

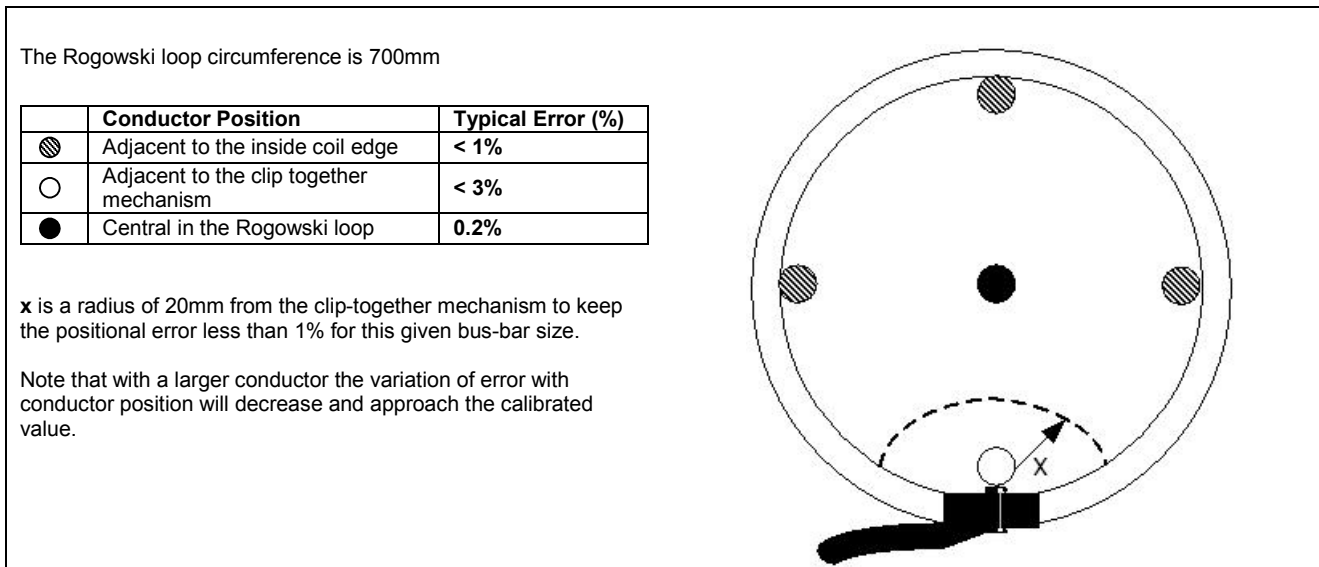
## RCTi Accuracy

### Conductor position in the Rogowski loop

Due to small variations in the winding density and coil cross sectional area the transducer output varies slightly depending on the position of the current in the loop and also the size of the current conductor relative to the loop.

A given bus-bar conductor of area (140mm<sup>2</sup>) is moved around the Rogowski loop as shown in Figure 1. The Rogowski coil is calibrated with the conductor central in the Rogowski loop. The deviation in reading relative to the calibrated value, as the conductor is moved around the loop, is shown in Table 1.

The positional variation is at its worst where the coil clips-together, every effort must be made to keep the conductor away from this area.



*Relative accuracy for positions of the conductor within the Rogowski loop*

## Temperature

The variation in accuracy of the RCTi with temperature results from

1. Expansion of the plastic former onto which the Rogowski coil is wound. This reduces the sensitivity of the Rogowski coil.
2. Drift with temperature of the passive component values that set the integrator time constant

To overcome these problems the Rogowski coil is wound onto a plastic former with a very low coefficient of expansion and high stability resistors and capacitors set the integrator time constant.

The typical values for the various sources of error resulting from temperature change are as follows

	Drift %/°C
Coil expansion	- 0.01
Integrator drift	±0.012

*Sources of variation of accuracy with temperature*

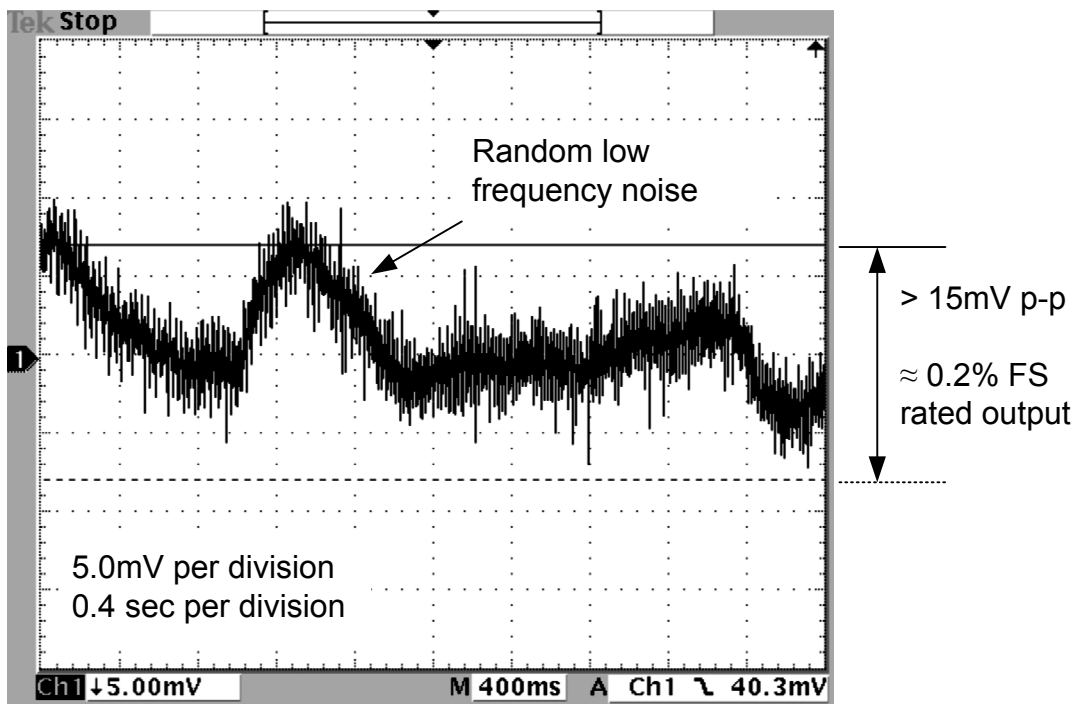
### Measuring small currents (< 5% of rated current)

On the shortform datasheet a typical accuracy is defined for 5 to 150% full-scale. The lower limit of 5% is very conservative and really represents best practice for good measurement. At small currents both the low frequency noise and the DC offset can affect the accuracy of the measurement.

#### Low frequency noise

The integrator op-amp generates random low frequency noise (often called  $1/f$  noise). This noise is distributed around the low frequency bandwidth  $f_l$  where the integrator gain is at a maximum. The magnitude of this noise is proportional to  $1/f_l H$  where H is the coil sensitivity in (Vs/A).

The figure below shows typical low frequency noise for an RCTi / 3 on the x2 range. This noise reduces as the current rating of the RCTi increases. The peak to peak noise values are listed on the table below



Type	Range	Rated current (A)	Noise Max (mVp-p)
RCTi / 3	x1	500	30.0
	x2	1,000	15.0
RCTi / 4	x1	1,000	15.0
	x2	2,000	7.5
All other RCTi's	either range	-	5.0

#### DC offset

The output from the electronic integrator is decoupled into a buffer amplifier. The maximum DC offset at the output of the RCTi is as follows

Type	Range	Ambient temp (°C)	DC offset (mV)
All RCTi	x1	25	5.0
		65	6.0
	x2	25	10.0
		65	12.0

## External currents and voltages

Error can also arise due to the presence of currents close to but outside the Rogowski coil loop. A current of magnitude 100A close to the side of the coil will contribute an error of up to  $\pm 1A$  to the reading. This error will significantly decrease as the external current becomes more distant from the coil.

If the external current (outside the coil loop) is much greater than the current being measured (inside the coil loop) then the error may be significant. This is particularly relevant if the external current is flowing in a nearby multi-turn coil.

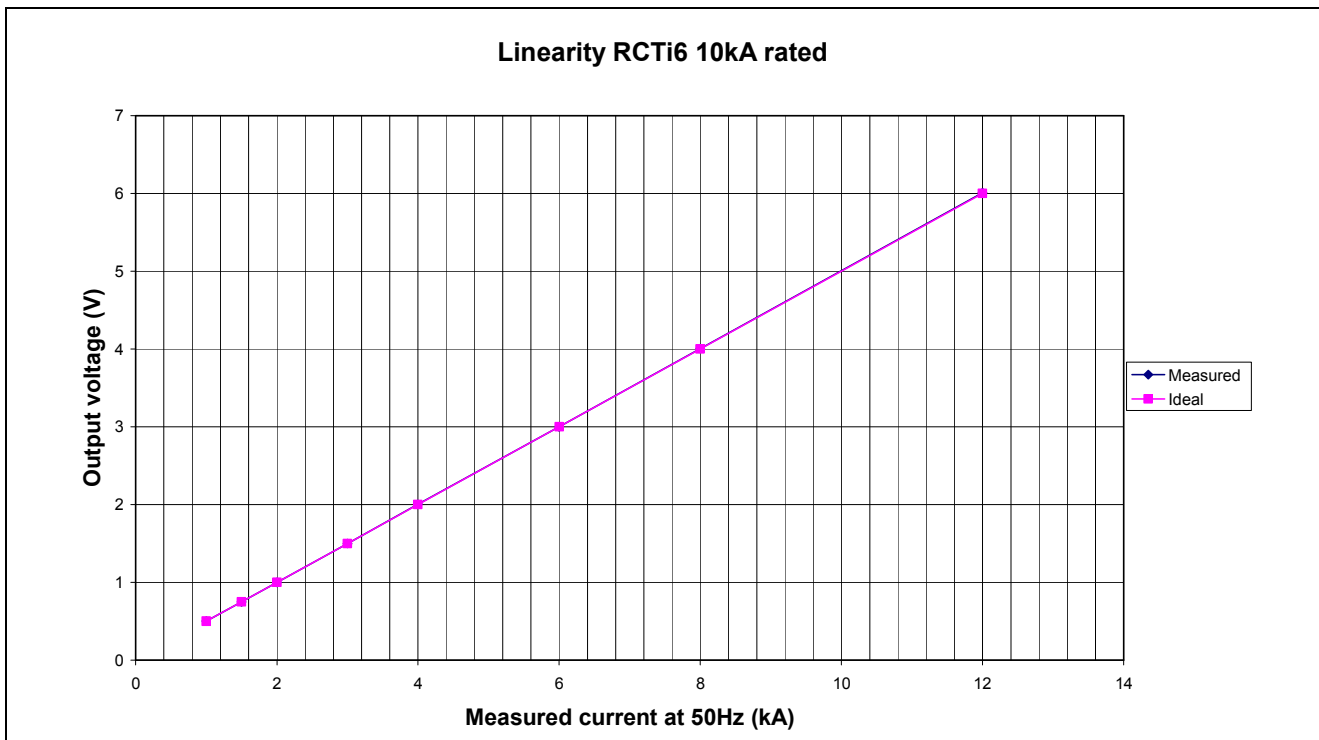
Similarly if there is a surface with a high voltage very close to the coil, and the voltage is subject to high rates of change (e.g. several 100 V/ $\mu$ s) or high frequency oscillations in the MHz range, then measurement error can arise due to capacitive coupling to the coil.

As a check for the effect of external currents or voltages the user should place the Rogowski coil in approximately the same position as used for measuring the desired current, but not looped around the desired current. Ideally there should be no measured signal. If there is interference then the same interference will be superimposed on the current waveform when it is measured and this can be taken into account when interpreting the measurement.

## Linearity

Linearity error is the difference  $\Delta I$  between the true current value  $I$  and the measured value  $V_{out}/R_{sh}$  (where  $R_{sh}$  is the transducer sensitivity V/A). For a fixed frequency and current position,  $\Delta I$  will vary with the current magnitude over the rated range, and can be expressed as a percentage of actual reading  $I$  ( $\Delta I/I \times 100\%$ ).

The linearity has been measured for a typical RCTi/6 rated at 10,000A, with a sensitivity of 0.5mV/A. The current was kept central to the coil loop and increased from 1000A to 12,000A rms. The transducer measurements are compared with those from the UKAS calibrated current transformer and the variation of output voltage with measured current is shown below. The graph shows a comparison of the 'ideal' theoretical output voltage = current  $\times$  0.5mV/A, and the actual **measured** output voltage from the RCTi/6.



The linearity was found to be better than  $\pm 0.2\%$  of actual reading. The transducer is expected to be very linear since there are no saturation or non-linear effects associated with the magnitude of the measured current.