APPLICATION NOTE

UTILIZING ACUCT FLEX PRO ROGOWSKI COILS FOR PROTECTION RELAYING

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1. INTRODUCTION

Modern protection systems demand high accuracy, wide dynamic range, and reliable performance under extreme fault conditions. Conventional iron-core current transformers (CTs) have long been used for protection applications; however, they are inherently limited by magnetic core saturation, size constraints, and installation challenges in high-current environments.

Unlike traditional CTs, Rogowski coils are air-core devices that produce a voltage proportional to the rate of change of primary current. Because they do not have a ferromagnetic core, they do not saturate even under high fault currents, making them particularly suitable for modern microprocessor-based protection relays.

This application note provides engineering guidance for utilizing the AcuCT Flex Pro Series Rogowski Coil in modern Low Power Instrument Transformer (LPIT) input-based feeder protection relays.

2. ABOUT ACUCT FLEX PRO SERIES

2.1 Characteristics

The **AcuCT Flex Pro** Series Rogowski Coil is a low-power passive current sensor specifically engineered for protection relay systems and advanced monitoring applications. It comes with a RJ45 connector. Designed in accordance with IEC 61869-10, the sensor meets protection accuracy 5P50kA and withstand fault currents up to 50 kA, ensuring dependable performance under severe short-circuit conditions.

With a rated transformation ratio of 500 A / 270 mV @ 60 Hz or 500 A / 225 mV @ 50 Hz, the sensor is optimized for direct integration with protection relays equipped with Rogowski or Low Power Current Transformer (LPCT) inputs. For example, at 120% of rated primary current (500 A × 1.2 = 600 A), a protection-class iron magnetic core current transformer (e.g., 5P or 10P class) may begin approaching magnetic saturation depending on its accuracy class, rated burden (VA), and knee-point voltage which is illustrated in Figure 1.

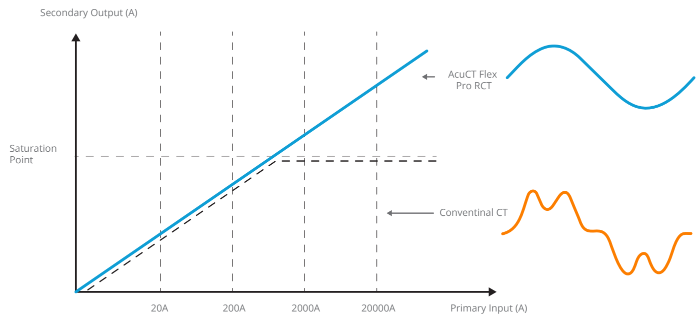

Figure 1 Performance Curve

As seen in Figure 1, the AcuCT Flex Pro with its air-core design, does not experience magnetic saturation and maintains linear output response beyond rated current, ensuring accurate measurement under overload and fault conditions.

2.2 Correction Factors

The amplitude and phase error of the **AcuCT Flex Pro** Rogowski current sensor are inherent characteristics of the Rogowski coil. Each AcuCT Flex Pro sensor is supplied with specific correction factors for:

Amplitude Correction Factor (CFI): Multiplicative scaling factor applied to the rated transformation ratio to compensate for amplitude (ratio) error of the sensor.

Phase Correction Factor ($\varphi_0$cor): Angular compensation value (in degrees) applied by the protection relay to correct the phase displacement error of the current sensor.

(+ sign indicates lagging output signal while the - sign indicates leading output signal).

These values are provided on the product label as shown in Figure 2.

To achieve the specified accuracy class, the correction factors must be entered into the connected relay before commissioning.

Please note that the phase correction factor ($\varphi_0$cor) for the AcuCT Flex Pro RCT is specified in arcminutes (arcmin).

Figure 2 AcuCT Flex Pro RCT Label

If the connected relay requires the phase correction factor in degrees, convert the value by dividing the arcminute value by 60:

$$\text{Phase correction } (^\circ) = \frac{\phi_{0cor}(\text{arcmin})}{60}$$

For example, a phase correction factor of 6 arcminutes corresponds to 0.1°.

3. APPLICATION OF ACUCT FLEX PRO SERIES WITH SEL-751 RELAY

3.1 Connections at the Relay

A typical utilization of AcuCT Flex Pro Series RCT with SEL-751 relay in a feeder protection scenario is shown in Figure 3. The user should ensure that the arrow on the RCT latch points towards the load.

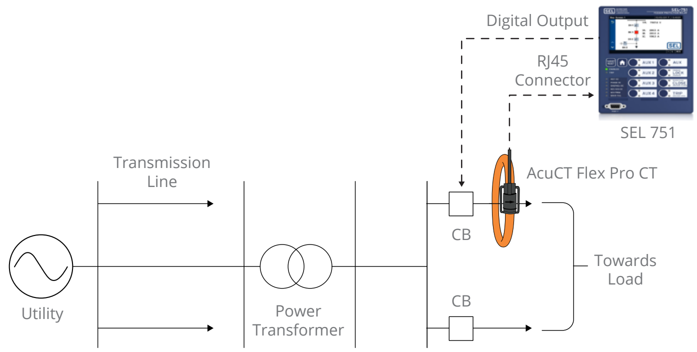

Figure 3 Application of AcuCT Flex RCT with SEL-751 Feeder Protection Relay

The SEL-751 feeder protection relay comes with Slot Z inputs designed specifically for Rogowski current sensors, as well as low-power voltage sensors, instead of the traditional 1 A or 5 A instrument transformer inputs. These sensor-based inputs are provided through RJ45 connectors.

As shown in Figure 4, the relay includes three RJ45 ports dedicated to current inputs on the left side and three RJ45 ports for voltage inputs on the right side. The AcuCT RCT RJ45 pin configuration is compliant with IEC 61869-10 (Table 1003), ensuring standardized signal assignment. This enables direct plug-and-play integration with compatible LEA interfaces without the need for custom wiring.

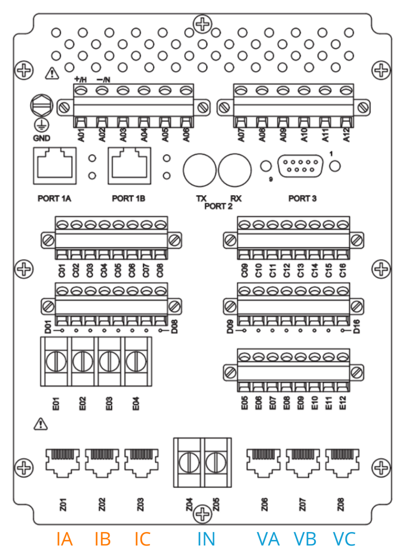

Figure 4 SEL-751 Low Energy Analog (LEA) Input Layout

The SEL-751 automatically scales the gain of its current input channels so it can accommodate Rogowski coil sensors that produce full-scale RMS voltages between approximately 4 V and 128 V during fault conditions. The relay can measure currents up to 30 times the nominal feeder current without signal clipping. Therefore, when using AcuCT Rogowski coil and defining the feeder current settings, the expected maximum fault-induced clipping voltage must be calculated to ensure it remains within the 4–128 Vrms operating range supported by the relay.

Figure 5 illustrates the linear relationship between the AcuCT Flex Pro Series Rogowski coil output voltage and the corresponding primary current, derived from its rated transformation ratio of 500 A / 270 mV at 60 Hz. The green shaded region represents the recommended SEL-751 measurement window (approximately 65 mV to 4160 mV), corresponding to roughly 120 A to 7700 A primary current for the AcuCT Flex Pro 500P model. Below this range, signal levels approach the relay pickup threshold, while voltages beyond the upper boundary may enter the clipping region depending on relay configuration.

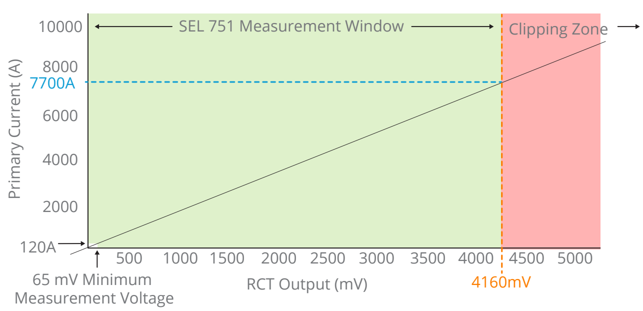

Figure 5 Linear relationship between Primary Current and AcuCT Flex Pro Series Rogowski coil output voltage (500 A / 270 mV at 60 Hz) and corresponding SEL-751 measurement window

3.2 Example for Configuring AcuCT Flex Pro RCT in SEL-751

Assume that three AcuCT Flex Pro Series RCTs are installed, one per phase, and connected to the SEL-751 protection relay. The system parameters used in this case study are summarized in Table 1.

Table 1 System Parameters for Sample Case

Feeder Full Load Current	800 A
System Frequency	60 Hz
Selected Sensor	AcuCT Flex Pro RCT16
Rated Sensor Primary Current (Ipr)	500 A
Rated Sensor Secondary Voltage (Usr)	270 mV @ 60 Hz
Rated Sensor Burden	2 MΩ/50 pF
Phase correction factor ($\varphi_0$cor)	A: 0.1°/B: 0.1°/C: 0.1°
Amplitude correction factor (CFI)	A: 0.9966°/B: 0.9954°/C: 0.9968°

3.2.1 SEL-751 LPCT Configuration Settings

To integrate the AcuCT Flex Pro Series with the SEL-751, the relay must be configured with the appropriate LEA input parameters to ensure accurate scaling and measurement of the Rogowski coil output. This configuration is typically performed using SEL AcSELerator QuickSet® software. From the information in Table 1, the slot Z is configured as shown in Table 2.

Table 2 SEL-751 Slot Z CT Configuration Settings

Setting Prompt	Setting Parameter
Phase Current Sensor Type	CS_TYPE: RCOIL
Primary Nominal Current (amps)	IPR: 500
Rated Sensor Voltage (mV@FNOM)	USR: 270
Nominal Current Secondary (amps)	INOM: 1
Rated Feeder Current Primary (amps)	FDR_CURR: 800
Phase ILEA Scale (auto calculated)	ILEA_SC: 800

The parameters CS_TYPE, IPR, USR, INOM, and FDR_CURR are provided to the relay for LEA current inputs. Choose the nominal relay current (INOM) as would be used for a conventional CT, typically 1A or 5A. The ILEA_SC setting is auto calculated by the relay and is not available for setting. ILEA_SC is derived as the ratio of feeder current to nominal current, $ILEA_{SC} = \frac{FDR\_CURR}{INOM}$

Clipping Voltage calculation:

$$\text{Sensor Output Voltage at 800A} = \frac{270\text{ mV}}{500\text{A}} \times 800\text{A} = 432\text{ mVrms}$$

$$\text{Clipping Voltage} = 432\text{ mVrms} \times 30 = 12.96\text{ Vrms}$$

NOTE: The multiplier of 30 used in this calculation is based on the SEL-751 relay's specified maximum measurable current range (up to 30 times the configured feeder current) without signal clipping. Calculated clipping voltage is within 4–128 Vrms range for Rogowski coils. Hence, with this RCT and feeder current, even at 30 times overload, system stays within relay voltage limits.

3.2.2 SEL-751 Correction Factor Settings

In SEL-751 with LEA inputs, Global settings IARCF, IBRCF, ICRCF, IAPAC, IBPAC, and ICPAC are applied to the current inputs, IA, IB, and IC. Table 3 shows the correction factor settings for the configuration.

Table 3 LEA Ratio and Phase Correction Settings for Phase Current

Setting Prompt	Setting	Input Unit
IA Ratio Correct	IARCF: 0.9966	-
IB Ratio Correct	IBRCF: 0.9954	-
IC Ratio Correct	ICRCF: 0.9968	-
IA Angle Correct	IAPAC: +0.1	Degrees
IB Angle Correct	IBPAC: +0.1	Degrees
IC Angle Correct	ICPAC: +0.1	Degrees

4. APPLICATION OF ACUCT FLEX PRO SERIES RCT WITH SIEMENS 7SY82 RELAY

4.1 Connections at the Relay

A typical utilization of AcuCT Flex Pro RCT with Siemens 7SY82 relay in a feeder protection scenario is shown in Figure 6.

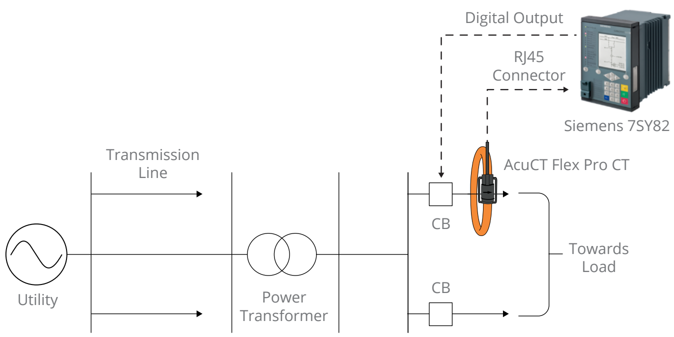

Figure 6 Application of AcuCT Flex RCT with Siemens 7SY82 Relay

As seen in Figure 6, the user should ensure that the arrow on the RCT latch points towards the load.

As shown in Figure 7, the terminals associated with the IO141 input and output module include 4 RJ45 inputs (A1-A4) for measuring current values and voltage values. The AcuCT RCT RJ45 pin configuration is compliant with IEC 61869-10 (Table 1003), ensuring standardized signal assignment. This enables direct plug-and-play integration with Siemens 7SY82 LPCT interfaces without the need for custom wiring.

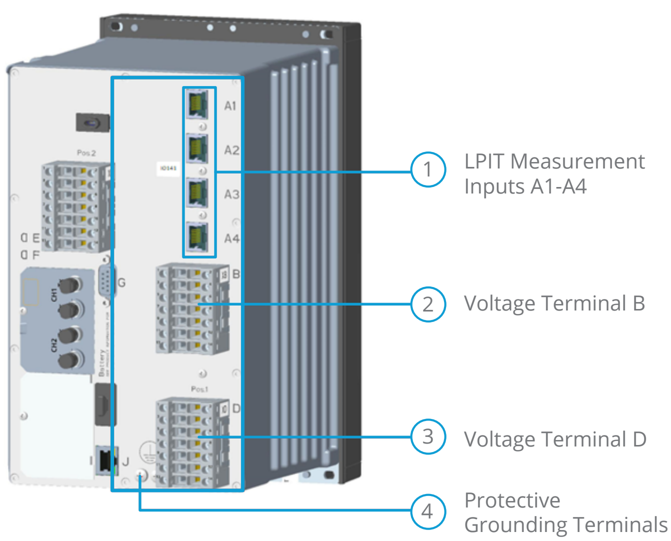

Figure 7 Siemens 7SY82 LPIT Input Layout

Figure 8 illustrates the linear relationship between the AcuCT Flex Pro Series Rogowski coil output voltage and the corresponding primary current, derived from its rated transformation ratio of 500 A / 270 mV at 60 Hz. The green shaded region represents the recommended Siemens 7SY82 measurement window (approximately 0.9 mV to 13.5 V), corresponding to roughly 1.7 A to 25 kA primary current for the AcuCT Flex Pro 500P model. Below this range, signal levels approach the relay pickup threshold, while voltages beyond the upper boundary may enter the clipping region.

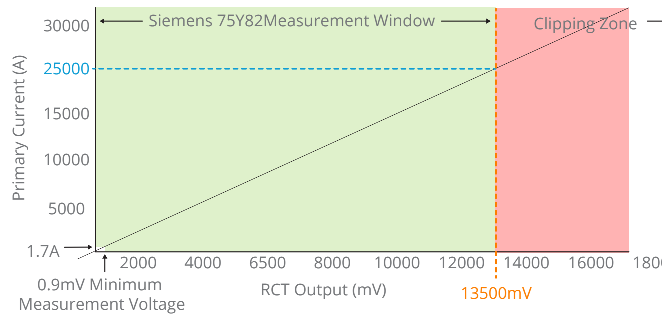

Figure 8 Linear relationship between primary current and AcuCT Flex Pro Series Rogowski coil output voltage (500 A / 270 mV at 60 Hz) and corresponding Siemens 7SY82 measurement window.

4.2 Example for Configuring AcuCT Flex Pro RCT in Siemens 7SY82

Assume that three AcuCT Flex Pro Series RCTs are installed, one per phase, and connected to the Siemens 7SY82 relay. The same case study parameters presented in Table 1 are used in this example.
DIGSI 5 is the engineering and operating tool for all SIPROTEC 5 devices. It is used to create system topologies, configure hardware and communication networks, and perform many other tasks.
The Rogowski coil's sensor data can be set in the LPIT general setting in DIGSI 5 as seen in Figure 9. LPIT ratio, nominal burden, and corrective factor, and angle can be set up in this section.

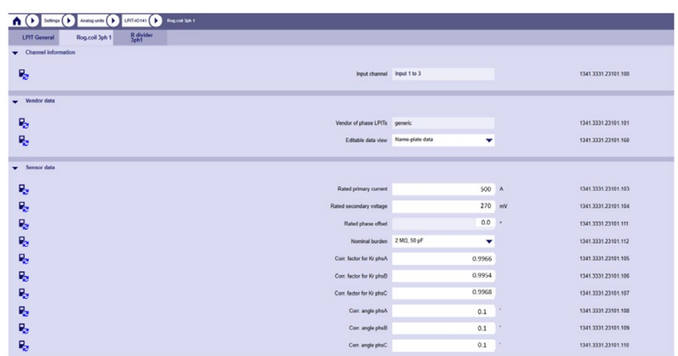

Figure 9 AcuCT Flex Pro RCT Configuration in DIGSI 5

The relay protection channel operates over an input range of 0.9 mV to 50 times the $V_{(rated,RCT)}$.
If $V_{(rated,RCT)}$ for AcuCT Flex Pro Series, is rated at 270 mV at 60 Hz, this corresponds to an operating range of 0.9 mV to 13.5 V. According to the relay manufacturer's specifications, the maximum permissible Rogowski coil input voltage is 35 V. Therefore, the AcuCT Flex Pro Series RCT operates well within the allowable input limits of the relay.

5. ORDERING GUIDE & TECHNICAL SUPPORT

To ensure a solution that perfectly matches your protection requirements, please verify the following before ordering:

Relay Model Verification: Confirm if your protection relay supports LEA/LPCT inputs (e.g., checking for Slot Z on SEL-751, inputs A1-A4 on Siemens 7SY182)

Coil Size & Lead Length: Measure the busbar circumference and add a 20% margin for the coil length. This Rogowski coil comes with 2 meters lead length.

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Please consult the Accuenergy Technical Support team for any technical queries or the Sales team to discuss your project requirements at marketing@accuenergy.com

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