For UK & European sales, support, service and deliveries:
New Tel: 01788 519911 Fax: 0870 0940135
Int'l Tel: +44 1788 519911 Int'l Fax: +44 870 0940135
Email: info@powertekuk.com Website: www.powertekuk.com

For USA sales, support, service and deliveries:
Tel: +1 631 615 6279 Fax: +1 973-273-5893
Email: info@Powertekus.com Website: www.powertekus.com

RCT*rms* Basic Operation

The Rogowski coil and integrator – *the Rogowski transducer*

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.

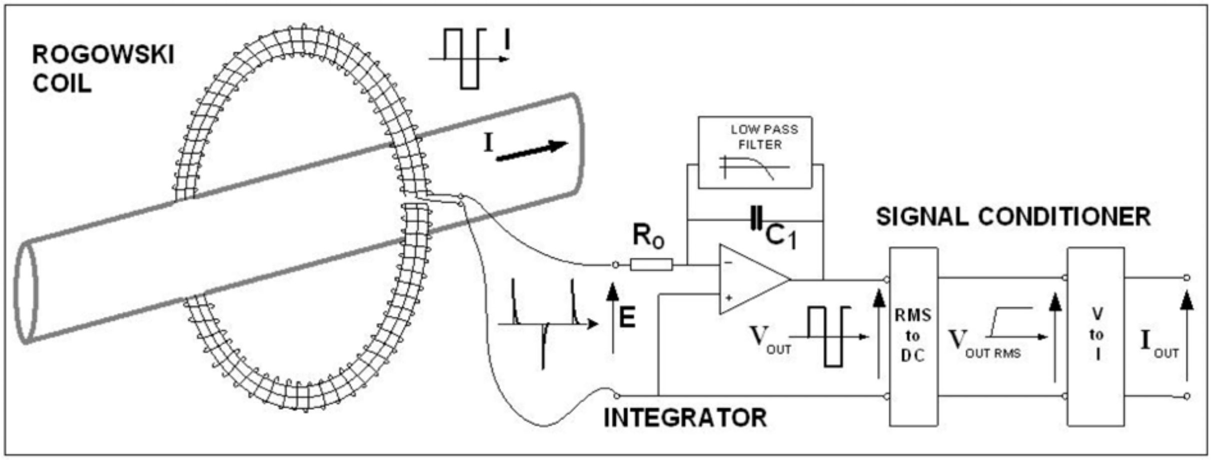

Figure 1. The Basic Rogowski coil and integrator with signal conditioner

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

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

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), then

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

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 2Hz. 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 gain at the output of the integrator is therefore given by

$$V_{out} = R_{sh}\, I$$

where $R_{sh} = H/C_1R_o$ is the Rogowski transducer sensitivity (V/A).

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. This defines the low frequency bandwidth.

The signal conditioner

The output from the integrator V_{out} is subsequently fed into a high accuracy, true rms converter which performs the calculation

$$V_{out\ rms} = \sqrt{\ } Avg(V_{out})^2$$

Thus $V_{out\ rms}$ is a dc voltage proportional to the rms value of V_{out}. The converter is capable of calculating the rms value of complex waveforms with crest factors up to 5.

Unlike PEM's other Rogowski transducers it is this process of rms conversion that limits the overall bandwidth of the rms transducer. The bandwidth is defined as the range of frequencies for which steady state sinusoidal currents can be measured to within 3dB of the specified sensitivity (V/A).

Finally a high precision voltage to current converter changes $V_{out\ rms}$ to I_{out} to provide high noise immunity current mode signal transmission.

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