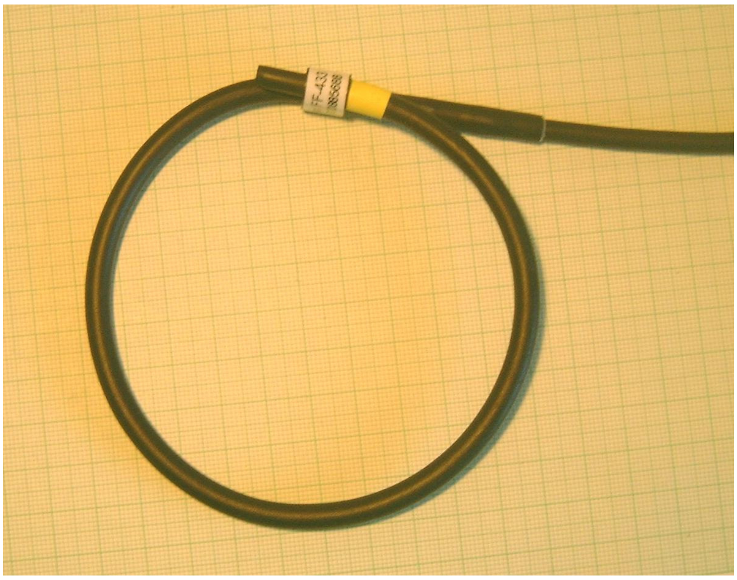
Rocoil® 4000 SERIES ROGOWSKI COILS



FEATURES

- Flexible Rogowski coil with simplified overlapping end location.
- Accuracy 1%.
- Good rejection of external magnetic fields.
- Low sensitivity to the position of the coil within the conductor.
- Coil cross-section can be as small as 6mm.
- Very flexible
- Rugged construction.
- Two-layer insulation.
- Yellow inner layer of insulation indicates if the insulation is damaged.
- Screened or un-screened versions available.
- Low cross-section 'free end' facilitates fitting round conductors in confined spaces.
- Available in lengths up to several metres.
- Can be used to measure at frequencies from less than 1Hz to more than 100kHz.
- Economically priced.

INTRODUCTION

The Rocoil® Type 4000 flexible Rogowski coils are available in a range of lengths up to several metres in screened and un-screened versions. Type 4000 coils differ from the Type 1000 series coils in that the ends of the coil are aligned by overlapping them which results in a simplified construction. Most Type 4000 coils are built with a small cross-sectional diameter of about 6mm which gives very good flexibility

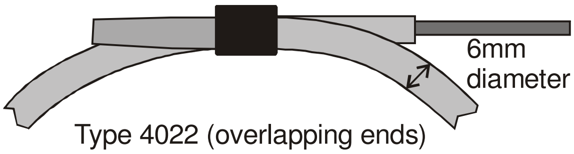
With a suitable electronic integrator these coils can be used to measure low currents with a resolution as low as 10mA and high currents of greater than 1MA. The Rogowski coil sensors provide complete isolation from the circuit being measured and have no effect on the current being measured even for very low-impedance circuits.
There are other devices that measure electric current without making electrical contact with the conductor. Many of these, including the conventional current transformer, use a ferromagnetic core and are subject to magnetic saturation effects that limit the range of currents that they can measure.

A Rogowski coil, on the other hand, is ‘linear’; it does not saturate and the mutual inductance between the coil and the conductor is independent of the current. Many of the useful features of Rogowski coil systems result from their linearity.

1. They have a wide dynamic range so that the same coil can be used to measure both very small and very large currents.
2. Calibration is easier because the coil may be calibrated at any convenient current level and the calibration will be accurate for all currents including very large ones.
3. Coils can be built which are very compact and can be fitted in confined spaces. They are thus very useful for retro-fit applications.

Flexible Rogowski coils can be used for measuring electric current in large or awkwardly-shaped conductors, where space round the conductor is limited and for the measurement of very large currents (thousands of kA).

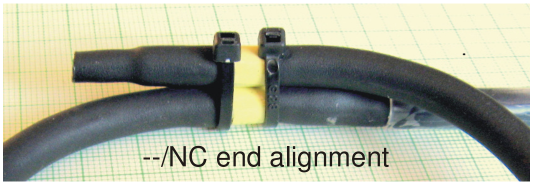
COIL VERSIONS: The Type 4000 series refers to coils that have overlapping ends rather than the butted-together end alignment used with the Type 1000 series coils. This eliminates the need for the end-gap compensation coil used with the Type 1000 coils but it means that there is a gap between the coil ends which in some circumstances can increase the interference from magnetic fields caused, for example, by adjacent conductors. The overlapping construction ensures that the 'direction' of the gap is such that interference effects are minimised and in many cases are negligible. The thinner the coil, the smaller the gap so in practice Type 4000 coils are built using a small cross-section (6 - 7mm). The following versions are available:



Type 4022 (overlapping ends)

4022: Unscreened coil with a plastic clip to locate the ends as in the picture at the start of this memo. This coil is most suitable for situations where the coil is to be moved around to different locations.

4022/NC: The ends are held together using cable ties. This coil is most suitable for long-term installations. The ends of the coil are marked to ensure correct alignment


--/NC end alignment

4122/NC: This is a screened version of the 4022/NC. A screen is used with low-current measurements (less than about 50A) to minimise electrostatic interference. This coil has a cross-sectional diameter of about 7mm.

The current rating of a measuring system is determined by the integrator and not by the coil design. The same coil can be used for measurements of a few amps up to many thousands of amps.

INSTALLATION: The coil is fitted by wrapping it round the conductor to be measured and bringing the ends together. The ends are fitted with a locating system to ensure that they are aligned correctly. The locating system can be either a 'push-together' type or a simple arrangement where the coil ends are held in position using cable ties.

It is not recommended that coils are installed or removed from conductors that can carry dangerous voltages whilst they are live.

Electrical connection to the coil is at one end only. The other end is ‘free’ to be threaded round awkwardly-shaped conductors or conductors in confined spaces. With Type 4000 coils the 'free end' of the coil does not have a plastic fitting so the tip of the coil is no thicker than the main body.

The coil insulation is smooth and there are no parts which are likely to 'catch' when the coil is being removed. Coils with the push-together clip can be removed from the conductor using one hand only. It is not necessary to mount the coil so that it is circular nor is it necessary to have the conductor exactly in the centre of the loop. Off-centre operation does not normally introduce errors of more than l - 2%. If the coil is long enough it can be wrapped more than once round the conductor provided the ends are brought together correctly. The output is proportional to the number of wraps.

CALIBRATION: The coil calibration is defined by its mutual inductance. A typical mutual inductance is 0.1 microHenries, equivalent to a direct output from the coil of about 31mV for 1kA at 50Hz.

Coils that are supplied without integrators are individually calibrated and the calibration values can be supplied to the user. Exact values cannot be guaranteed and for a batch of coils made at the same time there will be a spread in mutual inductances of about 4%. Where coils are supplied with 'dedicated' integrators (e.g. Type 8000 system) the integrator is adjusted to suit the coil. We also have an interchangeable coil system which can be used with appropriately-designed integrators. This allows coils to be replaced or interchanged between integrators without the need to re-calibrate the integrator.

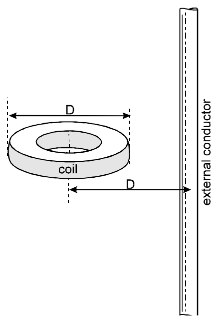
CONNECTIONS: The coils are connected to the integrator by a 'twinax' cable (twisted pair with overall screen) which is permanently attached to the coil. The standard cable length is 2m but the length can be at least 100m if required.

INSULATION: Coils are normally insulated in a double layer of polyolefin sleeve (UL E35586, AMS-DTL-23053/4 Class 3). The outer layer is black with a yellow inner layer. Sample coils have been tested to withstand at least 7kVAC by stressing between the winding and a foil wrapped round the outside. This is sufficient for 600V Cat IV conditions. Whenever possible additional insulation should be used with conductors carrying dangerous voltages. **Coils should not be used on conductors carrying dangerous voltages if the insulation appears damaged in any way.**

TEMPERATURE RATING: Coils have been tested at ambient temperatures up to 80℃ with less than 1% change in output. However prolonged use at high temperatures should be avoided if possible. At high temperatures some of the materials used in the construction will soften and it may be necessary to provide additional support for the coil.

INFLUENCE OF EXTERNAL MAGNETIC FIELDS: The alignment of the coil ends ensures minimum pick-up from external magnetic fields. The pick-up from an external conductor is used as a quality check and all coils are tested. The coil is usually placed a distance of one diameter away from the conductor as shown in the figure.

In the figure the coil is shown with its plane perpendicular to the conductor. For this alignment the pick-up is less than 1%. If the coil is positioned with its plane parallel to the conductor there is a small additional pickup caused by the overlapping ends. Provided the overlapping join is more than 100mm from the adjacent conductor the pick-up will be less than 1%



INFLUENCE OF CONDUCTOR POSITION: If the conductor is moved from the central position by a distance equal to 0.5 x the coil radius the output will change by less than 1%.

PHASING: If two coils are being used for current summing they should be mounted in the same sense (i.e. with both the output leads coming off clockwise or both anti-clockwise) and the outputs will then add. If the coils are mounted in the opposite sense the outputs will subtract.

COIL LENGTHS: These coils can be built in lengths from about 200mm up to several metres.

MULTIPLE-WRAP COILS: Type 4000 coils are very flexible and can be wrapped several times round the conductor to increase the output.

FREQUENCY: The low-frequency performance is determined by the design of the integrator. With a suitable integrator these coils can be used to measure at frequencies below 1Hz (-3dB). The upper frequency limit depends on the coil type and the length of the output lead but it is typically greater than 100kHz. Longer coils and longer output leads will reduce the frequency. To get the flattest frequency response the coil must be terminated with a resistor of the correct value to damp out self-resonance effects.

ORDERING INFORMATION: This should include:

1) The length of the coil needed to go round the conductor
2) The length of the output cable
3) Whether screening is required
4) End joining (plastic clip or cable ties)
5) Any special requirements such as environmental considerations.

THE ROGOWSKI COIL PRINCIPLE

The coil is an 'air cored' toroidal winding placed round the conductor such that the alternating magnetic field produced by the current induces a voltage in the coil. The coil is effectively a mutual inductor coupled to the conductor being measured and the voltage output direct from the coil is proportional to the rate of change of current. The special design of the coil ensures that its output is not influenced significantly if the conductor is positioned 'off-centre'. The design also ensures that the influence from currents and magnetic fields external to the coil is minimal.

To complete the transducer the coil output voltage is integrated electronically to provide an output that reproduces the current wave-form. This combination of coil and integrator provides a system where the output is independent of frequency, which has an accurate phase response and which can measure complex current wave-forms. By varying the integration parameters (C and R) the sensitivity of the complete measuring system, measured in Amperes per Volt, can be varied over about five orders of magnitude. The output from the integrator can be used with any form of electronic indicating device such as a voltmeter, oscilloscope, protection system or metering equipment.