ISSUE: June 2024

## A Guide To Designing Your Own Rogowski Sensor (Part 3)

*by Gregory Mirsky, Design Engineer, Deer Park, Ill.*

In parts 1 and 2[1,2] we discussed designs of the Rogowski coil and integrator. In part 3 we are going to check how the coil and integrator work together as the complete Rogowski sensor through simulation of the previously derived sensor schematic (Fig. 1). To verify the sensor's accuracy, these simulations are carried out for current waveforms over a range of duty cycles and frequencies with different waveshapes and both unipolar and bipolar currents.

The coupling between the current carrying bus and sensor has a very low value of 0.05. In other words, just 5% of the magnetic field created by the bus crosses the turns of the Rogowski sensor, which is reasonable. Therefore, the output of the Rogowski coil sees just a portion of the differentiated current through the bus L2. The voltage proportional to the differentiated current is integrated by operational amplifier U2, which has a wide enough operating frequency bandwidth. It is worth noting that the Rogowski sensor is intended for use with ac current, and therefore, slow schematic instabilities do not affect the result.

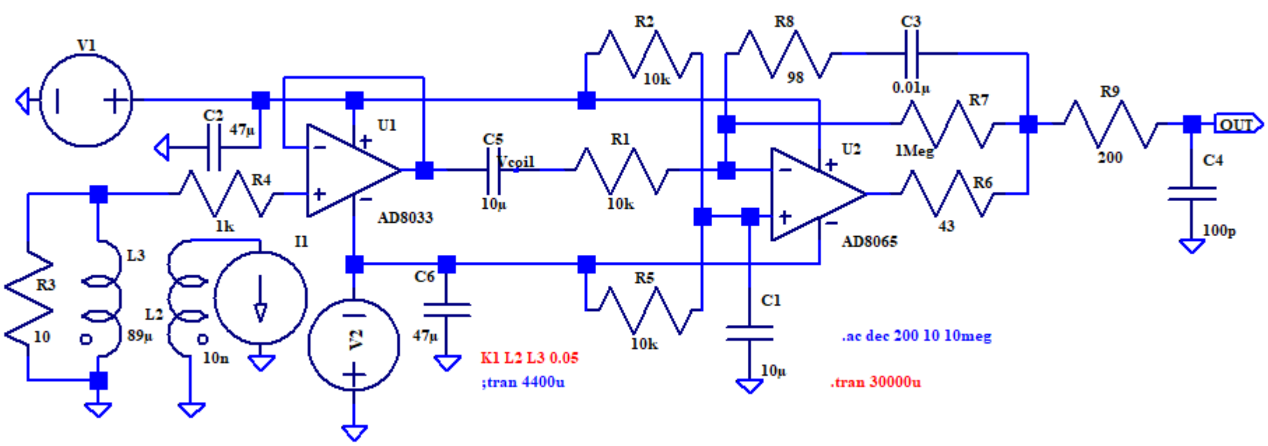


*Fig. 1. Schematic of the simulated Rogowski sensor. The integrator uses the AD8033 and AD8065 op amps.[3,4]*

### Simulation Results

The plots below in Figs. 2 through 9 show the measured current I(I1) (the blue trace), whose name was $I_b$ in the previous parts. Its name was changed to better accommodate LTspice's default notation for waveforms. The sensor output voltage V(out) is shown (the green trace) on the same graph for an easier comparison of the measured current and sensor output voltage.

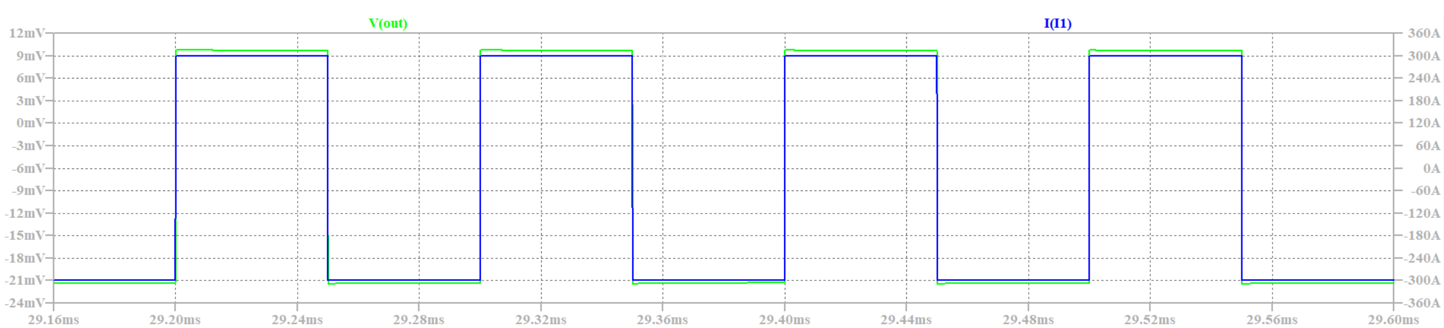


*Fig. 2. Output voltage has the same waveform as the measured current at I1 = 50% duty cycle and 10-kHz square wave.*

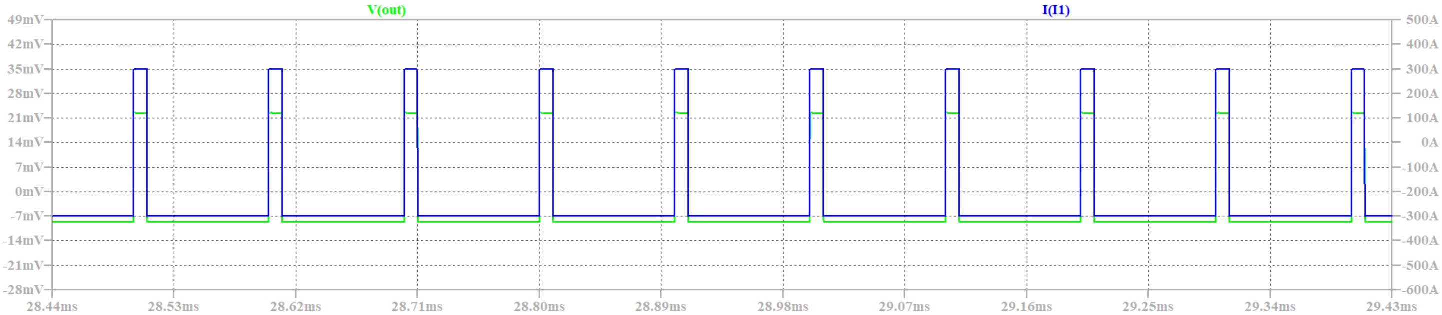


*Fig. 3. Output voltage at I1 = 10% duty cycle and 10-kHz square wave.*

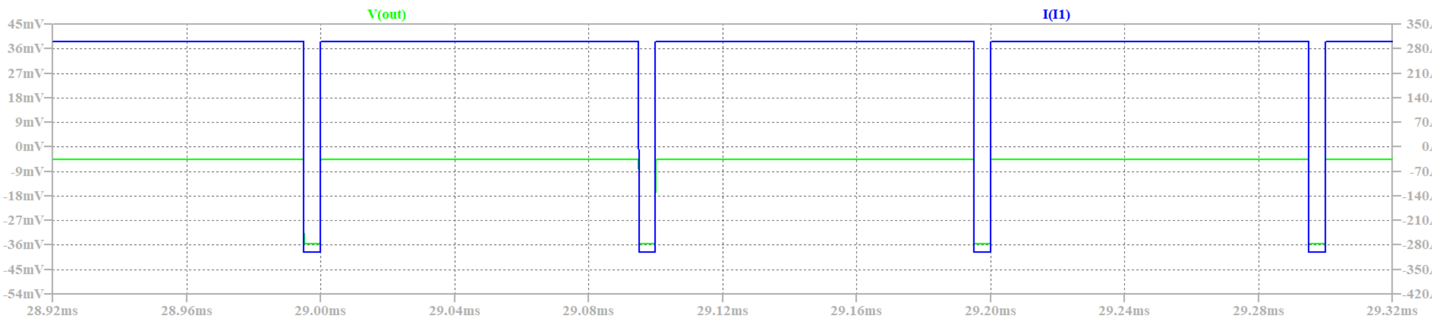


*Fig. 4. Output voltage at I1 = 95% duty cycle and 10-kHz square wave.*

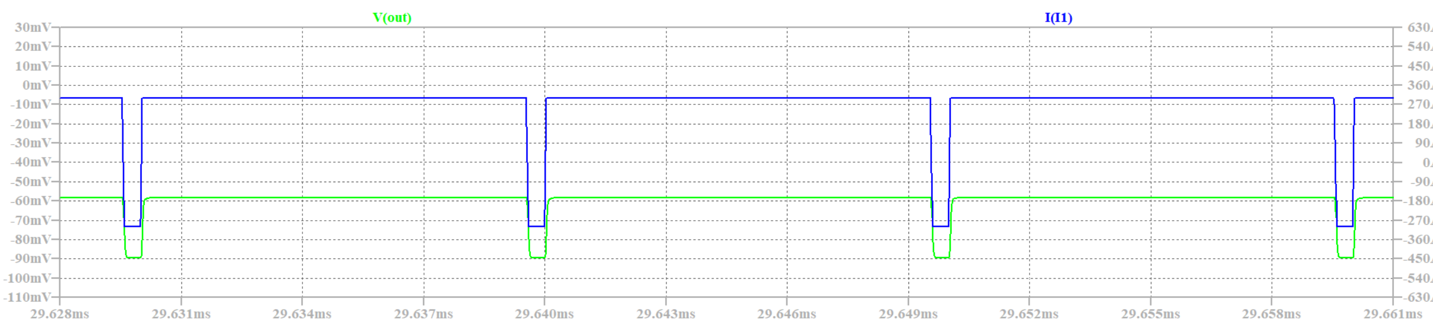


*Fig. 5. Output voltage at I1 =95% duty cycle and 100-kHz square wave.*

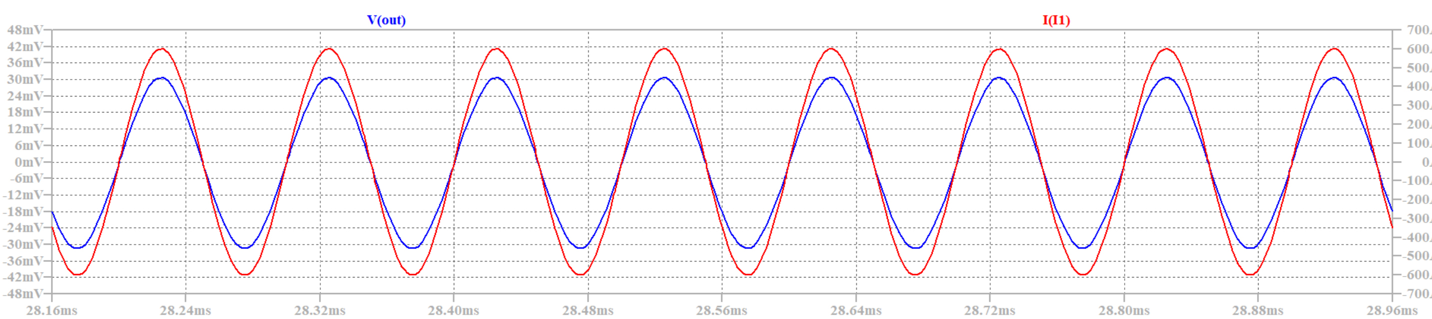


*Fig. 6. Output voltage at I1 = 10-kHz sinusoidal bipolar current.*

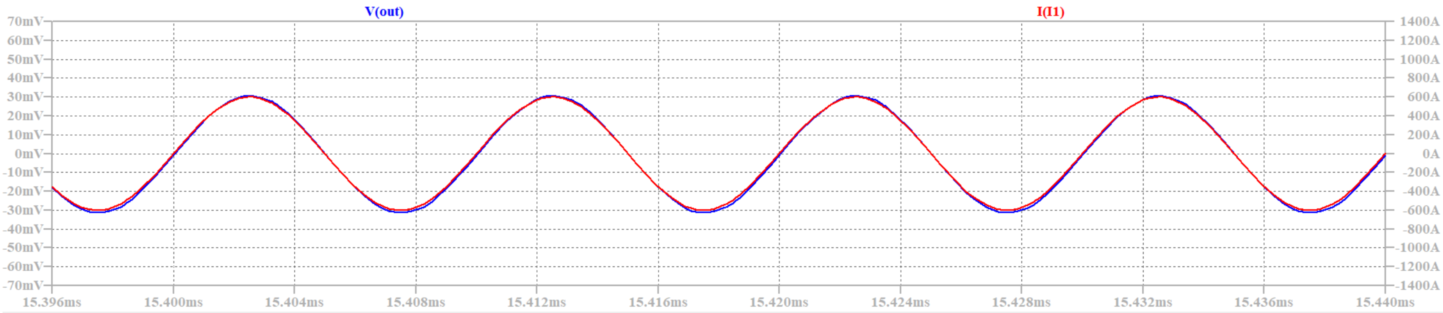


*Fig. 7. Output voltage at I1 = 100-kHz sinusoidal bipolar current.*

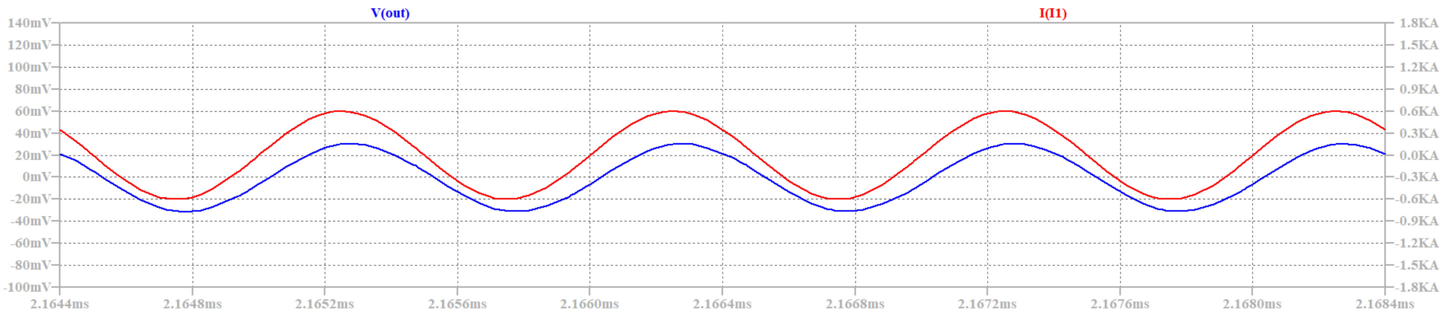


*Fig. 8. Output voltage at I1 =1-MHz sinusoidal bipolar current. A phase shift is noticeable, which means the frequency response has some downslope.*

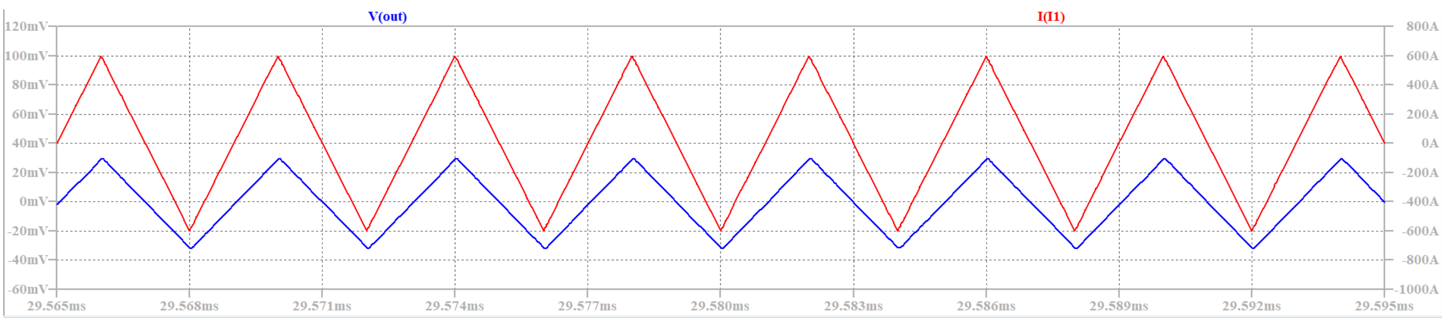


*Fig. 9. Output voltage at I1 =125-kHz triangular bipolar current.*

From these results we can see that the designed Rogowski sensor can be successfully used for laboratory measurements within the frequency band of up to 1 MHz for currents of any waveshape. Over this same frequency range, measurement accuracy is estimated to be about 1% given the high-frequency operational amplifiers specified above for the sensor circuit.

Further information relevant to this sensor design can be found in reference 5, which describes a sample design of an integrator for the Rogowski sensor.

**Reference**

1."A Guide To Designing Your Own Rogowski Sensor (Part 1)" by Gregory Mirsky, How2Power Today, April 2024.

2. "A Guide To Designing Your Own Rogowski Sensor (Part 2)" by Gregory Mirsky, How2Power Today, May 2024

3. AD8065/8066 datasheet.

4. AD8033/8034 datasheet.

 

5. "Active Integrator for Rogowski Coil Reference Design With Improved Accuracy for Relays and Breakers," TI Designs, published April 2016, revised September 2016.

### About The Author

*Gregory Mirsky is a design engineer working in Deer Park, Ill. He currently performs design verification on various projects, designs and implements new methods of electronic circuit analysis, and runs workshops on MathCAD 15 usage for circuit design and verification. He obtained a Ph.D. degree in physics and mathematics from the Moscow State Pedagogical University, Russia. During his graduate work, Gregory designed hardware for the high-resolution spectrometer for research of highly compensated semiconductors and high-temperature superconductors. He also holds an MS degree from the Baltic State Technical University, St. Petersburg, Russia where he majored in missile and aircraft electronic systems.*

*Gregory holds numerous patents and publications in technical and scientific magazines in Great Britain, Russia and the United States. Outside of work, Gregory's hobby is traveling, which is associated with his wife's business as a tour operator, and he publishes movies and pictures about his travels online.*

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