AN OVERVIEW OF ROGOWSKI COIL CURRENT SENSING TECHNOLOGY

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ABSTRACT

The following pages present a brief overview of Rogowski coil current sensing technology. The intent of this document is to allow the reader to develop a basic understanding of the versatile Rogowski coil technology. The first section includes an outline of the theory of operation. The reader is encouraged to consult the reference material listed if further information is required. The second section covers many of the construction techniques and configurations that are available using Rogowski coil technology. A section covering the characteristics of commercially available Rogowski based products, including the advantages and limitations, provides the reader information to directly compare Rogowski technology with other forms of ac current measurement. Finally a brief discussion of the many applications of Rogowski technology is provided.

INTRODUCTION

Rogowski coils, also called air-cored coils, evolved from simple solenoids and have been in use since 1912. Early applications of the technology were limited because the low output voltage was inadequate to drive the measuring equipment of the day. As the sensitivity of measurement equipment improved, Rogowski coils began to be used in a variety of specialized ac current monitoring applications. Solid state electronics and increased use of microprocessor technology provides opportunities to apply Rogowski coil technology in an ever widening range of applications. More recently Rogowski technology has been incorporated into commercially available sensor products in a variety of configurations, including the popular flexible type. These products offer several distinct advantages over other forms of ac current measurement, in some cases at lower cost.

In many applications the use of traditional iron core transformers (CTs), solid or split, may be limited by both electrical characteristics and mechanical design. Iron core CTs have typically been used in permanent applications while iron core clamp-on CTs have long been the standard in portable test and measurement applications.

The mechanical design of these sensors can generate a number of problems in applications requiring measurement in tight spaces. The rigid jaw of clamp-on CTs can hinder or prevent installation in crowded panels and may only allow measurement of a single conductor. In some applications the user may be required to carry several different CTs to cover the ranges that may be encountered. This can be a significant problem if the user must measure high currents that require large, heavy CT's.

Accurate current measurement when using a typical split core or clamp on CT will depend on the alignment of the jaw. The split in the iron core requires the mating surfaces to be properly aligned for accurate measurement. Some applications may prevent these surfaces from aligning properly or allowing the user to determine if they are completely closed.

Installation and removal of iron core CTs on a live conductor can result in an inductive kick. This voltage surge can represent a significant hazard to both equipment and personnel. These hazards can also exist if the secondary becomes open circuited while installed on a live conductor.

Circuit loading can also be a problem when using iron core CTs in a low impedance circuit. The added load of the CT can actually change the characteristics of the measured circuit.

If dc current is present on the conductor being measured the iron core can become magnetically saturated. The CT must then be degaussed to remove any residual field before it can be used again.

Rogowski coils can overcome many of these problems. The new flexible Rogowski based current probes allow the user to easily install the measurement head in tight spaces that may be inaccessible with typical iron core CT products. The variety of diameters and current ranges available allow the user to carry only one lightweight probe for a wide range of applications. In addition Rogowski coils produce a safe low voltage output eliminating the hazards associated with misalignment and open secondary windings. The absence of an iron core virtually eliminates circuit loading and saturation concerns.

THEORY OF OPERATION

Rogowski coil theory is based upon Faraday's law that states "the total electromotive force induced in a closed circuit is proportional to the time rate of change of the total magnetic flux linking the circuit". A simple flexible Rogowski coil is shown in figure 1.

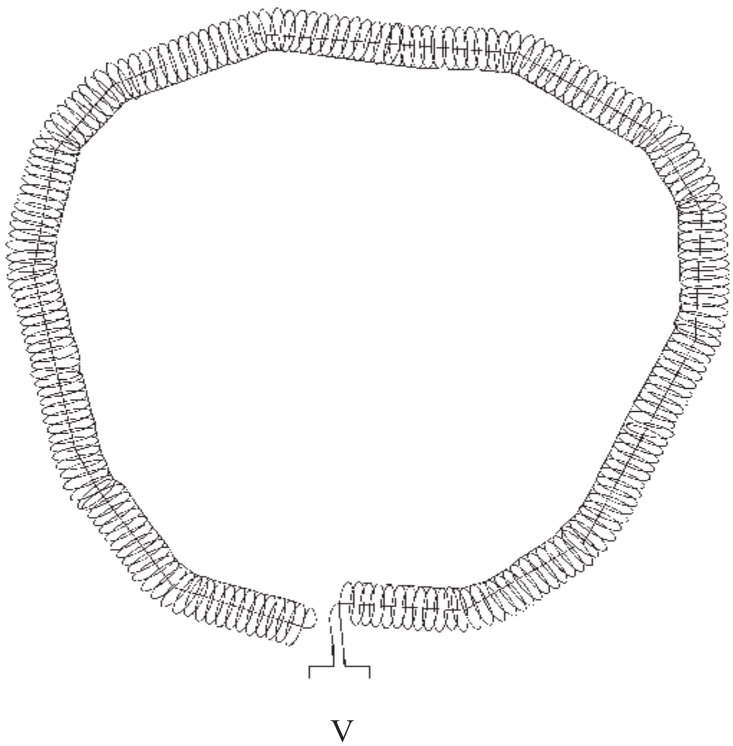

Figure 1
Flexible Rogowski Coil

A voltage can be induced in a wire loop by moving the conductor through a magnetic field or by placing the wire loop in a time varying magnetic field. The induced voltage will be defined by the following general equation (derived from Faraday's law and Maxwell's equation) shown below.

$$\mathbf{V} = \oint (u \times \mathbf{B}) \cdot d\mathbf{l} - \int_s \frac{\partial \mathbf{B}}{\partial t} \cdot d\mathbf{s}$$

Where

u =	Velocity of conductor segment, d**l**
B =	Flux density
$d\mathbf{l}$ =	Small segment of conductor
t =	Time
$d\mathbf{s}$ =	Small element of surface

This equation includes two components, the first term is a line integral taken around a closed circuit that is moving with a vector velocity in a magnetic field. The second term is a surface integral of a time varying field, taken over the entire surface bounded by the circuit. The polarity of the output voltage will be determined by Lenz's' law that states "the induced current in a loop is always in a direction as to produce a flux opposing the initial change in flux".

The wire loop may be configured as a single turn, a simple helix, a toroid, or other configuration used to form a sensor. The Rogowski coil sensor, as shown in figure 1, is shaped into a flexible coil of uniform cross section wound upon a non-ferrous core. The voltage measured across the coil will be proportional to the rate of change of the magnetic field.

One characteristic of this configuration is the coaxial routing of the coil end back to the beginning. This allows the coil ends to be temporarily separated to allow installation around a primary conductor. If this coaxial return was not incorporated the sensor would essentially become a one turn loop around the conductor and would be sensitive to any magnetic field that was perpendicular to the plane of the sensor.

The typical use of the coil is to bend it into a closed path in order to completely capture a signal proportional to the current passing through the aperture of the coil. In this configuration the sensor provides a voltage output proportional to the rate of change of the magnetic field expressed as follows:

$$\mathrm{V} = -\mathrm{K}\ \mathrm{N}\ \mathrm{A}\ \mathrm{d}ƒ/\mathrm{dt}$$

Where:
K = Constant
N = Turns per length
A = Average area of a turn
dƒ/dt = Time rate of change of magnetic flux

Since the rate of change of the magnetic filed is directly proportional to the rate of change of the primary current the voltage output of a Rogowski coil can be defined by the following simplified equation.

$$\mathrm{V} = -K_1\,NA\frac{d\,\mathbf{i}}{d\,\mathbf{t}}$$

Where:
K = Permeability of a vacuum
i = Instantaneous current
di/dt = Time rate of change of the instantaneous current

The output voltage of the Rogowski coil is equal to the derivative of the instantaneous primary current. In the case of a sinusoidal primary current this voltage output is 90 degrees out of phase with the primary current, the equation can be further simplified as shown below.

$$\mathrm{V} = K_2\,\mathrm{I}_{RMS}\ '\ \mathrm{Hz}$$

Where:
Hz = Frequency

It is necessary to integrate the coil output voltage to accurately recreate the original primary current waveform in shape, phase, and magnitude. Therefore most commercially available Rogowski based current probes are supplied with an integrator. Some users have tried to use Rogowski coils without an integrator and have had many problems. For example, if the primary current contains a tenth harmonic, then this component of the output voltage is 10 times its magnitude compared to the primary current component.

This section has dealt primarily with the Rogowski coil measurement head. As we have shown, the majority of applications will require the measurement head to be connected to an integrator to provide the user with accurate information. The integrator circuits that may be employed can vary considerably in complexity and specifications. Close attention should be given to the integrator circuit in the areas of bandwidth and low end stability.

CONSTRUCTION TECHNIQUES

A = High Current LEM-flex
B,C = LEM~flexII, LEM~flex
D, E, F, H = Segmented Coil Sensores (Rogowski Variant)
G = Model COP (Used for High Current dc Applications)

Figure 2
Various Rogowski Coil Configurations

Since the introduction of the first Rogowski coils over eighty years ago numerous magnetic field and current measurement applications have been addressed. Many of these applications have dictated their own electrical and mechanical requirements. Some variations of the basic Rogowski coil are designed for only portable applications and others are designed to be permanently installed on the primary conductor. Figure 2 shows several configurations. The following outlines some of the various designs, advantages, and limitations of Rogowski coil technology. This is not an exhaustive list, Rogowski coils are configurable in virtually any form that will allow a coil to be wound.

Flexible Coils

As shown in figure 1 a simple form of Rogowski coil is the helix with the end of the coil coaxially routed through the center of the coil. Although this is the most common form of construction for flexible Rogowski coils other return paths can be used. The return path can be configured as another layer of turns or as a layer outside the coil. However, these techniques can increase interwinding capacitance and decrease bandwidth.

In some applications the coil is actually formed around square or rectangular cores, such as a bobbin. This type of construction can be used to create a variant of the Rogowski coil that allows several discreet, discontinuous coils to be connected in series. This type of sensor provides many of the benefits of Rogowski technology, but with higher output and greater durability. An example is shown below.

Figure 3
Segmented Coil Variation of Rogowski Coil

Rigid Coils

Any configuration of Rogowski coil must effectively compensate for the interruption in turns at the ends of the coil. Accurate measurement with Rogowski coils is dependent on a coil of uniform cross section. Any “gap” in this coil can cause errors and contribute to increased position sensitivity. Additional windings at the termination of the coil will compensate for these gaps. Several variations of rigid configurations are described below.

As the flexible example above some coils are actually made from sets of straight coils. The return path is closed by simply butting the coils against transformer steel corner blocks. This technique allows the use of a rigid, linear coil still completing the magnetic circuit and minimizing the effects of external fields.

It is also possible to wind the coil as a toroid around a rigid form. However, the form must allow for the coaxial return from the end of the coil.

Another form of rigid coil is constructed of paired coil sets with different diameters but but with the same area turns sensitivity. In this form the different diameter of the coils allows the ends to simply be inserted together to form a closed path. This configuration provides a closed path from rigid, linear segments, minimizing position sensitivity and external field errors.

In some high current measurement applications Rogowski coils are constructed in a deep “U” pattern, or fork. This allows the user to install and measure current on high current carrying conductors in difficult to reach installations. Accurate measurement using this configuration requires the “U” channel to be very deep relative to the diameter of the conductor or thickness of the bus. This configuration is also very susceptible to external magnetic fields.

Signal Strength

The major limitation to applying Rogowski coils has been the very low voltage output. However, it has become easier to use smaller diameter coils as electronic integrators have been improved with smaller, more stable, energy conservative components. These smaller diameter coils are more flexible and much easier to thread into tight locations, facilitating measurements that may have previously been unattainable.

It is possible to improve the output of the coil in several ways, but many tradeoffs exist. Decreasing the size of the wire allows more turns per unit length although small gauge wire may be too fragile and reduce the coil reliability. Increasing the size of the average turn produces greater output but the resulting increased diameter limits the possible locations where the sensor can be used. Additional layers of turns can be used to strengthen the signal, but also results in increased diameter. This method increases inter-winding capacitance and will limit bandwidth.

Error Sources and Compensation

There may be small errors generated wherever the Rogowski coil is not of uniform turns density or where the area of the turn varies. This is particularly an issue to be dealt with at the junction of the two ends of the flexible coil where, for a short gap, there cannot be the normal turns structure. Most manufacturers compensate for this by adding turns density immediately adjacent to the gap. Installation of the coil in such a way that this junction is as far as possible from the primary conductor will minimize this effect. Problems of non-uniform turns density can also exist if the coil is not wound with a uniform spacing between adjacent turns. Gaps or overlaps in the winding cause errors that become noticeable in the presence of strong external magnetic fields. These non-uniformities can also contribute to position sensitivity where there are large gradients in the fields impinging on different parts of the sensor, such as measuring current on a small conductor relative to the measurement head.

Bending the flexible coils into a closed path slightly deforms the manufactured circular cross section turns into an oval, with a corresponding decrease in the area of the average turn. Most manufacturers calibrate these coils in their closed path form eliminating concern for deformation errors. Exceeding the minimum bend radius of the flexible form can cause some turns to permanently shift spacing or even be broken.

DC Measurement

Some rigid coils are constructed so the sensor can be opened and closed to surround a conductor, creating a change in flux linkages, for the purpose of measuring dc currents. This technique utilizes the first part of the equation shown in the previous section. The measurement is performed in two steps. The sensor is closed with no primary current passing through the aperture and a stable integrator is zeroed. The sensor is then opened, moved to surround the primary dc carrying conductor and closed again. The dc current captured by the mechanical act of encirclement is indicated by the integrator that tracked the change in flux couplings from one condition to the other. In this application the integrator design must establish the base zero dc level of the waveform. The measurement of unidirectional pulse currents is also possible with Rogowski sensors.

CHARACTERISTICS OF ROGOWSKI BASED CURRENT SENSORS

The following specifications are based on a survey of commercially available Rogowski based current measurement products. In most cases the use of a Rogowski based sensor system consists of a measurement head and integrator electronics, typically referred to as a current probe. Unless specifically indicated the specification should be interpreted to include the effect of both the measurement head and integrator electronics. Every attempt has been made to provide a comprehensive representation of the capability of commercially available Rogowski based current probes as a technology and to avoid comparing the specific product features of various manufacturers.

1. Linear Current Range

Rogowski coils have an extremely wide range of measurement. Commercially available Rogowski based current probes are available from 30A full scale to more than 100kA full scale. The maximum current range of a Rogowski measurement head is affected by both the frequency and magnitude of the measured current. The integrator electronics will also impose limitations on the magnitude of the integrated signal.

2. Current Linearity

The linearity of commercially available Rogowski based current probes typically includes the effects of both the measurement head and integrator and range from ±0.2% of reading to ±0.5% of full scale. Measurement head non-linearity is determined by the reactance of the sensor head. Construction variables such as wire gauge, unit turns and cross sectional area of the sensor head will affect the reactance. Integrator non-linearity will be determined by amplifier gain limitations.

3. Temperature sensitivity

Most commercially available Rogowski based current probes specify the temperature range of the measurement head and integrator electronics separately. Temperature sensitivity specifications, though not provided by all manufacturers, typically include both components and range from ±0.03% / °C to ±0.08% / °C.

Temperature ranges for the measurement head vary from (10°C - 80°C) to (-20°C - 90°C). Applications that require higher temperature ranges can be accommodated through special treatment of the measurement head or special calibration. Sensitivity of the measurement head will be affected by thermal expansion of the turns, thermal expansion of the former on which the coil is wound, and the temperature coefficient of the wire used to make the coil.

Temperature ranges for electronics vary from (10°C - 40°C) to (-20°C - 55°C). Temperature sensitivity of the integrator electronics will be primarily due to zero drift and the change of capacitance with temperature.

4. Response Time

There are several definitions of response time. LEM defines response time as the time required for a transducer to reach 10% of full scale value when a step function input is applied. Response time is typically not specified for commercially available Rogowski based current probes. However, testing of the some Rogowski coils have indicated that 1m S response times can be realized. Response time for Rogowski coils will be determined by the reactance of the sensor head.

5. Bandwidth

Rogowski based current probes are available with bandwidths ranging from 1kHz to 1.5Mhz. with significant price differences between the moderate and high frequency products. A tradeoff between bandwidth and current range exists due to the nature of the technology (refer to item 1). Some Rogowski based probes exhibit significant phase shift as the frequency of the measured current increases. This will vary by manufacturer and can be a concern if the user is ultimately interested in measuring power, particularly at high frequencies. Figure 4 is a plot of the frequency range of the LEM-flexII current probe.

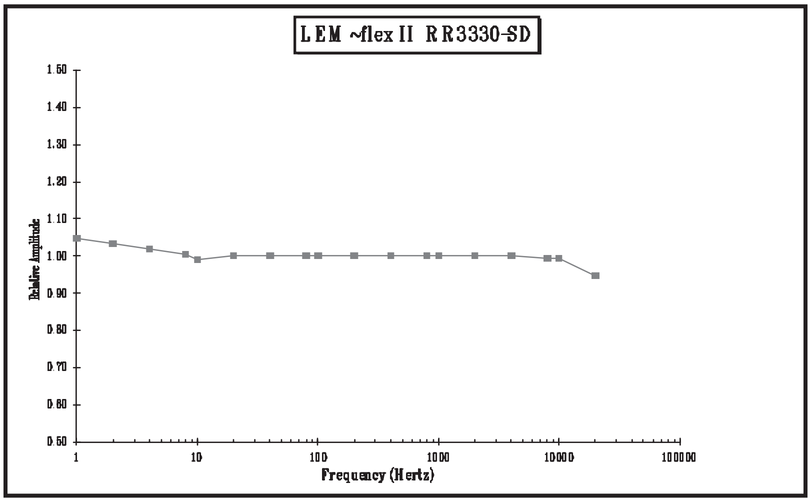

Figure 4
Bandwidth of a Rogowski Based Current Probe

6. Maximum Voltage

Like current transformers Rogowski coils provide galvanic isolation between the conductor being measured and the measurement instrumentation. Typical working voltage for most commercially available Rogowski coils range from 60V to 1000V. However, specialized coils are available with ranges of more than 5kV.

7. Maximum Current

Commercially available Rogowski based current probes are available with full scale current ranges of 30A to more than 100kA. The maximum current that can be measured with a commercially available Rogowski based probe will actually be limited by the integrator electronics “clipping” and is not specified by manufacturers. The maximum current a Rogowski coil can measure will be a function of the frequency and magnitude of the current to be measured and is only limited by the breakdown voltage of the sensor. In practice the upper limit of the current measuring capability of a Rogowski coil exceeds the practical capability to test the maximum.

8. Core Saturation

Not applicable to Rogowski coils.

9. Isolation

Like a typical current transformer, Rogowski coils provide Galvanic isolation from the primary conductor. Several of the commercially available Rogowski based current probes have double or reinforced insulation. Insulation level is a function of the outer jacket material and thickness. Rogowski coil sensors that comply with IEC-1010 (CE) are hi-pot tested for 5550VAC RMS minimum.

10. DC Offset

DC offset on a Rogowski based probe is a function of the amplifier and circuit in the integrator electronics. It is typically specified as a maximum offset, (mV), evident on the output of the probes. DC offset specifications range from below 1mV to 50mV depending on current range. Low current measurement ranges and relatively high output voltages require high gain in the integrator electronics, this can result in higher dc offset. DC offset is not specified by all Rogowski based probe manufacturers and does not typically present a problem when the probes are used with ac coupled display or recording devices.

11. Slew Rate

Slew rate is not specified by any of the Rogowski based current probe manufacturers although the specification may apply to the amplifier within the integrator electronics. Refer to item 25 that addresses the di/dt of both the measurement head and integrator electronics.

12. Common Mode Rejection

Common mode rejection is not specified by all Rogowski based current probe manufacturers. There are many application specific variables that can affect common mode rejection, typical common mode rejection ranges from 80dB to 100dB. Common mode interference can exist between the primary conductor and the output of the integrator electronics due to capacitive coupling between the measurement head and the primary or adjacent conductors. Susceptibility to common mode noise will increase with gain, whether from increased turns density in the measurement head or amplifier gain. In most applications common mode interference is negligible.

13. Accuracy

The accuracy of commercially available Rogowski based current probes ranges from $\pm$1% of reading to $\pm$2% of full scale. In addition to the calibration tools and procedures, accuracy will be affected by the winding tolerance, turns density and cross sectional area. In addition Rogowski coils exhibit some sensitivity to the position of the conductor within the measurement window. Split Rogowski probes exhibit the maximum error at the measurement head split. Testing of these "Position sensitivity" errors has found a typical range of $\pm$1% to $\pm$4%, however errors of up to $\pm$6% can be observed if the measured conductor is touching the coupling. Position sensitivity errors can be minimized through careful design and construction techniques to compensate for this gap.

14. Noise Immunity

Manufacturers of Rogowski based current probes do not provide a specification for noise immunity. However, current probes that comply with IEC 1010 (CE) must meet defined EMI/RF requirements. Consult the manufacturer for specific details if required. Some manufacturers provide a maximum noise specification, refer to item 15.

15. Noise Generation

Some manufacturers provide a maximum noise specification expressed as a maximum level of current on the input (e.g., 200mA) or as a maximum level of voltage on the output of the integrator electronics (e.g., 2mV max.). Noise specifications range from 0.002% to 1.6% of full scale depending on how the noise is specified and the full scale range of the current probe. All manufacturer specifications were converted to percentage of full scale for comparison.

16. External Power Requirements

Most commercially available Rogowski based current probes include battery powered integrator modules, (the measurement head is driven by magnetic field changes). Some manufacturers offer probes that can be powered by external ac adapters or provide an integral cable or connector to allow the user to supply external power. Typical power requirements are 3Vdc to 24Vdc or $\pm$15V. Passive integrators are available but exibit severely limited bandwidth.

17. Tolerance to overcurrent

Manufacturers of commercially available Rogowski based current probes do not provide an overcurrent specification. As previously stated Rogowski coils can be used to measure very high currents and provide excellent overcurrent tolerance. Refer to item 7 for more detail on over current.

18. Output Type

Commercially available Rogowski based current probes provide a safe voltage output that is typically expressed as a sensitivity ranging from 0.01mV/Amp to 100mV/Amp. Full scale output ranges from 200mV to 10V are available. Some manufacturers will provide special scaling or outputs. The output of the measurement head is a voltage proportional to the rate of change of the input current. Some manufacturers will provide only the measurement head but this requires the user to develop their own integrator electronics.

19. Ruggedness

Not all manufacturers of Rogowski based current probes provide specifications for shock and vibration although some indicate compliance with IEC standards. Some manufacturers provide ratings compared to IEC 529 (also called IP ratings). These provide the user with information as to the susceptibility of the probe to environmental conditions such as water, dust, and damage caused by objects such as tools.

When these specifications are provided, the measurement head and enclosure are specified separately. Most commercially available current probes are designed to provide reliable performance in an industrial environment. The measurement head of flexible Rogowski based probes can be damaged if the minimum bend radius is exceeded and some materials can become brittle at low temperature extremes. The measurement head material may also soften if the temperature exceeds specifications.

20. Circuit Loading

Rogowski based current probes do not significantly load the circuit under test due to the absence of an iron core.

21. Sensing Circuit Power Loss

Most commercially available Rogowski based current probes are battery operated and/or provide the option of supplying external power. Most manufacturers provide a simple LED battery condition indicator. This LED will flash or illuminate if the battery voltage drops below a preset threshold, alerting the user to a low battery condition.

22. System Cost

Commercially available Rogowski based current probes range in price from less than $100.00 to several thousand dollars and typically include a measurement head and integrator electronics. These prices will vary based on construction, circumference of the measurement head, current range, bandwidth, temperature range, and manufacturer. Some manufacturers will provide only the measurement head as an economical solution if the user is able to develop or provide the integrator electronics. However engineering, testing, and manufacturing times for the circuit(s) need to be considered.

23. Zero Crossover

Not applicable to Rogowski coils.

24. Hysteresis

Not Applicable to Rogowski coils

25. di/dt

This specification is not provided by manufacturers of Rogowski based current probes. However, testing has indicated that commercially available Rogowski based current probes can provide capability from 250A/Second to 250A/μS. Design and construction of the measurement head can limit high di/dt response, particularly if a shield is used. Other variables such as number of windings and cross sectional area will affect di/dt. Changes in the design of the measurement head can increase or decrease di/dt to accommodate special applications.

The lower limit of di/dt will be determined by the integrator design. Scaling, amplifier gain, and zero drift can also affect di/dt.

26. Size

Commercially available Rogowski based current probes are available in many different sizes based on the configuration. The standard circumferences for flexible Rogowski based current probes are 24", 36", 48", and 60". Some manufacturers offer special measurement head lengths. Split or fixed through hole type Rogowski coils are available in several rigid configurations ranging from "donut" style to PCB mount.

27. Signal to Noise Ratio

Manufacturers of Rogowski based current probes do not specify a signal to noise ratio although maximum noise specifications are typically provided. The signal to noise ratio will improve as the full scale or measured range of the current probe increases, and amplifier gain decreases. Refer to items 12, 13 and 15 for more details.

28. Calibration Requirements

Some manufacturers of commercially available Rogowski based current probes recommend annual recalibration of the system. Whether this is required will depend on the calibration method (fixed or potentiometer), the likelihood of drift, and the application. The user should certainly follow the standards of good practice as with any sensing devices. Most manufacturers will offer recalibration at the factory for their products.

APPLICATIONS

Rogowski coils have been in use for over 85 years. Early applications of Rogowski technology were limited to measurement of magnetic fields due to the low signal output. The advancement of electronics has provided opportunities to use Rogowski coil technology in a wide range of applications. In particular, the low voltage output of Rogowski coils is compatible for use with microprocessor based systems. The advantages offered by Rogowski technology; accuracy, measurement range, bandwidth, unlimited short circuit current tolerance, and design flexibility are rapidly generating interest in a number of applications.

Power and Power Quality Monitoring

Flexible Rogowski based current probes have gained rapid acceptance in the power monitoring and power quality industry. The advantages of a flexible measurement head and light weight are important factors to those involved in field studies of power and power quality. The advantages of bandwidth and measurement range provide the user with confident measurement of transients and harmonics when used with a range of power quality analyzers, power recorders and data loggers. The applications for power quality measurements range from monitoring office equipment to utility distribution equipment.

Rectifier Monitoring

Although Rogowski coils are insensitive to dc they can be used to measure pulsed dc currents. Rogowski coils have been used in high power rectifiers to measure pulsed dc from six phase legs. These currents can then be summed to determine the total rectifier current. Each leg in a rectifier may be constructed of several rectifier elements connected in parallel. Rogowski coils have also been used to determine the current distribution between these parallel paths. Figure 5 shows a flexible Rogowski coil installed in a high current rectifier.

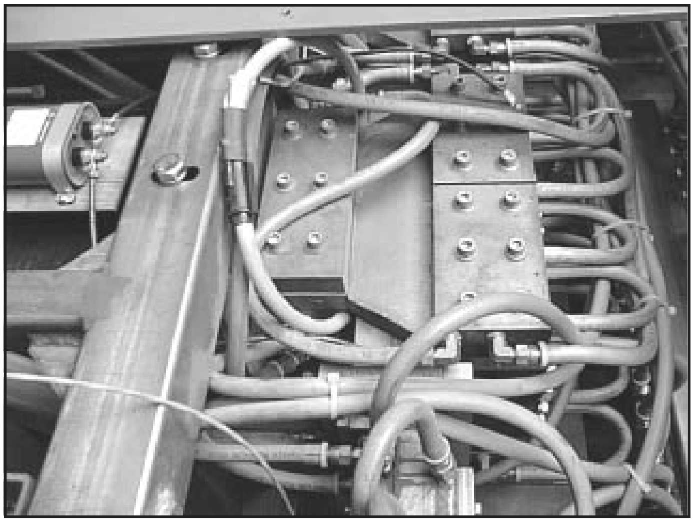

Figure 5
Flexible Rogowski Coil Installed Around Rectifier Bus

DC Current

Electrochemical processing plants such as aluminum or chlorine require the measurement of very high dc currents. These measurements are typically made in areas with active nearby conductors carrying similar or higher currents. Iron core CTs are very prone to errors caused by these magnetic non-linearity's. Rogowski coils are used in this application to measure intercell bus currents and current distribution within individual cells. The measurement head is moved through the magnetic field, creating the flux coupling change, and the dc current level is displayed and/or recorded.

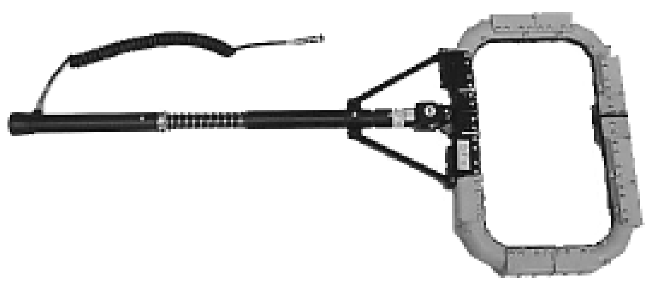

Figure 6
Segmented Coil Used For dc Current Measurement

Wiring Integrity

Flexible Rogowski coils can be provided that are of sufficient length to encircle a group of conduits, large wire or cable trays, or bus work. In this application the "net current" is measured to determine such problems as illegal neutral to ground connections or crossed neutrals.

Fuse Monitoring

Very small Rogowski coils have been used to monitor single-barrel and multi-barrel current limiting fuses. Multi barrel fuse designs use two or three fuses in parallel to increase the current rating. The Rogowski coils were used to monitor current distribution between the fuses to optimize fuse design.

Relay Protection

Microprocessor-based relays do not accept the 1A or 5A signal directly from a CT secondary but require low voltage inputs in the range of 5V. In a typical application the signal from the CT secondary is transformed to the low voltage level by the insertion of scaling transformers. The low voltage output of a Rogowski coil can be connected directly to the relay voltage input eliminating the need for scaling transformers. Any required amplification of the low voltage signal can be done during integration of the signal.

Switchgear

In the 1980's studies were conducted that indicated Rogowski coils could be used for relay protection in medium voltage switchgear. Recently, some switchgear manufacturers have begun to use Rogowski coils as an alternative to traditional CT's in medium voltage switchgear.

These represent a few of the applications in which Rogowski technology is used or could be utilized. The design and construction flexibility, improved cost/performance ratios, and the increased use of microprocessor based measurement and control systems are sure to widen the range of applications in which Rogowski technology will be used in the future.

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