PASSIVE INTEGRATORS

Rocoil®
PRECISION ROGOWSKI COILS

FEATURES

- Single channel integrator.
- No power supply needed
- Can measure up to hundreds of kA.
- Sensitivity can be specified by the user.
- Excellent for transient measurements.
- Frequency response up to several hundred kHz.
- Can be used with flexible Rogowski coils.
- Simple rugged construction.

1. INTRODUCTION

The Rocoil® passive integrator can be used in conjunction with flexible Rogowski coils to provide accurate current measurement to more than 1 million amps where an analogue output voltage is required. It is excellent for measuring transient and pulse currents. The integrator uses a simple resistor/capacitor network to perform the integration. The main disadvantage of passive integrators is their limited low-frequency response.

2. COIL SENSORS (Rogowski Coils)

Passive integrators are normally used with flexible coils. These are available in 'standard', 'low-output' and 'extra low-output versions. Low output coils are used to measure currents which are changing very rapidly and could induce large voltages in standard output coils.

2.1 Flexible Coils: 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 well in excess of 100kHz and for the measurement of very large currents.

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.

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

2.3 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 INTEGRATOR PERFORMANCE

3.1 Description The integrator uses a passive resistor/capacitor network to convert the output from the coil to a voltage which accurately reproduces the current waveform. A schematic circuit is shown in the figure.

Sensitivity is defined in Amperes/Volt (A/V). The current is equal to the instantaneous voltage at the output multiplied by the A/V value. For example at 100kA/V a 1V output means an instantaneous current of 100kA. The actual sensitivity values can be specified by the user.

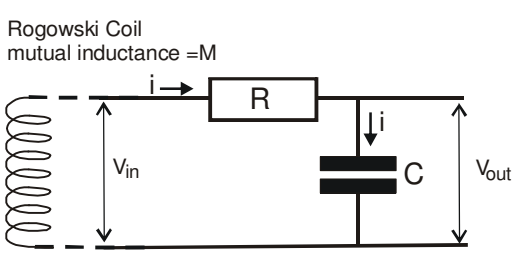


Figure 1: Basic circuit

3.2 Frequency Response

3.2.1 High frequencies: The upper frequency response is determined mainly by the properties of the coil which is used with the integrator. For a standard Type 1000 coil this would be in the region of 100kHz but this depends on the length of the coil and the length of the output cable. For low-output coils the high-frequency limit will be much higher.

3.2.2 Low frequencies: The low-frequency performance is one of the limitations of a passive integrator. The low-frequency behaviour is determined by the time constant, RC, (see the figure above) and this depends on both the coil output and the required sensitivity. For pulse waveforms the limited low-frequency capability results in 'droop'. The best way to illustrate this is with an example. However, every case is different and for reliable information reference should be made to Rocoil.

We consider a 20kA pulse with a rise-time of 10µs. A suitable coil for this measurement would be a low-output coil. To get a large output signal we could choose a sensitivity of 5kA = 1V. Figure 2 shows the calculated response of the passive integrator. The blue trace is the current being measured and the red trace is the response of the coil + passive integrator. There is a considerable droop effect.

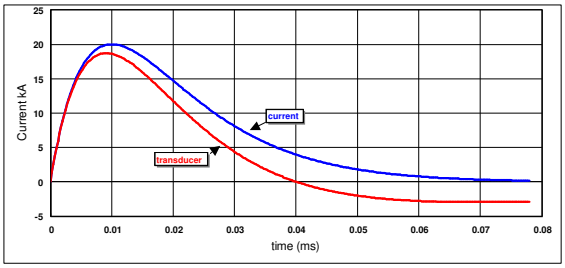
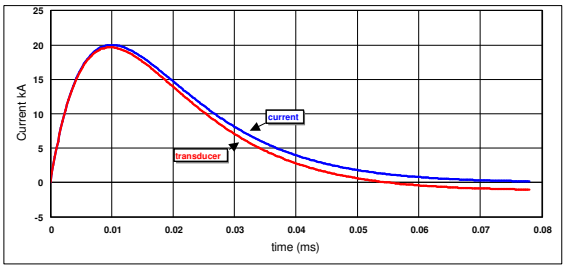


Figure 2:

Calculated response for a passive integrator. sensitivity = 5kA/Volt.



If we choose a sensitivity of 20kA = 1V the droop effect is much less as shown in Figure 3.

Figure 3:

Calculated response for a passive integrator with sensitivity = 20kA/Volt.

In choosing the sensitivity of a passive integrator system it is necessary to make a compromise between the disadvantages of a low signal level and the errors caused by droop. However, for waveforms that are subject to droop it is possible to apply a droop correction to a recorded waveform.

For more information about droop see https://www.rocoil.co.uk/dealing-with-droop/

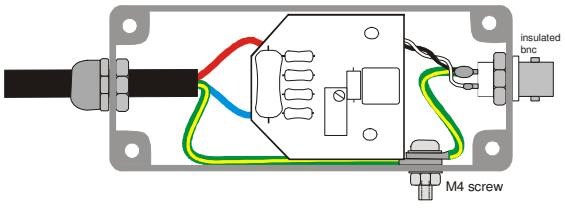
4 Installation Requirements:

These integrators are designed to work into a high-impedance input and NOT a 50Ω termination.

Experience shows that with this type of integrator the earthing arrangement is especially important. It is recommended that the integrator should be earthed somewhere.

Ideally one side of the output should be earthed preferably at the input to the measuring instrument. If the measuring instrument has differential inputs one of these should be earthed. The integrator enclosure should be positioned so that it is not inadvertently touching an earthed surface.

The earthing arrangement has deliberately been left flexible so that it can be modified, if needed, to suit local conditions. As supplied, the coil screen is connected to the metal enclosure of the integrator. It is also connected to the outer shell of the BNC output connector. If necessary the link between the enclosure and the output can be disconnected by removing the tab under the M4 screw or simply by cutting the link between the case and the BNC connector (Figure 4)



It is appreciated that some of the issues relating to the specification of passive integrators are complex and Rocoil engineers will be happy to discuss any specific requirements.