Continental Control Systems, LLC

RCSL-yy.y-xxxx
RCLL-yy.y-xxxx

Rogowski Coil Current Sensor with Internal Conditioning Circuit

The RCSL (small) and RCLL (large) series flexible Rogowski coil current sensors are ideal for applications where regular current transformers will not fit. The RCSL coil end cap is only 0.408 inch (10.35 mm) diameter so the coil can fit through narrow openings. The coil can be flexed to fit around multiple conductors where a rigid CT would not fit.

The wide range of sizes and amperage ratings allow the RCSL and RCLL to be used anywhere from residential monitoring to high-current three-phase industrial or commercial applications.

The RCSL and RCLL include an internal integrator conditioning circuit, eliminating the need for an external circuit.

Features

- Flexible coil for easier installation
- Rated currents: from 200 to 5000 amps
- Shielded coil and cable for noise immunity
- Opening diameters: 1.5 to 11.8 inches (40 to 300 mm)
- Excellent linearity and low phase angle error
- Built-in conditioning circuit
- UL Listed

Links

- **Product page:** ctlsys.com/p/rcxl/
- **Manual:** ctlsys.com/m/RCSL-RCLL-Install-Guide.pdf

1 Models and Options

The RCSL and RCLL models include a conditioning circuit (integrator). This makes the output compatible with WattNode meters. The model number scheme is RCSL-**yy.y-xxxx** for the smaller housing with a thinner coil and RCLL-**yy.y-xxxx** for the larger housing with a thicker coil. "**yy.y**" is the opening (inside) diameter in inches and "**xxxx**" is the rated current in amps.

Without the conditioning circuit (integrator), the output of a Rogowski coil is the derivative of the current being measured. These models include an integrating conditioning circuit to restore the output signal to a voltage proportional to the original current.

Table 1: Models

Model	Rated Primary Current	Maximum Current	Output Signal at Rated Amps	Nominal Opening (Inside) Diameter
RCSL-1.5-0200	200 A	400 A	0.33333 Vac	1.5 in (40 mm)
RCSL-3.1-0250	250 A	2000 A	0.33333 Vac	3.1 in (80 mm)
RCSL-3.1-0600	600 A	2000 A	0.33333 Vac	3.1 in (80 mm)
RCSL-3.1-1000	1000 A	2000 A	0.33333 Vac	3.1 in (80 mm)
RCLL-4.7-1000	1000 A	2000 A	0.33333 Vac	4.7 in (120 mm)
RCLL-4.7-2000	2000 A	2000 A	0.33333 Vac	4.7 in (120 mm)
RCLL-7.8-1000	1000 A	5000 A	0.33333 Vac	7.8 in (200 mm)
RCLL-7.8-2000	2000 A	5000 A	0.33333 Vac	7.8 in (200 mm)
RCLL-11.8-2000	2000 A	5000 A	0.33333 Vac	11.8 in (300 mm)
RCLL-11.8-5000	5000 A	5000 A	0.33333 Vac	11.8 in (300 mm)

Note: the nominal opening dimensions are provided in inches and millimeters. The actual opening will be as large as the metric (millimeter) dimension.

Rated Primary Current: also called “rated amps”, this is the nominal full-scale current rating for the sensor. At the rated primary current, the RCSL or RCLL will output its nominal output of 0.33333 Vac. The accuracy is specified at percentages of the rated primary current.

Maximum Current: also called “maximum continuous amps” or “max amps” is the UL Listing maximum continuous current rating for a particular sensor model.

1.1 Connection Diagram

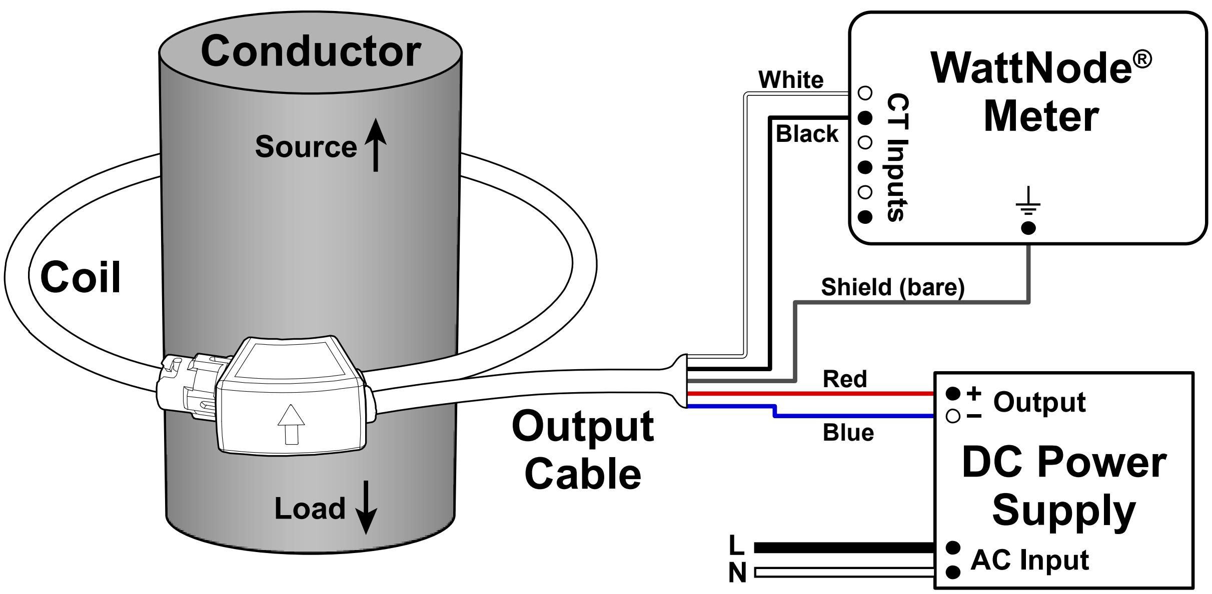


Figure 1: RCSL or RCLL Connection Diagram

1.2 Changes from the CTRC Series

The RCSL and RCLL Rogowski coils have changes from the previous CTRC series Rogowski coils.

- The conditioning circuit output is changed. The RCSL and RCLL models are compatible with the CCS WattNode, Meter Module, and MCM meters, but may not be compatible with other meter models.
  - **CTRC:** single-ended output, 48 Ω source impedance, output isolated from the power supply inputs
  - **RCSL/RCLL:** differential output, 200 Ω source impedance, biased 1.65 Vdc above the power supply ground input (blue)
- The DC power requirements changed:
  - **CTRC:** 10 – 30 Vdc (12 Vdc or 24 Vdc recommended), 50 mA typical, 70 mA maximum
  - **RCSL/RCLL:** 3.5 Vdc to 13.5 Vdc (5 Vdc or 12 Vdc recommended), 6 mA typical, 20 mA maximum

- The RCSL and RCLL recommended power supply is different
- The RCSL is UL Listed to UL 2808, while the CTRC is UL Recognized
- The RCSL and RCLL have lower phase angle errors
- The RCSL and RCLL have more stable gain vs. AC line frequency
- The RCSL and RCLL have lower positional errors
- The RCSL and RCLL are less sensitive to the magnetic fields from external conductors
- The RCSL and RCLL have the conditioning circuit built into the housing
- The RCSL and RCLL have different housing and coil dimensions
- The RCSL and RCLL have different available rated primary currents
- The RCSL and RCLL have a less flexible coil jacket material to meet new UL 2808 requirements
- The RCSL and RCLL have a new latching mechanism
- The RCSL is rated for 600 V, CAT IV (service entrance), while the CTRC is only CAT III
- The RCSL and RCLL have a wider operating temperature range

2 Specifications

2.1 Electrical

- **Nominal Line Frequency:** 50 to 60 Hz
- **Maximum Continuous Primary Current:** see **Table 1** above.
- **Maximum Voltage:** 600 Vac
- **Overvoltage and Measurement Category:**
    - 600 Vac, CAT IV (service entrance) for pollution degree 2
- **Output Cable:**
    - **Length:** 8 ft (2.4 m)
    - **Conductor Wire Gauge:** #24 AWG (0.25 mm^2)
    - **Voltage:** ≥ 600 Vac
    - **Temperature Rating:** 105°C (**note**: the overall sensor is rated to a lower temperature)
    - **Style:** AWM, shielded, four-conductor, twisted, white/black/red/blue
- **DC Supply:**
    - **Input Voltage:** 3.5 Vdc to 13.5 Vdc
    - **Input Polarity:** red = positive, blue = common (negative)
    - **Input Current:** 6 mA typical, 20 mA maximum (excluding short-circuits of the output leads)
- **Output:** 0.33333 Vac nominal at rated primary current with 1.25 Vdc bias relative to DC supply common (blue)
    - **Polarity:** white = current transformer positive (in-phase with current) signal, black = current transformer negative (180 degree phase to current) signal
- **Expected Load Resistance:** (see **Effect of Output Loading section**)**:** 23kΩ

2.2 Accuracy

- **Output Accuracy from 50 to 60 Hz at 25°C:**
    - **Accuracy (% of reading):** ±1.0% from 3% to 120% of rated primary current
    - **Typical Phase Angle:** ±0.10 degrees (6 minutes) from 3% to 120% of rated primary current
    - **Maximum Phase Angle:** ±0.20 degrees (12 minutes) from 3% to 120% of rated primary current
- **Temperature Sensitivity:**
    - **Accuracy:** additional ±0.5% over operating temperature
    - **Phase Angle:** no added error over operating temperature
- **Conductor Position and Orientation Sensitivity:** typical ±0.5%, maximum ±1.0%
  The quoted gain accuracy is with the measured conductor centered in the coil opening and perpendicular to the coil. Moving the conductor off-center or tilting the coil will reduce the accuracy. The phase angle varies by less than 0.01 degrees at varying positions and orientations.

2.3 Power Supply

The recommended power supply is the Mean-Well HDR-15-12. It is available from CCS and other vendors.

- **HDR-15-12**
  - **Make:** Mean-Well Industrial
  - **Type:** DIN-rail mount supply (DIN rail TS-35/7.5 or 15)
  - **AC Input Voltage:** 85 – 264 Vac, 100 – 240 Vac nominal
  - **Input Frequency:** 47 – 63 Hz
  - **Operating Temperature:** -30°C to 70°C (-22°F to 158°F) full load at 50°C, 50% load at 70°C
  - **Input Current:** less than 0.5 A RMS typical
  - **Output Voltage:** 12 Vdc, ±1.0%
  - **Output Current:** 1.25 amps (this is sufficient to power at least 50 sensors)
  - **Maximum Output Power:** 15 watts
  - **Emissions:** CISPR22 class B
  - **Features:** No minimum load, over-voltage protection, overload protection, short-circuit protection
- **Alternate Supplies:** Alternate supplies may also be used, provided the output meets the specifications in section **2.1 Electrical, DC Supply**.

2.4 Regulatory

- **UL:** UL listed, XOBA, UL 2808, CAN/CSA C22.2 No. 61010-1-12, 3rd Edition, E363660
- **RoHS compliant**
- **CE**

2.5 Environmental

- **Operating Temperature:**
  - **RCSL-1.5 and RCSL-3.1:** –40°C to +75°C (–40°F to 167°F)
  - **RCLL-4.7:** –40°C to +75°C (–40°F to 167°F)
  - **RCLL-7.8 and RCLL-11.8:** –40°C to +60°C (–40°F to 140°F)
- **Operating Humidity:** 0 to 95% relative humidity (RH)
- **Operating Altitude:** Up to 2000 m (6562 feet)
- **Pollution Degree:** 2; controlled environment
- **Indoor Use:** Suitable for indoor use
- **Outdoor Use:** Suitable for outdoor use when mounted in a NEMA 4 or 4X (IP 66) rated enclosure, provided the ambient temperature will not exceed the operating temperature limits

2.6 Mechanical

2.6.1 RCSL Mechanical

- **Coil End Cap Diameter:** 0.408 in (10.35 mm)
- **Housing Material:** Polycarbonate (PC), UL 94 V-0 flame rating
- **Coil Jacket Material:** Thermoplastic vulcanizate (TPV), UL 94 V-0 flame rating

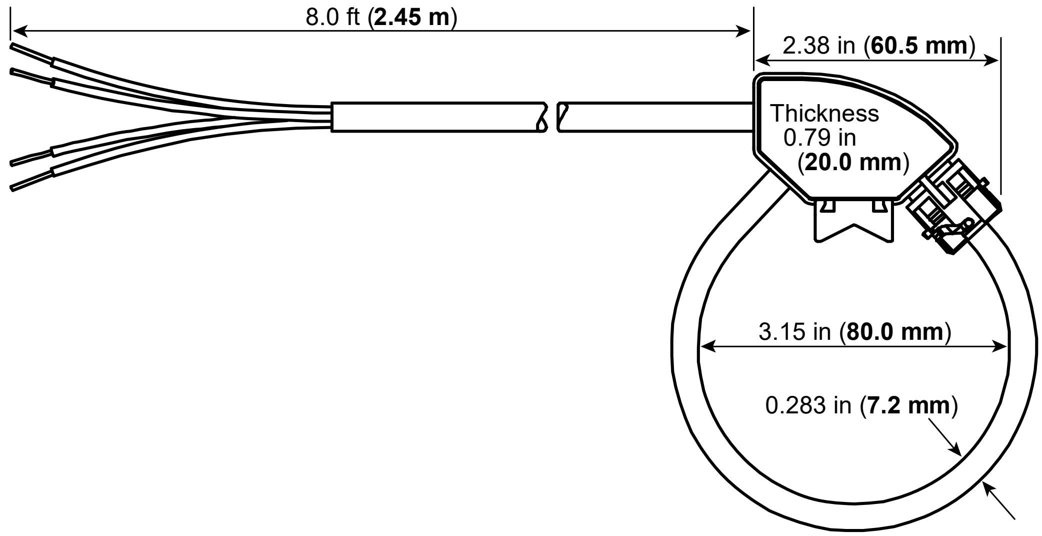


Figure 2: RCSL Dimensions

2.6.2 RCLL Mechanical

- **Coil End Cap Diameter:** 0.443 in (11.25 mm)
- **Housing Material:** Polycarbonate (PC), UL 94 V-0 flame rating
- **Coil Jacket Material:** Thermoplastic vulcanizate (TPV), UL 94 V-0 flame rating

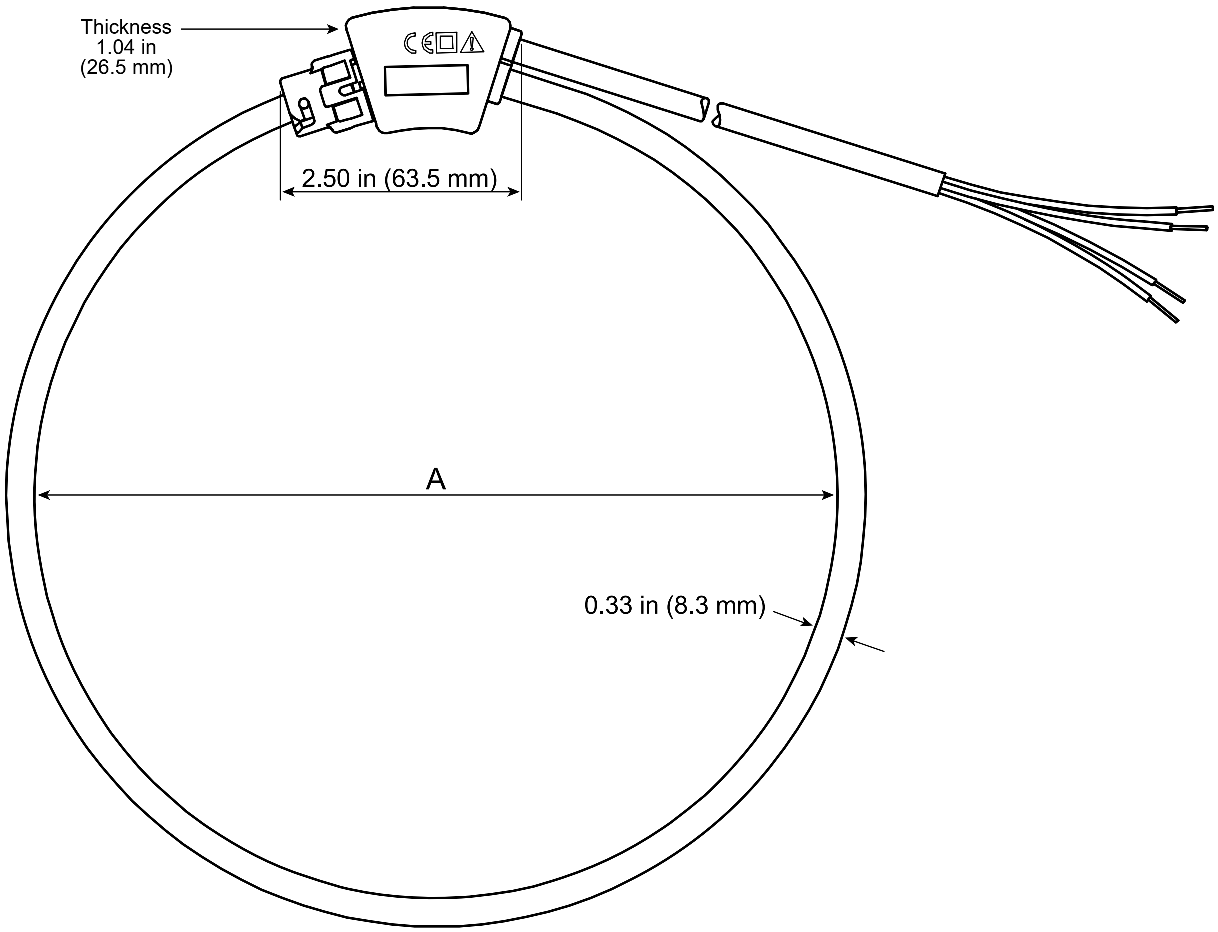


Figure 3: RCLL Dimensions

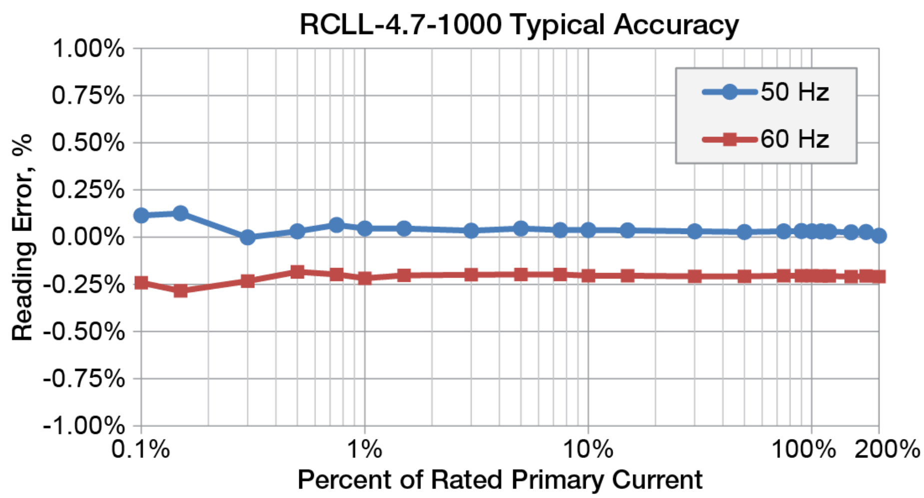
Dimension 'A' is the "Nominal Opening (Inside) Diameter" from **Table 1: Models**.

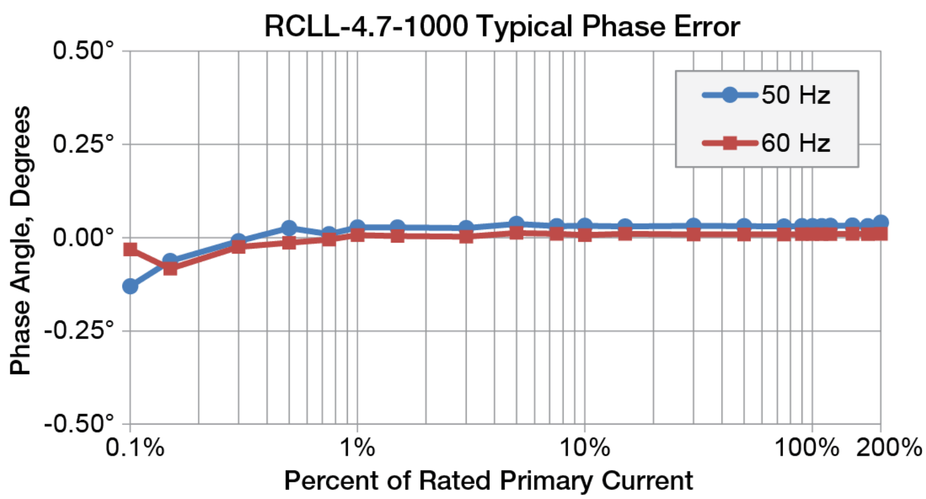
2.7 Miscellaneous

- **Label barcode:** Data matrix, "Model ; SerialNum"

3 Typical Accuracy

In the following graphs, a positive phase angle error indicates that the output (secondary) of the sensor leads the primary current. The following graphs are for 60 Hz.





3.1 Effect of Output Loading

If you are using the RCSL or RCLL Rogowski coil sensors with a WattNode meter, you may disregard this section because they have been optimized for the standard 23kΩ loading of a WattNode meter. For anything other than a WattNode meter, the meter's input impedance may affect the gain, because the meter's input impedance appears as an output load.

Load resistances different from 23kΩ will cause small shifts in the gain. A higher load than expected will result in higher gain, while a lower load will result in a lower gain. The phase angle error is not materially affected by the loading.

The worst-case effects of different loads follow:

- 1.0MΩ load: gain will be high by 0.42%
- 10kΩ load: gain will be low by 0.56%

To precisely compute the effect of non-standard output loadings, use the following.

$$R_O = RCSL\ or\ RCLL\ Output\ Resistance = 100\Omega$$

$$R_D = Designed\ Output\ Loading = 23k\Omega$$

$$R_A = Actual\ Output\ Loading$$

$$e\% = Gain\ Error\ (percentage)$$

$$e\% = 100\frac{R_O(R_A - R_D)}{R_D(R_O + R_A)}$$

Examples:

RCSL-yy.y-xxxx with 10kΩ load: $R_O = 100,\ R_D = 23000,\ R_A = 10000,\ e\% = -0.56\%$ (low)

RCSL-yy.y-xxxx with 1.0MΩ load: $R_O = 100\ \ R_D = 23000,\ R_A = 1{,}000{,}000,\ e\% = +0.42\%$ (high)