Rocoil® 1000 SERIES ROGOWSKI COILS

FEATURES

- Flexible Rogowski coil with easy push-together end location.
- 'Screw-together' end location also available for permanent installations.
- Internal compensation coil minimises interference from adjacent conductors.
- 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.
- 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.

INTRODUCTION

The Rocoil® Type 1000 flexible Rogowski coils are available in a range of lengths and cross-sectional diameters as well as in screened and un-screened versions. With a suitable electronic integrator these coils can be used to measure low currents with a resolution as low as 1mA 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.

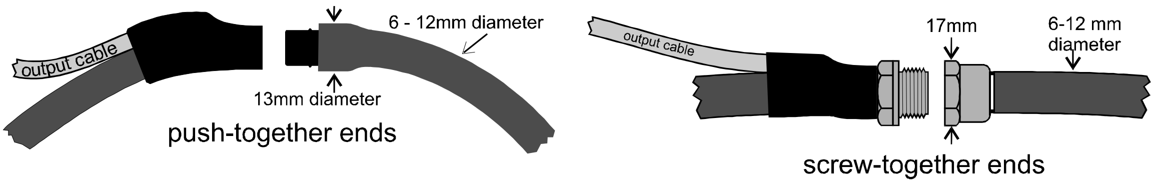
There are other devices that measure electric current without making electrical contact with the conductor. Many of these, including the conventional current transformer, use a ferromagnetic core and are subject to magnetic saturation effects that limit the range of currents that they can measure. A 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.

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 'screw-together' type. Screw-together is more suitable for permanent installations. Push-together is better if the coil is being moved frequently from place to place because the ends are located together simply by pushing them together until they click. **It is not recommended that coils are installed or removed from conductors that can carry dangerous voltages whilst they are live**.

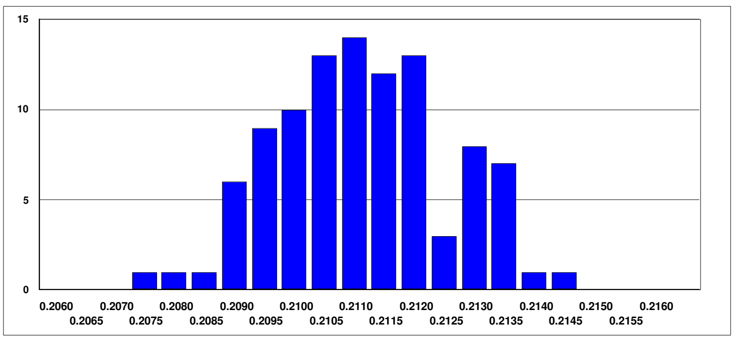
Electrical connection to the coil is at one end only. The other end is 'free' to be threaded round awkwardly-shaped conductors or conductors in confined spaces. With push-together ends the free end of the coil has a diameter of 13mm which is small enough to allow the coil end to be threaded through tight spaces. The coil insulation has a smooth transition onto the coil end fitting so that the end is less likely to 'catch' when the coil is being removed.

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 I - 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.
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).



NOTE: Push-together ends should be pushed together firmly enough until they 'click'.

CALIBRATION: The coil calibration is defined by its mutual inductance. Coils that are supplied without integrators are individually calibrated and the calibration values can be supplied to the user. Typical mutual inductance values are given in the table. 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. The figure shows the spread in mutual inductance values for a batch of 100 Type 1012 coils manufactured at the same time.

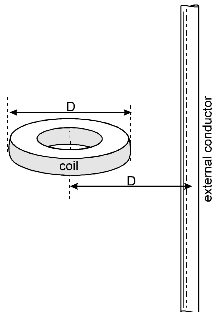
CONNECTIONS: The coils are connected to the integrator by a 'twinax' cable (twisted pair with overall screen) which is permanently attached to the coil. The cable normally fitted is sheathed in a single layer of PVC but UL/CSA rated cable can be used or a special double-insulated cable with polyurethane sheath. The standard cable length is 2m but the length can be at least 100m if required.

INSULATION: Coils are insulated in a single or 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 conductors 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. **Coils should not be installed on uninsulated conductors when they are live.**

Some very long coils may be insulated in 'Conform Sleeve' which is a silicone-rubber coated fibreglass sleeving that has excellent thermal and electrical properties.

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 internal compensation coil fitted to all Type 1000 series coils 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. The coil is turned in all orientations to find the maximum pick-up. For flexible coils the pick-up is normally 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: All coil designs can be built in lengths of several metres (we have built coils longer than 9m). The minimum length for 1012 and 1112 coils is 350mm. The other designs can be made shorter than this.

FREQUENCY: The low-frequency performance is determined by the design of the integrator. With a suitable integrator the higher output versions (1012, 1112) can be used to measure at frequencies well below 1Hz (-3dB). The upper frequency limit depends on the coil type and the length of the output lead. As an indication, typical values are given in the table below for a 500mm coil with a 2m output lead. 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.

PRODUCT CODES: Coil types are specified by a 4 - digit code:

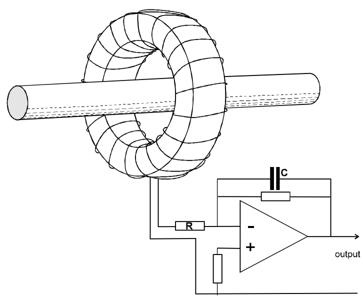
1st digit 1 - butted together ends with internal compensation coil
2nd digit 0 - no screen, 1 - braid screen, 2 - foil screen,
3rd digit 1 - standard cross-section, 2 - small cross-section, 3 - low output.
4th digit 0 - no insulation, 1 - single layer of insulation, 2 - double insulation.

Type	screen	diameter of coil body (mm)	approx. mutual inductance(μH)	Typical output (1kA at 50Hz)	Typical output (1kA at 60Hz)	frequency -3dB 500mm coil
1012	no	10.5	0.211*	66.3mV	79.6mV	450kHz
1112	yes	12.0	0.211*	66.3mV	79.6mV	300kHz
1022	no	6.0	0.111	34.9mV	41.9mV	360kHz
1122	yes	7.0	0.111	34.9mV	41.9mV	300kHz
1232	yes		0.023	7.2mV	8.7mV	2.0MHz

*A higher output version is available with a mutual inductance of 0.332 (104mV for 1kA/50Hz, 125mV for 1kA/60Hz).

2. 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.