer housings do not have any metal surfaces with large contact areas.

Characteristic values and calculation

In principle, the construction, and thus also the calculation, correspond to a normal transformer. The basic relationship between input and output current is determined by the ratio of the number of turns N of the primary and secondary sides. An important characteristic value in the design of a current transformer is therefore the transformer ratio.

$$I_{\text{Out}} = N_1/N_2 \cdot I_{\text{In}}$$

Technical terms of current transformers

Term	Explanation
Primary rated current I_{pr} (alternative symbol I_N)	Value of the rated current on the primary side
Secondary rated current I_{sr}	Value of the rated current on the secondary side.
Rated power S_r	Value of apparent power (in [VA]) that the transformer can deliver to the secondary circuit at secondary rated current and rated load
Rated frequency f_R	Value of the rated frequency.
Accuracy class	Indication that the measurement deviations are within specified limits under prescribed conditions of use.
Rated insulation level U_m	<p>Highest voltage; RMS value of the highest conductor-to-conductor voltage for which a measuring transformer is rated with respect to its insulation</p> <p>The value of the rated insulation level is given in three values:</p> <ol style="list-style-type: none"> 1. maximum value of the conductor-to-conductor voltage for which the insulation of the transformers is designed; 2. value of the rated short-duration power frequency withstand voltage (50 Hz, 1 min), with which the insulation safety of the devices is tested 3. value of the surge voltage level (this specification is mostly unoccupied here, since according to IEC 61869/1 a specification is only required for transformers with a conductor-to-conductor voltage of > 1.2 kV)
Overcurrent limiting factor (FS)	Ratio of rated limiting current to primary rated current.
Rated continuous thermal current I_{cth}	Value of the continuous current in the primary winding at which the overtemperature does not exceed the value specified in the standard, with the secondary winding loaded with the rated load.
Rated short-time thermal current I_{th}	Value of short-time current for a limited time in the primary winding at which the overtemperature does not exceed the value specified in the standard, with the secondary winding loaded with the rated load.
Rated peak current I_{dyn}	Maximum value of the primary current whose electromagnetic force effect does not cause electrical and mechanical damage to the current transformer with short-circuited secondary winding.
"Open voltage" of current transformers	<p>Current transformers which are not directly connected to a load must be short-circuited on the secondary side for safety reasons!</p> <p>A current transformer operated open on the secondary side induces very high peak voltage values at its secondary terminals. The magnitudes of these voltages can reach values of up to several kilovolts, depending on the dimensioning of the current transformer, and thus represent a danger to persons and the functional safety of the transformer. For safety reasons, open operation should generally be avoided in order to prevent magnetization of the core iron during secondary open operation.</p>
Grounding of secondary terminals	According to DIN VDE 0141 (01/2000) paragraph 5.3.4, current and voltage transformers for nominal voltages from $U_m = 3.6$ kV must be grounded on the secondary side. For low voltages ($U_m \leq 1.2$ kV), grounding is not required if the transformer housings do not have any metal surfaces with large contact areas.

Principle of the fluxgate current measurement technology

While all SCT transformers except the SCT5xxx are based on the transformer principle described above, the technology of the all-current sensitive differential current transformers is fundamentally different.

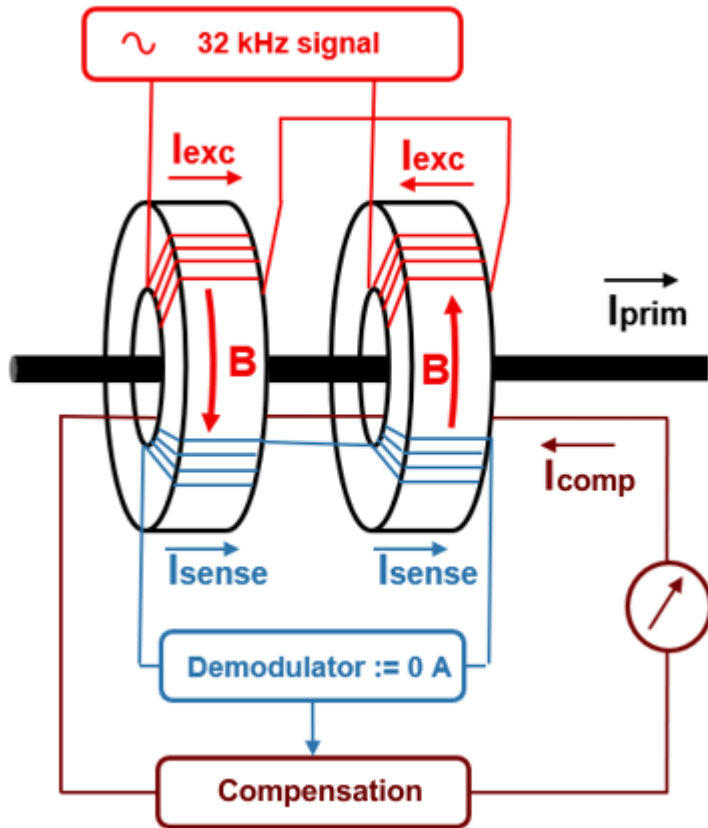


Fig. 4: Principle fluxgate current measurement technology

The measuring principle of the SCT5xxx is based on a differential current measurement of two oppositely excited cores in the transducer. For this purpose, both cores are brought into saturation with an excitation winding (red) with an internally generated 32 kHz signal, whereby the first core is driven in the positive and the second in the negative range of the y-axis. See fig.)

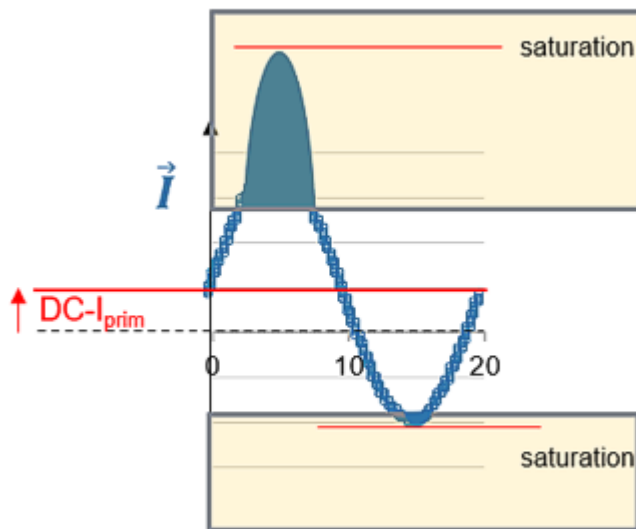


Fig. 5: Characteristics fluxgate current measurement technology

The detection winding now measures the induced current of the excitation winding (blue). If the measuring current I_{prim} is 0, then 0 A is also measured, since no compensating current is generated for compensation.

If the measuring current I_{prim} is not equal to 0, a compensating current is generated through both cores, which again compensates for the disproportion of the magnetic flux density B in core 1 and core 2. Due to the compensation, I_{sense} is 0 again.

The measured compensating current provides information about the current to be measured I_{prim} .

Together with a fixed excitation frequency, this leads to improved accuracy and stability.

General description of the fluxgate current measurement technology

The SCT series SCT5xxx is used for monitoring differential currents in electrical power supply systems that do not require fast system shutdown. The SCT5xxx type B/B+ can measure DC and AC residual currents at frequencies up to 100 kHz.

This makes this differential current transformer compatible with a wide range of industrial applications, loads and power sources. With its user-selectable settings, this series provides a flexible platform for differential current measurement suitable for any possible application, both at the time of industrial plant design and when expanding with new modern loads operating at DC voltages or high switching frequencies that increase the amount of leakage current in the system.

The SCT5xxx have an analog 4 - 20 mA output, which represents the real-time RMS value (TRMS) of the measured residual current for connection to a PLC, for example. In addition, a potential-free relay output (NO / NC) with a freely selectable residual current limit can be used for warning or even system shutdown if the TRMS residual current measured value has exceeded the preset value. The status of the relay output is replicated on an LED for visual indication on the device itself. A built-in test button and an external test button input are provided for periodic testing of the SCT5xxx according to the applicable product standards. Only a single 24 Vdc power supply should be provided for the SCT5xxx.

2.3 Product categories – SCTxxxx current transformer

Breakdown of the type designation of the SCT current transformer

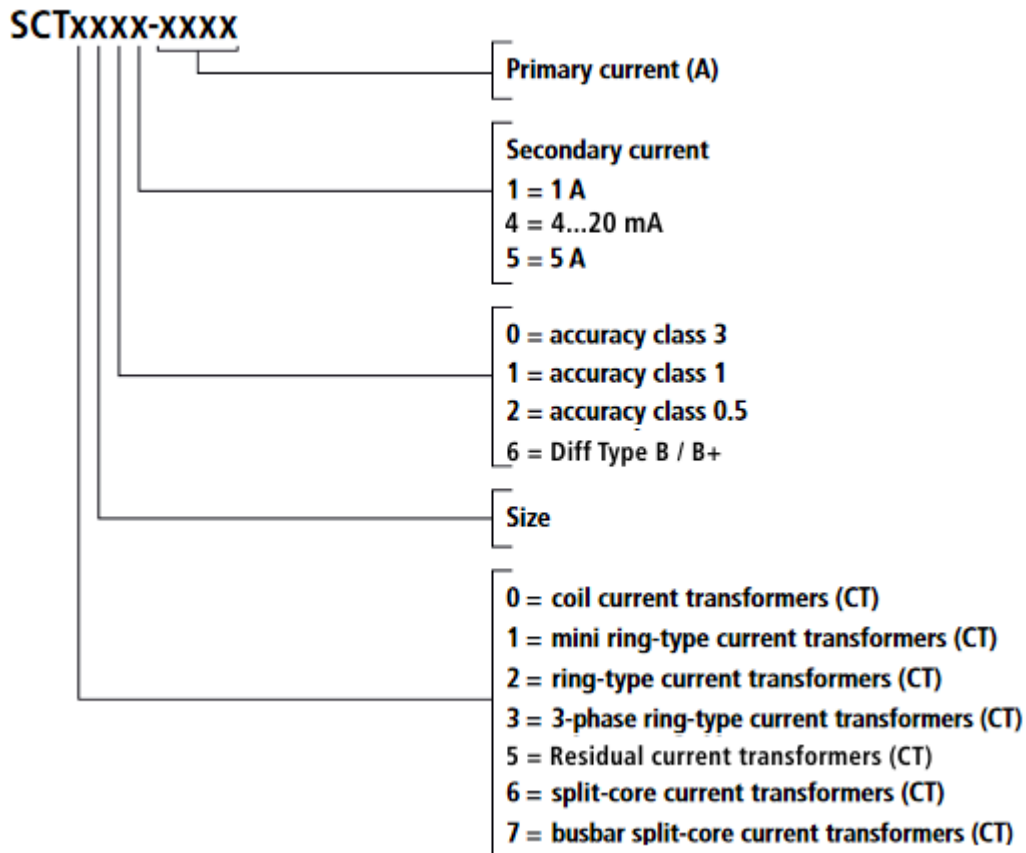


Fig. 6: Designation key of the SCT current transformers

Coil current transformers



Fig. 7: SCT0xxx

In order to guarantee the power transmission, current transformers need a correspondingly large measuring core volume with decreasing primary nominal currents. The dimensions of standard current transformers would quickly hit their limits on the basis of this physical principle. The SCT0xxx coil current transformers with electrical isolation are specially designed for these low primary nominal currents and are used in corresponding applications.

Coil current transformers	
<u>SCT0111</u>	Accuracy class 1, Primary current 0...1 A AC to 0...30 A AC, Secondary current 1 A AC
<u>SCT0121</u>	Accuracy class 0.5, Primary current 0...1 A AC to 0...30 A AC, Secondary current 1 A AC

Mini ring-type current transformer

Fig. 8: SCT1xxx

The SCT1111 mini ring-type current transformer can be positioned on a DIN rail by means of snap-on mounting and is thus suitable for measurements in very tight installation spaces, e.g. directly in the sub-distribution unit. Two current transformers are attached to the DIN rail, while the third current transformer is plugged into the fastened current transformers. The connection is realized via removable picoMAX® connectors, which enables pre-wiring.

Mini ring-type current transformer	
SCT1111	Accuracy class 1, Primary current 0...32 A AC to 0...64 A AC, Secondary current 1 A AC, Max. diameter round conductor 7.6 mm (size 1)

Ring-type current transformer



Fig. 9: SCT2xxx

The SCT2xxx series offers a large selection of ring-type current transformers for primary currents from 60 to 2500 A in six sizes and two accuracy classes. The innovative screwless connection technology for rigid and flexible conductors saves time – ferrules can be dispensed with here.

Ring-type current transformer	
<u>SCT2111</u>	Accuracy class 1, Primary current 0...60 A AC to 0...500 A AC, Secondary current 1 A AC, Max. diameter round conductor 25.7 mm (size 1)
<u>SCT2121</u>	Accuracy class 0.5, Primary current 0...125 A AC to 0...600 A AC, Secondary current 1 A AC, Max. diameter round conductor 25.7 mm (size 1)
<u>SCT2211</u>	Accuracy class 1, Primary current 0...600 A AC / 750 A AC, Secondary current 1 A AC, Max. diameter round conductor 31.8 mm (size 2)
<u>SCT2221</u>	Accuracy class 0.5, Primary current 0...600 A AC / 750 A AC, Secondary current 1 A AC, Max. diameter round conductor 31.8 mm (size 2)
<u>SCT2311</u>	Accuracy class 1, Primary current 0...800 A AC / 1000 A AC, Secondary current 1 A AC, Max. diameter round conductor 43.7 mm (size 3)
<u>SCT2321</u>	Accuracy class 0.5, Primary current 0...800 A AC / 1000 A AC, Secondary current 1 A AC, Max. diameter round conductor 43.7 mm (size 3)
<u>SCT2411</u>	Accuracy class 1, Primary current 0...1250 A AC / 1500 A AC, Secondary current 1 A AC, Max. diameter round conductor 43.7 mm (size 4)
<u>SCT2421</u>	Accuracy class 0.5, Primary current 0...1250 A AC / 1500 A AC, Secondary current 1 A AC, Max. diameter round conductor 43.7 mm (size 4)
<u>SCT2515</u>	Accuracy class 1, Primary current 0...2000 A AC, Secondary current 5 A AC, Max. diameter round conductor 54.7 mm (size 5)
<u>SCT2525</u>	Accuracy class 0.5, Primary current 0...2000 A AC, Secondary current 5 A AC, Max. diameter round conductor 54.7 mm (size 5)
<u>SCT2615</u>	Accuracy class 1, Primary current 0...2500 A AC, Secondary current 5 A AC, Max. diameter round conductor 70 mm (size 6)
<u>SCT2625</u>	Accuracy class 0.5, Primary current 0...2500 A AC, Secondary current 5 A AC, Max. diameter round conductor 70 mm (size 6)

3-phase ring-type current transformers



Fig. 10: SCT3xxx

The compact SCT3xxx 3-phase ring-type current transformers for direct mounting below commonly used power switches measure primary currents from 3 x 50 to 3 x 600 A, with secondary currents of 1 or 5 A. The SCT3xxx series is available throughout in accuracy class 1 and is supplemented by the SCT3121-0125 and SCT3121-0150 current transformers in accuracy class 0.5.

3-phase ring-type current transformers	
SCT3111	Accuracy class 1, Primary current 3 x 0...50 A AC to 3 x 0...150 A AC, Secondary current 1 A AC, Max. diameter round conductor 13.5 mm (size 1)
SCT3121	Accuracy class 0.5, Primary current 3 x 0...125 A AC / 3 x 0...150 A AC, Secondary current 1 A, Max. diameter round conductor 13.5 mm (size 1)
SCT3215	Accuracy class 1, Primary current 3 x 0...100 A AC to 3 x 0...250 A AC, Secondary current 5 A AC, Max. diameter round conductor 18 mm (size 2)
SCT3315	Accuracy class 1, Primary current 3 x 0...250 A AC to 3 x 0...600 A AC, Secondary current 5 A AC, Max. diameter round conductor 22 mm (size 3)

Ring-type current transformer for differential current measurement

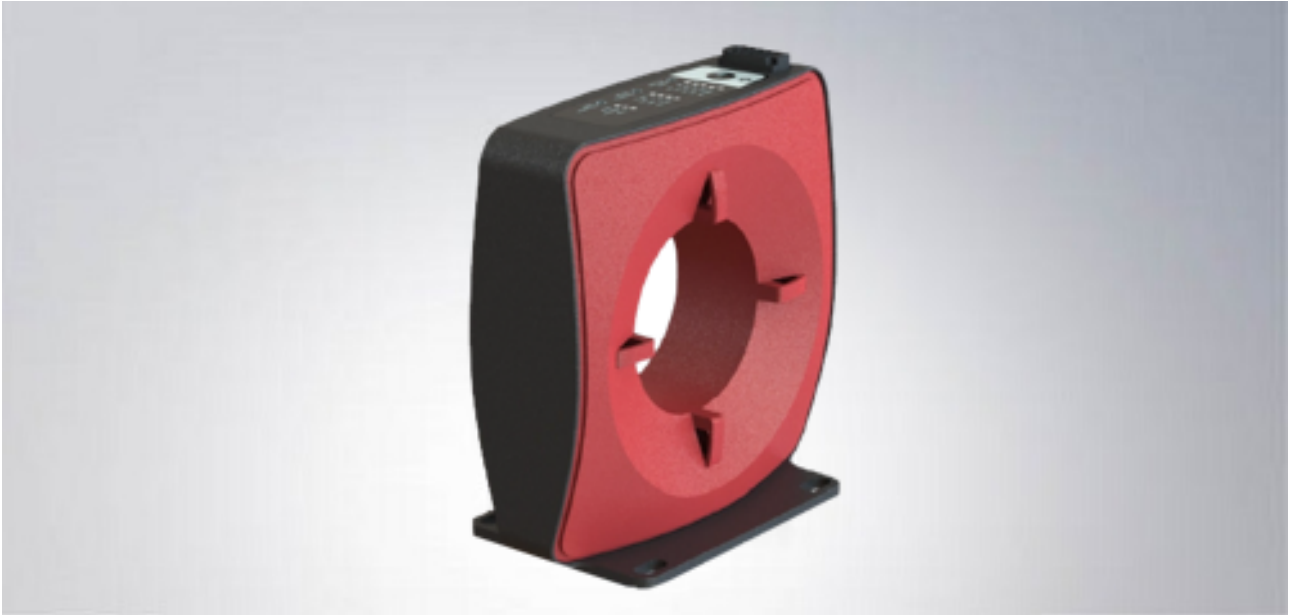


Fig. 11: SCT5xxx

The increasing prevalence of DC loads (e.g., LED lighting, DC motor drives, 48 V DC bus systems, etc.), distributed DC generation (e.g., PV systems, UPS, batteries, etc.), and high-frequency converters (e.g., SMPS, motor drives, etc.) in industrial environments makes it increasingly difficult to reliably measure insulation faults with conventional current transformers designed for AC 50/60 Hz with limited measurement bandwidth.

Differential current transformers of the SCT5xxx series can be used here. Monitoring residual currents with the SCT5xxx in real-time in a power system opens up the possibility of evaluating the condition of the electrical insulation based on the actual measured value, so that the long-term trend of the residual current value can be used for planning maintenance to detect significant deterioration of the insulation.

This means that residual current monitors (SCT5xxx) used in a condition-based monitoring scheme Industrie 4.0-Standards, can detect faults in a timely manner and increase the availability of power supplies or plants at a much lower cost than conventional, expensive, and time-consuming high-voltage insulation testing.

Ring-type current transformer for differential current measurement	
<u>SCT5564</u>	Measuring ranges 400 mA / 2 A, type B / B+, transformer opening 70 mm

Split-core current transformers



Fig. 12: SCT6xxx

The separable measuring system of the SCT6xxx split-core current transformers enables flexible retrofitting without disconnecting the primary conductor. Due to the minimal installation effort, they are suitable for use in places that are difficult to access or where space is limited. Four sizes are available. Accuracy class 3 is suitable for primary currents from 60 to 150 A, accuracy class 1 for 200 to 1000 A.

Split-core current transformers	
<u>SCT6101</u>	Accuracy class 3, Primary current 0...60 A AC to 0...150 A AC, Secondary current 1 A AC, Max. diameter round conductor 18.5 mm (size 1)
<u>SCT6311</u>	Accuracy class 1, Primary current 0...200 A AC / 0...250 A AC, Secondary current 1 A AC, Max. diameter round conductor 18.5 mm (size 3)
<u>SCT6321</u>	Accuracy class 0.5, Primary current 0...200 A AC / 0...250 A AC, Secondary current 1 A AC, Max. diameter round conductor 18.5 mm (size 3)
<u>SCT6411</u>	Accuracy class 1, Primary current 0...300 A AC to 0...500 A AC, Secondary current 1 A AC, Max. diameter round conductor 27.9 mm (size 4)
<u>SCT6421</u>	Accuracy class 0.5, Primary current 0...400 A AC / 0...500 A AC, Secondary current 1 A AC, Max. diameter round conductor 27.9 mm (size 4)
<u>SCT6615</u>	Accuracy class 1, Primary current 0...600 A AC / 0...750 A AC, Secondary current 5 A AC, Max. diameter round conductor 42.4 mm (size 6)
<u>SCT6625</u>	Accuracy class 0.5, Primary current 0...600 A AC / 0...750 A AC, Secondary current 5 A AC, Max. diameter round conductor 42.4 mm (size 6)
<u>SCT6715</u>	Accuracy class 1, Primary current 0...800 A AC / 0...1000 A AC, Secondary current 5 A AC, Max. diameter round conductor 2 x 42.4 mm (size 7)
<u>SCT6725</u>	Accuracy class 0.5, Primary current 0...800 A AC / 0...1000 A AC, Secondary current 5 A AC, Max. diameter round conductor 2 x 42.4 mm (size 7)

Busbar split-core current transformers



Fig. 13: SCT71xx

Like the SCT6xxx series, the SCT7xxx busbar split-core current transformers for primary currents up to 5000 A can be retrofitted to existing systems with no great mounting effort. From 500 A, there is a choice between accuracy class 0.5 and 1 for each primary current. The SCT7105-0100 and SCT7105-200 current transformers support accuracy class 3.

Busbar split-core current transformers	
SCT7105	Accuracy class 3, Primary current 0...100 A AC / 0...200 A AC, Secondary current 5 A AC, Max. diameter round conductor 20 mm (size 1)
SCT7115	Accuracy class 1, Primary current 0...200 A AC / 0...450 A AC, Secondary current 5 A AC, Max. diameter round conductor 20 mm (size 1)
SCT7125	Accuracy class 0.5, Primary current 0...400 A AC, Secondary current 5 A AC, Max. diameter round conductor 20 mm (size 1)
SCT7215	Accuracy class 1, Primary current 0...500 A AC / 0...600 A AC, Secondary current 5 A AC, Max. diameter round conductor 50 mm (size 2)
SCT7225	Accuracy class 0.5, Primary current 0...500 A AC / 0...600 A AC, Secondary current 5 A AC, Max. diameter round conductor 50 mm (size 2)
SCT7315	Accuracy class 1, Primary current 0...750 A AC to 0...1500 A AC, Secondary current 5 A AC, Max. diameter round conductor 80 mm (size 3)
SCT7325	Accuracy class 0.5, Primary current 0...750 A AC to 0...1500 A AC, Secondary current 5 A AC, Max. diameter round conductor 80 mm (size 3)
SCT7415	Accuracy class 1, Primary current 0...1500 A AC to 0...5000 A AC, Secondary current 5 A AC, Max. diameter round conductor 80 mm (size 4)
SCT7425	Accuracy class 0.5, Primary current 0...1500 A AC to 0...5000 A AC, Secondary current 5 A AC, Max. diameter round conductor 80 mm (size 4)

3 Technical data

3.1 SCT5xxx | Ring-type current transformer for differential current, size 5

3.1.1 SCT5564

Primary side	SCT5564
Rated primary current I_n	100 A ($I_{\Delta n} = 30 \text{ mA}$) 300 A ($I_{\Delta n} = 100\text{-}1000 \text{ mA}$)
Thermal differential continuous current $I_{\Delta \text{cth}}$	100 A
Thermal differential short-time current $I_{\Delta \text{th}}$	200 A (max. 10 ms)
Differential impulse current $I_{\Delta \text{dyn}}$	10 kA
Rated frequency f_n	50 / 60 Hz
Permissible primary current frequency range	0...400 Hz
Rated voltage U_n	690 V (RMS)
Pulse dielectric strength U_{imp}	8 kV

Current output	SCT5564
Output current	4...20 mA
Measuring ranges	0.4 A (RMS) for ($I_{\Delta n} = 30\text{-}300 \text{ mA}$) 2 A (RMS) for ($I_{\Delta n} = 0.5\text{-}1 \text{ A}$)
Resolution	0.01 mA
Update interval	1 ms (1 kHz)
Measurement uncertainty	< $\pm 2 \%$ typ. (< $\pm 5 \%$ max.) for 10-400 Hz < $\pm 3 \%$ typ. (< $\pm 7 \%$ max.) for DC-10 kHz (relative to full scale value) ^{*)}
Differential current frequency range - adjustable	DC-100 Hz**) DC-2 kHz DC-20 kHz DC-100 kHz
Integration time - adjustable	Short (100 ms) Medium (400 ms) Long (1000 ms)

*) Please pay attention to cable routing (see [mounting instructions \[► 27\]](#))!

**) The frequency range of 100 Hz makes the SCT5xxx less sensitive to higher frequencies and does not correspond to type B according to IEC62020-1

Relay output	SCT5564
Relay output	NO+NC
Relay switched on	100 % $I_{\Delta n}$ +0 % - 20 % at 50 / 60 Hz
Relay switched off	50 % $I_{\Delta n}$ +20 % - 0 % at 50 / 60 Hz
Relay voltage / current	max. 30 V and 1 A AC/DC
Switching cycles	> 20,000

General	SCT5564
Supply voltage	24 V dc +10 % / -15 %
Permissible ambient temperature range during operation	-20...+55 °C
Permissible ambient temperature range during storage	-40 ... +85 °C
Permissible relative air humidity	20 ... 80 % (no condensation)
Protection rating	IP20
Connection secondary	DFMC 1.5-3.5 2x5way (PN: 1790519), or compatible
Conductor cross-section secondary	0.2 ... 1.5 mm ² / 16-24 AWG
Strip length	10 mm
Size	5
Dimensions (W x H x D)	151.3 mm x 161 mm x 83.4 mm
Weight	typ. 900 g
Standards/Regulations	EN / IEC 62020-1:2020
Approvals/markings ^{*)}	CE

^{*)} Real applicable approvals/markings see type plate on the side (product marking).

SCT5564 dimensions, size 5

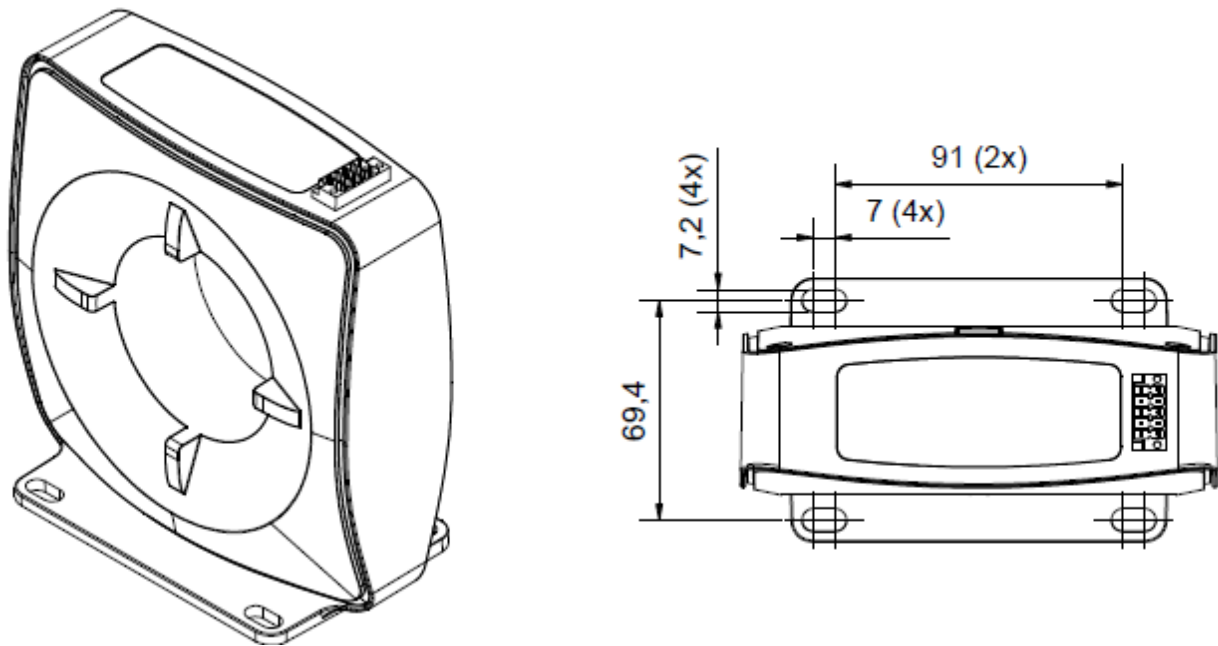


Fig. 14: Isometric view, top view; all dimensions in mm

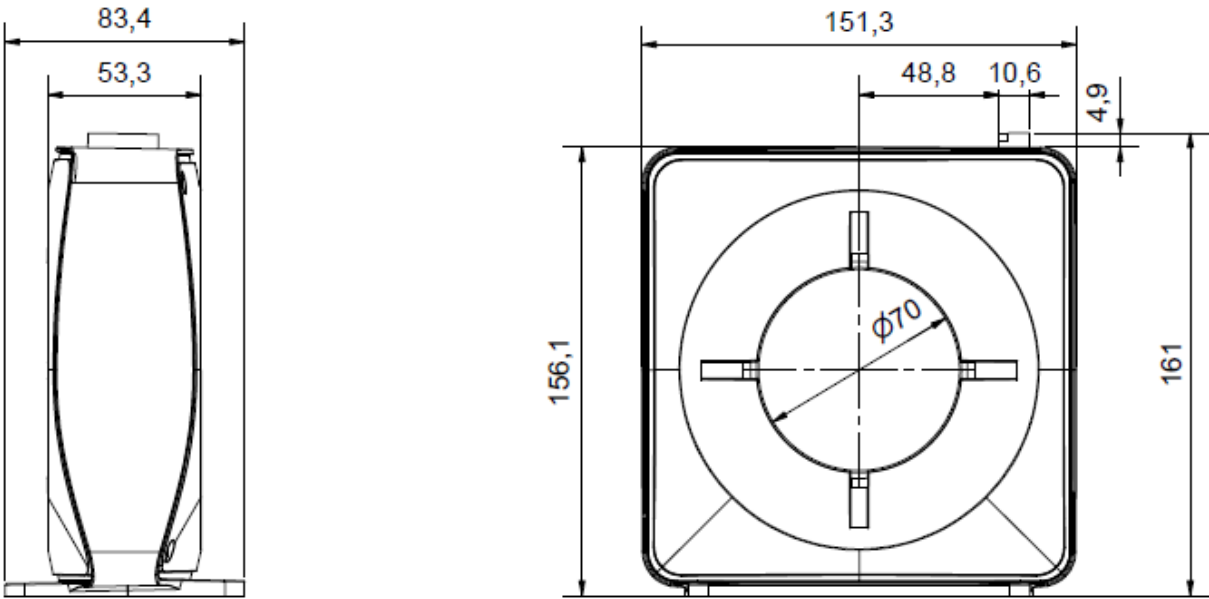


Fig. 15: Side view, front view, all dimensions in mm

4 Commissioning

DANGER

Open transformer circuits lead to electric shock and arc flashover!

Disregarding this will result in death, physical injury or considerable damage to property!

- Never open the secondary circuit of the current transformer under load.
- Short-circuit the secondary current terminals of the current transformer before removing the device.

WARNING

Hazardous voltage can lead to electric shock and burns!

- Make sure that the details on the name plate and in the "Technical data" correspond to the operating parameters of the system.
- Switch the system off before commencing with the installation!

WARNING

Induction of high voltages into the secondary circuit!

- If the secondary circuit of the current transformer is not under load (open), high voltages are induced on its secondary terminals. The voltage values occurring there represent a danger to persons and the functional safety of the current transformer.
- "Open operation", i.e. operation of the current transformer without secondary wiring, must be avoided at all costs.

4.1 Mounting instructions, mounting options

- Make sure that the working environment is safe during assembly, maintenance and installation work. Interrupt the power supply of the primary conductor and secure against being switched on again inadvertently.
- Install the current transformer on the primary conductor.
- To do this, feed the primary conductor through the opening of the current transformer housing
- The device can be fastened directly to the primary conductor or alternatively to a mounting plate. Use the fastening materials included in the scope of delivery for this.

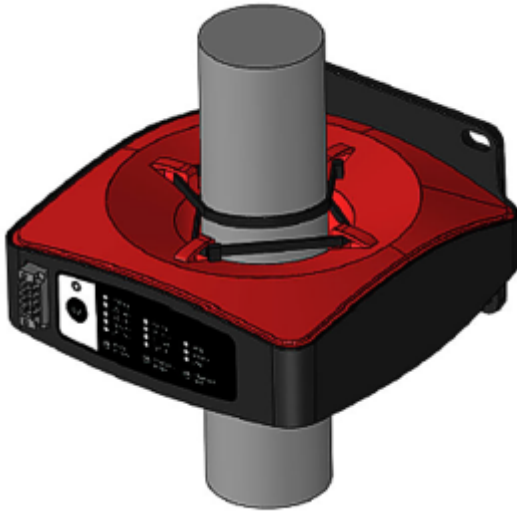


Fig. 16: Mounting SCT5xxx

- Fastening the base plate with screws in the four holes
- Free suspension on the cable with the help of cable ties through the hooks on the back for attachment
- All current-carrying conductors/lines must be routed together through the measuring current transformer [► 29], see Fig, "Use in single-phase and 3- and 4-pin three-phase systems".
- An existing protective conductor [► 29] must not be routed through the transformer
- Bending of the primary conductors may only take place from the specified minimum distance. The bending radii specified by the manufacturers must be observed.

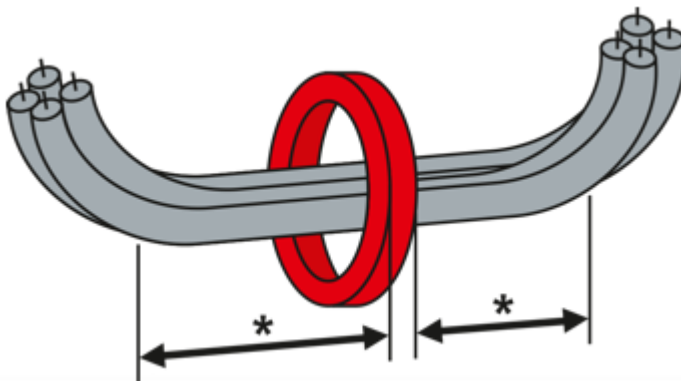


Fig. 17: Calculation bending primary conductor: *distance to 90° angle = 2x outer diameter

- The conductors are to be centered in the measuring transformer

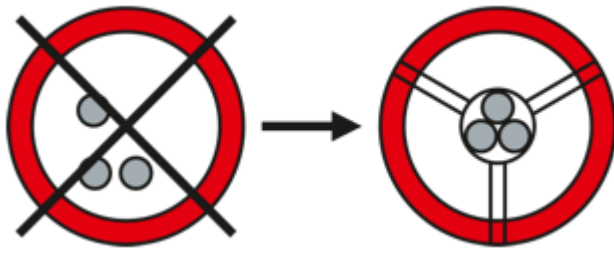


Fig. 18: Center conductors

4.2 Measurement circuit example SCT5xxx

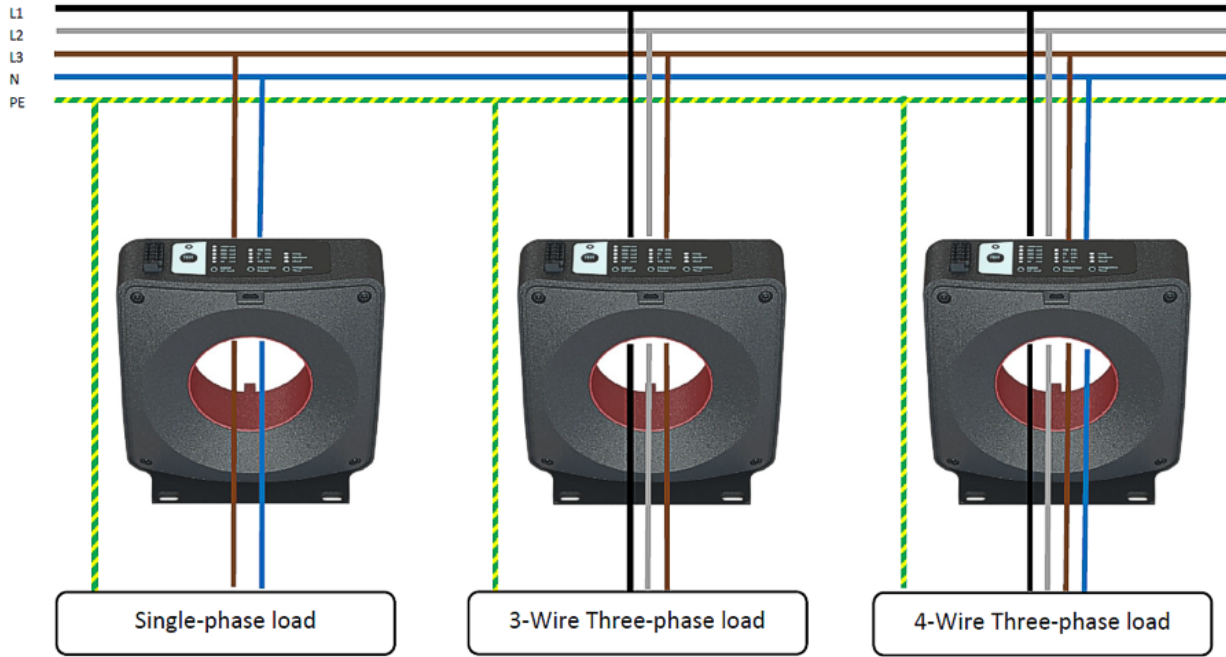


Fig. 19: Use in single-phase as well as 3- and 4-pin three-phase systems

4.3 Connection

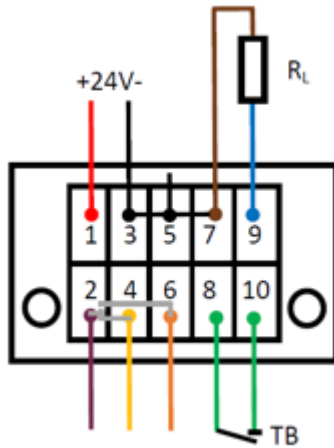


Fig. 20: Connection

Connection point	Description
1	24 Vdc
2	Relay ground
3	0 Vdc
4	Relay NC contact
5	0 Vdc
6	Relay NO contact
7	0 Vdc
8	External test button, contact 1
9	Analog 4-20 mA output
10	External test button, contact 2

4.4 Functional description SCT5xxx

The Beckhoff SCT5xxx ring-type current transformer for differential current measure the instantaneous real-time value of both DC and AC residual current using the built-in transformer head with integrated balanced flux gate detector. To protect the function and especially the fire protection of the electrical system, the SCT converts the True RMS (TRMS) value of the residual current, which corresponds to the amount of heat dissipated in the insulation. To provide a high degree of flexibility in the use of the SCT and to be suitable for as many potential applications as possible, these devices are equipped with three user-selectable parameters that affect the final TRMS value, which is output as an analog value at the 4-20mA output and displayed at the relay output and status LED.

The "Frequency Range (FR)" parameter limits the frequency bandwidth of the measured differential currents. After the desired frequency range has been selected, the "Integration time (IT)" parameter determines the length of the integration window for the TRMS value. Finally, the TRMS value is scaled into two different ranges according to the selected "Rated RC limit" (details in the electrical specifications tables). After these intermediate steps, the TRMS value of the differential current is ready to be output to the analog 4-20mA output. However, the behavior of the relay output and the status LED is influenced by some additional processing blocks as described below.

When the level set by the "Rated RC Limit (RL)" is exceeded by the weighted TRMS, the relay output and status LED toggle the state. The weighted TRMS is obtained from the TRMS value by applying a weighting filter that attenuates the residual currents with higher frequencies while allowing the low frequency residual currents to pass completely in accordance with the applicable product standards.

The reason for this choice is that higher values of high-frequency residual currents typically occur in switch mode power supplies when rapidly changing voltages are applied to, for example, the cable insulation, the output dv/dt filters, the EMC input filter and the Y capacitors to ground.

The determination of the status of the relay output is done with a comparator with hysteresis, i.e. after activating the relay, the TRMS value of the residual current must decrease by a certain hysteresis before the relay output is disabled. In case of repeated activation and deactivation of the relay, it will be locked in the activated state and the test button must be pressed for at least 3 seconds to reset it.

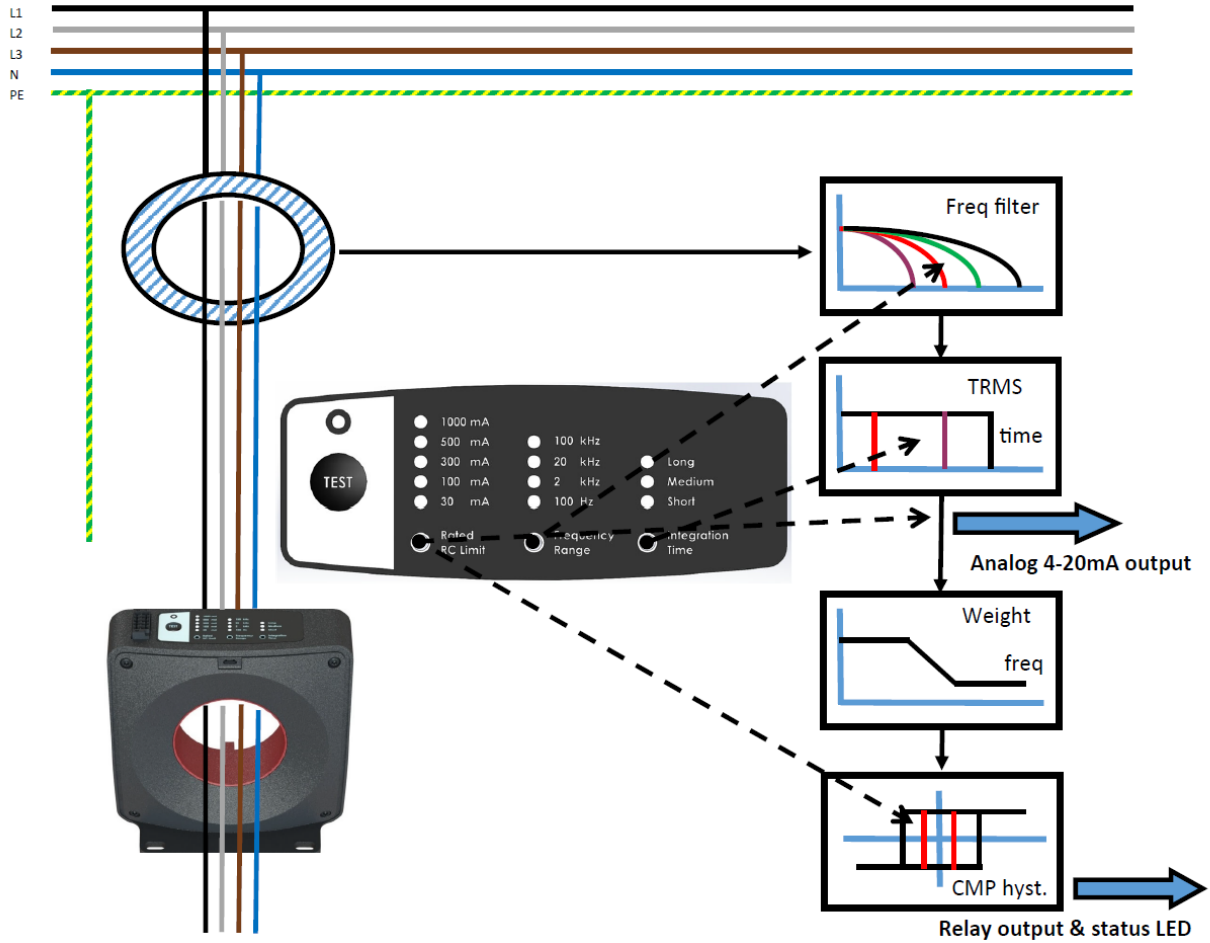


Fig. 21: SCT5xxx block diagram

4.5 Automatic setup

The Beckhoff SCT5xxx are capable of performing automatic setup of the user selectable settings for installations in proper condition taken as baseline. This means that during automatic setup, the SCT5xxx automatically measures the residual currents at the plant site with different frequency ranges and integration time settings and selects the nominal residual current limit that is at least 50% higher than the measured value.

In this way, the SCT5xxx operate with a comfortable margin for the future development of the measured residual current towards the trip limit of the relay. The automatic setting also suggests a suitable frequency range and integration time.

Required steps:

- Activate the auto setting by pressing the "Rated RC limit" and "Integration time" buttons simultaneously for more than 3 seconds.
- The device performs a series of differential current measurements with different settings.
- Proposed settings for "Rated RC limit", "Frequency range" and "Integration time" are marked with flashing LEDs.
- The proposed change of settings should be accepted by pressing the "Test" button.
- If the change is not accepted within 10 s, the RCM returns to the old settings.

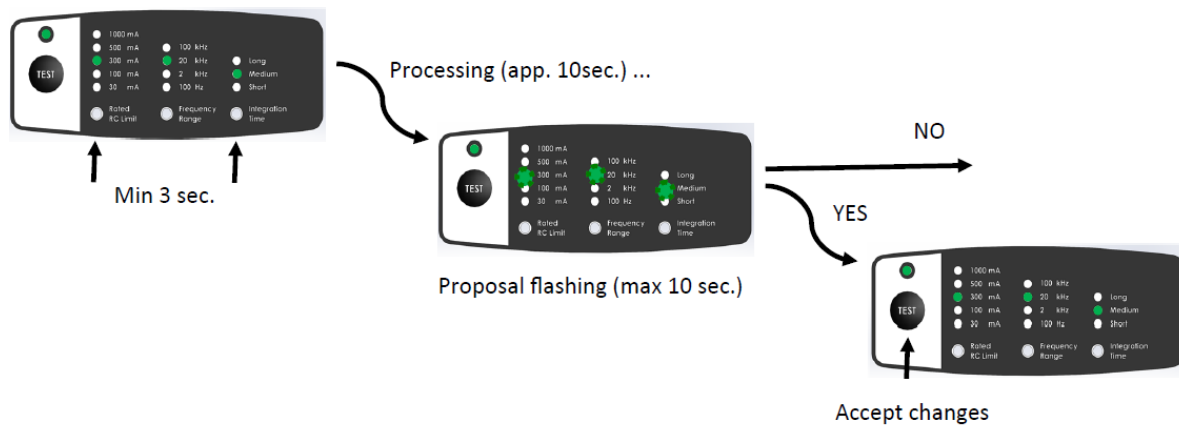


Fig. 22: Auto Setup Process

i Manual setting of the 100 Hz range

The frequency range of 100 Hz is not included in the automatic setting, i.e. the user must select it manually. The SCT5xxx always prefers the settings that make the instrument more sensitive, i.e. higher frequency ranges and shorter integration times.

4.6 Description of the User Interface SCT5xxx

The SCT5xxx have three user selectable parameters, for each of which 3-5 different values can be selected. The simple and intuitive user interface is located on the top of the device and is used to configure the transformer with three buttons located below the interface. These buttons can only be operated with a tool that prevents unintentional and unauthorized access in accordance with the applicable product standards. The interface also has a test button and a status LED for visual indication.

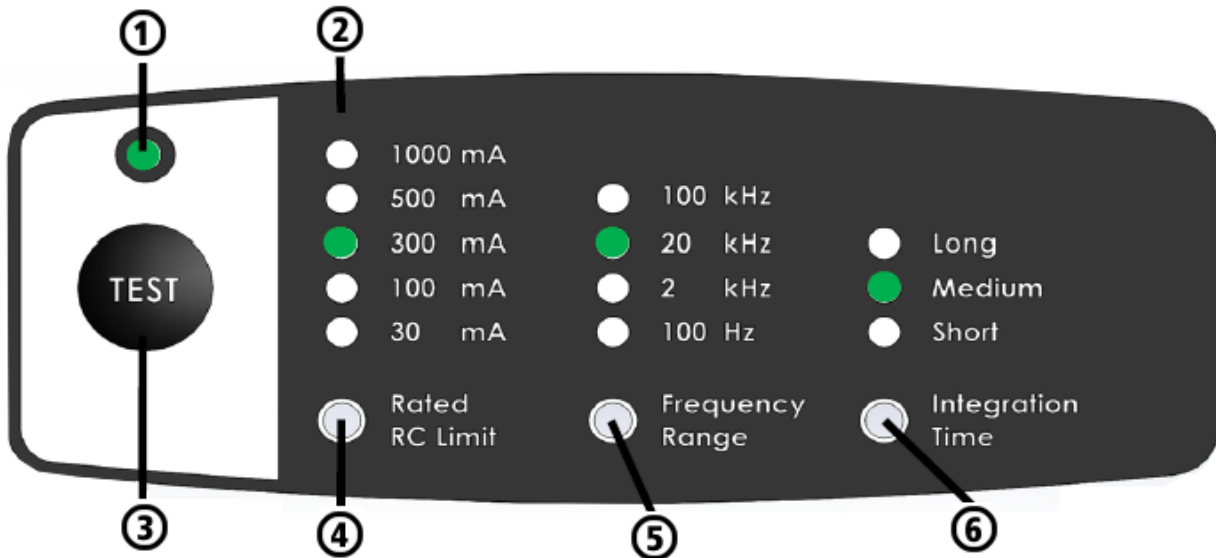


Fig. 23: User interface with input and test button

1. Power-on/ Status LED

The LED lights up green with heartbeat characteristic^{*)} during normal operation with low residual currents. If the color changes to red with heartbeat characteristic, the measured TRMS residual current is higher than the rated RC limit.

The LED flashes green during start-up. Continuous red light in combination with several flashing green LEDs of the "Rated RC limit" group indicates an error state.

*) The light intensity of the status LED changes continuously with a heartbeat characteristic to signal the correct execution of the software and to indicate that the SCT is in correct operational mode.

2. Error codes

LEDs (flashing), left group	Diagnosis
2x	Input voltage outside permissible range
3x	Relay activated too often
4x	Overtemperature
5x	Internal error

3. Test button

The test button is used to activate the test sequence for testing the operation of the SCT. If the test is successful, the relay is activated and the LED lights up red.

If the relay is locked due to too many activations, pressing the button for 3 seconds will reset the state when the differential current is normal.

4. Rated RC limit (RL)

The rated RC limit (RL) refers to the measured TRMS value of the residual current that will trip the relay output. Additionally, selecting the three lower trip limits (30-100-300 mA) changes the analog output range to 0 - 0.4 A_{rms}, while selecting the two upper trip limits (500 - 1000 mA) changes the analog output range to 0 - 2 A_{rms}.

Notes:

- Set the RL low if necessary to get early warning of increasing residual current values.
- To avoid false alarms, set RL to higher values that correspond to the residual current levels the user can tolerate in the electrical power system before system testing or maintenance is required.

5. Frequency range (FR)

Refers to the measurement bandwidth for the differential current.

Notes:

- If only DC and low frequency AC (50 / 60 Hz) are of interest, use the 100 Hz setting.
- If protection of frequency converters in switching mode is mandatory, increase FR towards 2 kHz, 20 kHz or even full bandwidth 100 kHz.

6. Integration time (IT)

Refers to the time window for the calculation of the TRMS value.

Notes:

- A longer IT makes the SCT less sensitive to short peaks during start-up; better for low-frequency operation
- Shorter integration times result in a faster response of the SCT, especially when short residual current pulses are of interest.

5 Application example

Residual current monitoring of a production machine with different speed-controlled motors

Today, the speed-controlled three-phase motor is a standard element in all automated process systems and commercial buildings. Highly efficient asynchronous motors, but especially motor technologies such as permanent magnet motors, EC motors and synchronous reluctance motors, require control via frequency converters; for many motor types, direct operation via a 3-phase standard power supply is even no longer possible at all.

This development is contrasted by decades of safety guidelines designed to guarantee personal, fire and plant protection. For example, periodic inspection of low-voltage installations must be performed in accordance with IEC 60364-6 (Edition 2.0 2016-04). Section 6.5.1.2 requires, among other things, a check of the insulation resistance, in which a test voltage is applied between the respective conductor and the PE protection potential. Many manufacturers of frequency converters explicitly prohibit this test on their devices. Therefore, the frequency converter must be disconnected during this measurement to prevent possible damage. IEC 60364-6 also offers us a way out under point 6.5.1.2. Here explains the standard:

"Where a circuit is permanently monitored by an RCM in accordance with IEC 62020 ... it is not necessary to measure the insulation resistance if the function of the ... RCM is correct."

IEC 62020, which is mentioned in connection with the SCT5xxx, describes the technical boundary conditions that a differential current monitor must fulfill in order to be recognized as a complete substitute for conventional insulation resistance measurement.



Fig. 24: Beckhoff SCT5 series

An increase in the measured levels with the residual current monitor may indicate a fault in the insulation of the system. A subsequent check of the plant can then be timed to avoid an uncontrolled shutdown of the plant and an unintentional interruption of the production processes. In contrast to conventional insulation measurement, the system is monitored seamlessly by differential current monitoring and faults in the insulation can be detected immediately.

It is therefore a procedure that can be classified as a predictive maintenance solution. When commissioning a differential current monitor, a number of boundary conditions must often be observed to ensure correct functioning.

Due to the use of frequency converters in production machines, in the vast majority of cases a system-related leakage current is present, which can cause problems for the commercially available Residual Current Protective Devices (RCDs). While residual currents mostly consist of a high ohmic component, the

system-related leakage currents are mainly capacitive. However, the RCD cannot distinguish between the different leakage currents. Therefore, it can already trip when the sum of all system-related leakage currents is above the tripping threshold. This is also possible during normal operation.

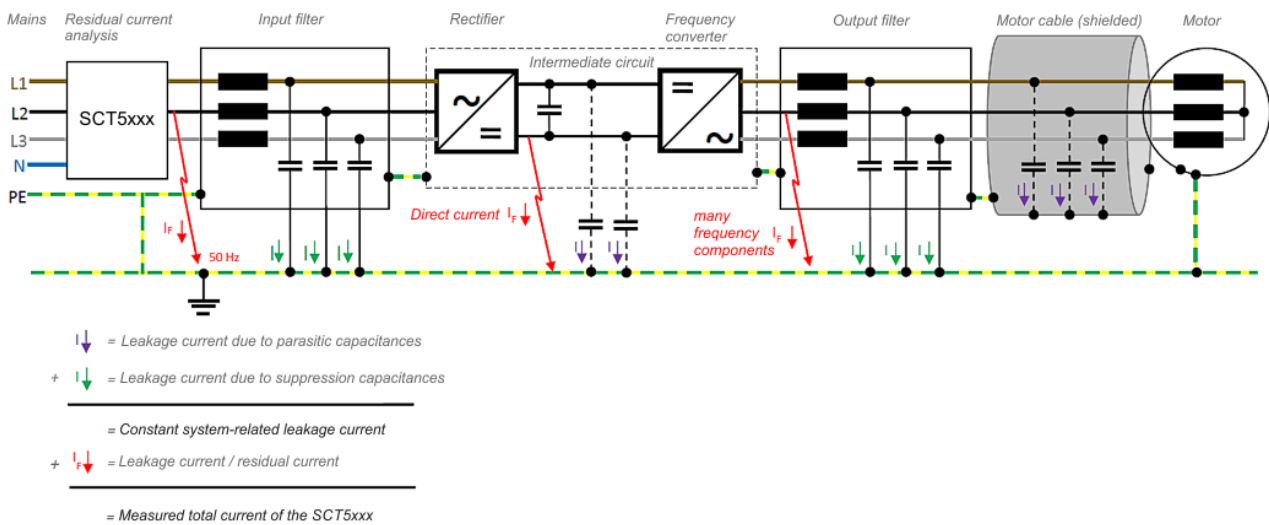


Fig. 25: Electrical equivalent circuit diagram of a speed-controlled motor

As shown in the figure, different frequency components can occur in the differential current from DC up to several kHz. When analyzing the measured differential current, the system-related differential current must always be considered as well, because this is present despite perfect insulation and cannot be technically separated. Also, due to inductances (e.g. motor), high current peaks can be generated during the switch-on processes, which can lead to relay tripping at the RCDs and RCMs.

In general, the different frequency components can be interpreted as follows:

Frequency	Typical causes
50 Hz	Power supply, mains filter (low-pass), interference suppression capacitors
50 Hz + 150 Hz	Single-phase frequency converter with internal EMC filter
150 - 1050 Hz	Three-phase frequency converter with internal EMC filter
2k - 50k Hz	Long shielded motor cable
50k - 150k Hz	Insufficient EMC filter
2k - 150k Hz	Long shielded motor cable + insufficient EMC filter

When commissioning a differential current monitor, it is important to know the actual system-related leakage current. Only in this way can appropriate warning thresholds and relay tripping thresholds be sensibly set.

6 Appendix

6.1 Documentation issue status

Version	Comment
1.2	- Chapter "Technical data" updated - Update structure
1.1	- Chapter "Introduction" updated
1.0	- First public issue
0.2	- Corrections complements
0.1	- Preliminary version

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