Rocoil *the flexible approach to current measurement*
PRECISION ROGOWSKI COILS

THE 6000 SERIES ROGOWSKI COIL INTEGRATORS

FEATURES

- Single channel integrator.
- Battery powered.
- Can measure up to hundreds of kA.
- Sensitivity can be specified by the user.
- Switch selection of up to four sensitivity values.
- Input and output protection against surges.
- Excellent low-frequency response.
- bandwidth to greater than 60kHz
- Withstands very large overloads for an indefinite time.
- Can be used with flexible or rigid Rogowski coils.
- True RMS and Overload Indication available as special options

1. INTRODUCTION

The **Rocoil®** 6000 series integrators can be used in conjunction with both flexible and rigid Rogowski coils to provide accurate current measurement over a range from less than 1 amp to over 1 million amps in a compact and portable measuring system which is simple to use.

The Rogowski coil sensors provide complete isolation from the circuit being measured and have no effect on the current even for very low-impedance circuits. The output from the integrator is a voltage waveform which accurately reproduces the current waveform. This includes complex waveforms which have a high harmonic content and transients.

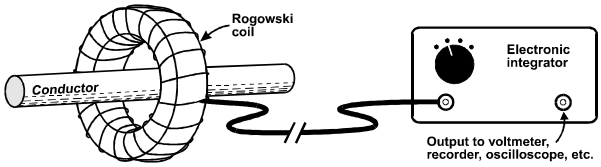
The measuring system cannot be harmed by current overloads. Also, unlike a current transformer there is no danger from high voltages if the output from the coil is open-circuited.

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. They respond accurately to transient currents, including asymmetrical transients which makes them an excellent choice for use in protection systems and for measuring current pulses.

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 waveform. 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 waveforms. 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.

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3. COIL SENSORS (Rogowski Coils)

Two types of Rogowski coil sensors are available; Flexible coils and Rigid coils.

3.1 Flexible Coils (types 1000, 1100, 1200): Flexible Rogowski coils can be used for measuring electric current in large or awkwardly-shaped conductors, where space round the conductor is limited, for high frequency measurements in excess of 100kHz and for the measurement of very large currents.

Flexible coils are suitable for measurements requiring an accuracy of about 1%.

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. 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.

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.

3.2 Rigid Coils (type 2100): Rigid Rogowski coils have a greater accuracy and stability than flexible coils and excellent rejection of interference caused by external magnetic fields. They are more suitable for low current and low frequency operation than flexible coils.

3.3 Phasing: If several coils are being used they should be mounted in the same sense (i.e. with all the output leads coming off all clockwise or all anti-clockwise) and the outputs will then be in phase.

3.4 Insulation: Unless otherwise specified it should not be assumed that the coils are insulated against high voltages. Additional insulation should be used with conductors carrying dangerous voltages.

3.5 Interchangeable Coils: Some systems are provided with interchangeable coils. This means that coils and integrators do not have to be calibrated as pairs. Coils or integrators can be replaced if they become damaged or they can be changed for coils of a different length without the need to re-calibrate the whole system. Integrators are marked to indicate the interchangeable system being used (e.g. '820R') and the coils are also marked, usually at the connector.
The interchangeable system used depends mainly on the length of the output lead between the coil and the integrator including any extension leads. The system number is 820R for lead lengths up to 5m, 430R for lengths 5 - 30m and 270R for lengths greater than 30m. The system number refers to the input impedance of the integrator.

4. INTEGRATOR POWER SUPPLY

4.1 Batteries

The transducer is powered from two PP3 batteries. These are accessed in compartments in the side of the transducer and can be changed without removing the lid of the transducer.

Battery life: The battery life depends on the design of the integrator. An integrator designed for use at power frequencies and power harmonics would have a battery life of about 80 hours continuous use from alkaline batteries. If the integrator has an RMS option or it is designed for low currents and low frequencies or for high frequencies the battery life will be shorter.

Low Battery Indicator: The red LED indicating that the integrator is on will start to flash when the battery voltage has dropped to about 7V.

4.2 Mains Power The integrator can be adapted to operate from an external power supply such as a wall-plug power pack.

5 INTEGRATOR PERFORMANCE

5.1 Description The integrator converts the output from the coil to a voltage which accurately reproduces the current waveform. Sensitivity is defined in Amperes/Volt (A/V) and is selected by a switch on the front panel. The current is equal to the instantaneous voltage at the output multiplied by the A/V value. For example at 100A/V a 1V output means an instantaneous current of 100A . This is the same as if the measurement were

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made using a 10mΩ shunt only there is no direct connection with the circuit being measured and the system does not respond down to DC. The actual sensitivity values can be specified by the user.

5.2 Specification

Output Voltage (AC Output): 1V output for the nominal sensitivity.

Overload Capability: With a fresh battery the output is linear up to at least 5.5 x the nominal sensitivity. (Note: this refers to the peak current not the RMS). As the battery voltage drops with use the peak voltage is also reduced.

Noise: Typically less than 1mV peak to peak referred to the output. For example at 100A/V, the noise is equivalent to less than 100mA p/p. For 'Long Battery Life' versions there may be a low-frequency noise component that exceeds 1mV.

Measurement accuracy: For flexible coils ±1%. For rigid coils ±0.1%

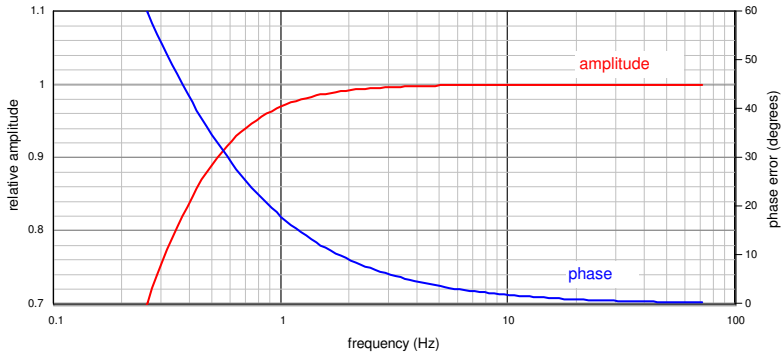
The coil/integrator combination is electrically floating. If it is used with mains-powered recording or monitoring equipment, one side of the input to the recording equipment should be earthed otherwise the readings may be inaccurate. This is particularly important with high frequencies and when there is a high voltage on the conductor being measured.

Effect of Coil Temperature on Accuracy: The temperature coefficient depends on the type of coil used and other factors and it is impossible to give an accurate general figure for this. A typical value would be 0.05% /°C.

Frequency Response (Standard Version): Stated accuracy applies in the range 20Hz to 2kHz

High frequency -3dB point (Standard Version): Typically 30kHz for rigid coils and greater than 100kHz for flexible coils. The high-frequency roll-off will be at a lower frequency for long flexible coils and with long output leads.

Low frequency -3dB point (Standard Version): Typically less than 1Hz. A typical low-frequency response is shown in the figure. For integrators that have a 'sensitive' range (e.g. 10A/V). the response will not extend to such low frequencies.



6 INTEGRATOR OPTIONS

A number of options is offered in addition to the standard design

6.1 RMS: An additional output giving a DC voltage equal to the true rms value of the AC output.

6.2 Overload: An indicator which shows when the output voltage is close to the maximum for the integrator. With a transient overload the light will remain on for about 1 second.

6.3 Mains Power: The integrator can be adapted to operate from an external power supply such as a wall-plug power pack.