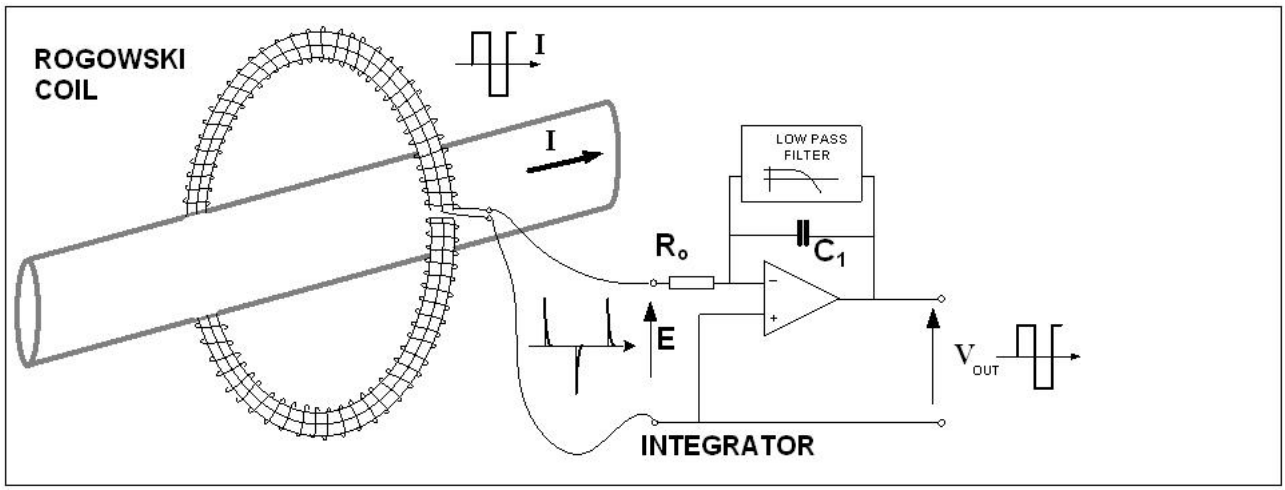
Power Electronic Measurements Ltd
Tel:+44 115 925 4212 Fax: +44 115 967 7685 Email: info@pemuk.com

RCT*i* Basic Operation

A Rogowski coil is a closely and evenly wound coil of **N** turns/m on a non-magnetic, usually plastic, former of constant cross sectional area **A** m^2, as shown below. For PEM coils, one end of the winding – the 'free' end – is returned to the other end along the central axis of the former and the two ends are permanently connected to a co-axial cable. The free end is normally inserted into a socket adjacent to the cable connection but can be unplugged to enable the coil to be looped around the conductor or device carrying the current to be measured.



The Basic Rogowski Current Transducer

Provided the coil constitutes a closed loop with no discontinuities, it may be shown that the voltage **E** induced in the coil is proportional to the rate of change of the encircled current **I** according to the relationship

$$E = H\, dI/dt \qquad (1)$$

where $H=\mu_o NA$ is the coil sensitivity (Vs/A) and is normally in the range 5 to 300 nVs/A depending on the design.

If the current varies sinusoidally with time at a frequency ***f*** (Hz)

$$E_{rms} = 2\pi f\, H I_{rms} \qquad (2)$$

To obtain an output voltage V_{out} proportional to **I** it is necessary to integrate the coil voltage **E**; hence an electronic integrator is used to provide a bandwidth extending down to below 1Hz. The Rogowski transducer cannot measure the dc component. However the dc component cannot saturate the Rogowski transducer. This enables small ac currents superimposed on a large dc to be measured.

The op-amp integrator, in its simplest form, with an input resistor R_o and feedback capacitor C_1 as shown in Figure 1, has a gain $1/(2\pi f C_1 R_o)$ at frequency ***f***. The overall transducer gain is therefore given by

$$V_{out} = R_{sh}\, I \qquad (3)$$

where $R_{sh} = H/C_1 R_o$ is the transducer sensitivity (V/A).

The relationship $V_{out} \alpha I$ is valid throughout the transducer bandwidth. The bandwidth is defined as the range of frequencies from f_L to f_H for which sinusoidal currents can be measured to within 3dB of the specified sensitivity R_{sh}.

At low frequencies the integrator gain increases and in theory will become infinite as the frequency approaches zero. This would result in unacceptable dc drift and low frequency noise; hence the integrator gain has to be limited at low frequencies. This limitation is achieved by placing a low pass filter in parallel with the integrating capacitor as shown by Figure 1. The low pass filter sets the **low frequency (-3dB) bandwidth,** typically this is less than 1Hz.

Furthermore, due to the distributed inductance and capacitance of the Rogowski coil there is a **high frequency (-3dB) bandwidth,** (generally 1MHz or greater) above which the measurement is attenuated and significant phase delay occurs. The bandwidth of the electronic integrator and the length of co-axial cable connecting the integrator to the coil also influence this limit.