Measurement Science
and Technology

Making Rogowski coils

To cite this article: P N Murgatroyd *et al* 1991 *Meas. Sci. Technol.* **2** 1218

Meas. Sci. Technol. 2 (1991) 1218–1219. Printed in the UK

DESIGN NOTE

Making Rogowski coils

P N Murgatroyd, A K Y Chu, G K Richardson, D West, G A Yearley and A J Spencer

Department of Electronic and Electrical Engineering, Loughborough University, Loughborough LE11 3TU, UK

Received 21 June 1991 accepted for publication 6 August 1991

Abstract. The Rogowski coil is a flux-to-voltage transducer for non-intrusive current measurement. This note describes fabrication methods for improving mechanical stability and increasing sensitivity.

The Rogowski coil is a flux-to-voltage transducer with many applications in non-intrusive current measurement and in instruments for determining the number of turns on coils. The theory has been given by Stoll (1975) and Ward (1985). The principle is illustrated by figure 1, which shows the Rogowski (or worm) coil encircling a conductor carrying a heavy current $i(t)$. Provided the diameter of the turns is small, the coil voltage is given by

$$e(t) \simeq -\mu_0 n A \frac{\mathrm{d}i}{\mathrm{d}t}$$

where n is the number of turns per unit length, which should be constant along the coil, and A is the turn area. As the result depends upon Ampère's theorem, it is not greatly affected by either the coil shape or the turn shape, nor the position of the worm relative to the encircled conductor. Rogowski coils can therefore be used to measure current, ampère-turns, or turns, and are particularly useful in awkward places or hostile environments.

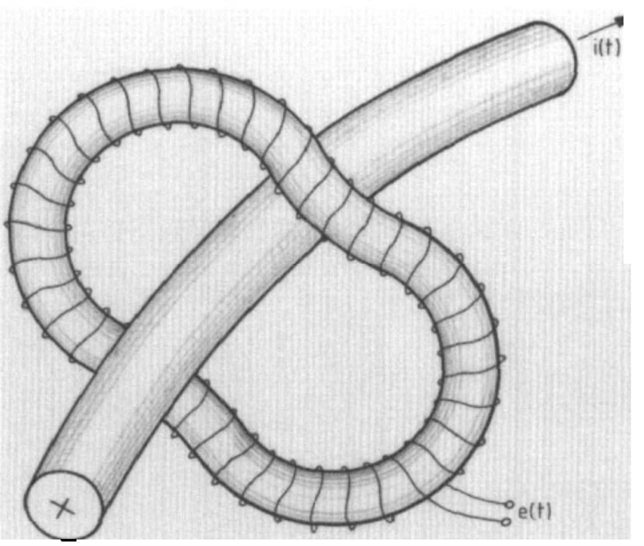

Figure 1. The Rogowski coil is a uniform helix around the unknown current.

This design note describes some practical features of coils developed for a turns-counting instrument, though the methods have quite general application. Basic requirements are that the coil be flexible and that the turn density n be uniform and stable. For low-frequency applications it may be desirable to increase the signal strength through the area A, but this can introduce a systematic departure from the simple theory because the measured flux-density is non-uniform over the turn area. The coil would therefore require calibrating in a fixed position. Thus it is more helpful to increase the density n, but this introduces problems of mechanical stability and uniformity wherever the coil is flexed. A further desirable feature of Rogowski coils is a central return conductor, which conveniently brings both terminals to the same end and eliminates spurious signals due to the whole coil acting as a one-turn search coil.

Our first design, shown in figure 2, is based on large-diameter RF coaxial cable which appears to have a uniform cross-sectional area. With the outer insulation

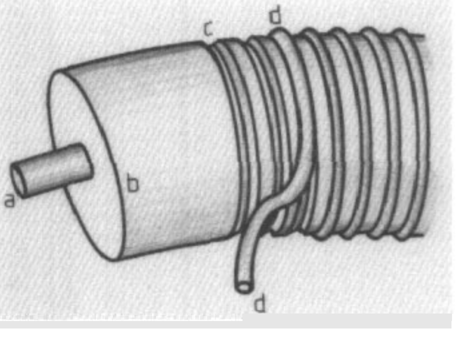

Figure 2. Rogowski coil based on co-axial cable core. (*a*) Core for return path; (*b*) insulation stripped of braid; (*c*) cut threads for location; (*d*) helix laid into threads.

0957-0233/91/121218 + 02 $03.50

and the copper braid layer stripped off, a die is used to cut a thread in the main insulation. Winding the turns into the thread ensures that the pitch of the Rogowski coil is uniform and stable. The central conductor becomes the return path. This construction is probably more useful at higher frequencies – the number density of turns is limited by the finest die thread available rather than the wire diameter, which can be much smaller.

Our second design shown in figure 3 uses a multicore cable. The screened type of cable, with a copper braid sheath enclosing the insulated cores, is not suitable. Motor-car trailer lighting cable (Halfords) has seven cores and no braid sheath, but with care the plastic outer covering will take a thread as described previously. The helix is made from seven fine enamelled copper wires, pre-twisted together between a drill and a vice. The bunch of seven is wound by hand into the thread. The core provides seven return paths, so all the wires of the helix are connected in series and brought out to two terminals at the same end. To protect the Rogowski coil in use, and to hold the helix permanently into the correct spacing, the helix is enclosed in 12.7 mm bore transparent heat-shrinkable sleeving (RS Components). The combination of techniques described in this model usefully raises the sensitivity through the number of turns per unit length, and still keeps the spacing correct and stable when the Rogowski coil is flexed.

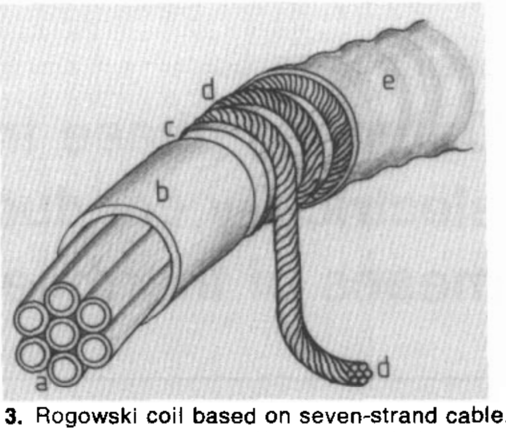

Figure 3. Rogowski coil based on seven-strand cable. (*a*) Seven cores in trailer cable; (*b*) cable insulation sheath; (*c*) cut threads for location; (*d*) seven-strand enamelled copper, pre-twisted; (*e*) heat shrink sheath.

References

Stoll R L 1975 Method of measuring alternating currents without disturbing the conducting circuit *Proc IEE* **122** 1166–7

Ward D A 1985 Precision measurement of AC currents in the range 1 A to greater than 100 kA using Rogowski coils *British Electromagnetic Measurements Conf. NPL* Conf. Digest 8/2