Current Sense Devices

• A **current sensor** is a device that detects electrical current (AC or DC) in a wire, and generates a proportional signal

• **AC current input,**
  - analog output, which duplicates the wave shape of the sensed current
  - unipolar output, which is proportional to the average or RMS value of the sensed current

• **DC current input,**
  - unipolar, with a unipolar output, which duplicates the wave shape of the sensed current
  - bipolar output, which duplicates the wave shape of the sensed current
  - digital output, which switches when the sensed current exceeds a certain threshold
Current Sense Transformer

A Current Sense Transformer is coil of wire that will pick up the magnetic field created by the current in the main conductor. The EMF is a voltage signal that will be proportional to the current change.
Current Sensing for Power Metering

• Accurate current sensing is critical for power metering applications.

• Several technologies exist for current sensing including
  ➢ Low resistance current shunts
  ➢ Current transformer with amorphous metal core
  ➢ Hall Effect devices
  ➢ Rogowski Coils
# Types of Current Sense Transformers

<table>
<thead>
<tr>
<th>Current Sensing Technology</th>
<th>Low resistance current shunt</th>
<th>Current Transformer</th>
<th>Hal Effect Sensor</th>
<th>Rogowski Coil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>Very Low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Linearity over measurement range</td>
<td>Very Good</td>
<td>Fair</td>
<td>Poor</td>
<td>Very Good</td>
</tr>
<tr>
<td>High Current measuring capability</td>
<td>Very Poor</td>
<td>Good</td>
<td>Good</td>
<td>Very Good</td>
</tr>
<tr>
<td>Power consumption</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>DC/high current saturation problem</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Output variation with temperature</td>
<td>Medium</td>
<td>Low</td>
<td>High</td>
<td>Very Low</td>
</tr>
<tr>
<td>DC offset problem</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Saturation and Hysteresis problem</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
Rogowski Coils

- Consists of wire wound on a non magnetic core or an air core
- Detects the magnetic field created by the current change in the conductor and generates an EMF voltage proportional to it

\[ \text{EMF} := \frac{\mu_{\text{air}} \cdot N \cdot L}{2 \cdot \pi} \cdot \ln\left( \frac{c}{b} \right) \cdot \frac{di}{dt} \]

- The Rogowski Coil output voltage must be integrated to obtain a voltage proportional to the measured current
Advantages of Rogowski Coils

- Low Cost
- Not influenced by external magnetic fields, and can be immune to magnetic tampering
- Are non-intrusive – draws no power from the main circuit
- Have a very wide Sensing bandwidth extending from 0.1 Hz up to 17 MHz
- Measures AC signals superimposed on a large DC Current
- Can measure large currents without saturating and can measure changes of current as fast as 40,000 A/μs
Development of Rogowski Coils

• Pulse is exploring the potential for use of Rogowski Coils as current sensors in power metering applications

• Issues for manufacturing Rogowski coils are being investigated:
  - Uniformity of the winding
  - Repeatability
  - Low output signal
  - Back winding of the coil to avoid external magnetic fields

• Pulse is working toward understanding the meter manufacturer’s design requirements surrounding the Rogowski Coils, and is looking to engage with the power meter IC vendors to develop the technology for wider use