American Wire Gauge

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In the United States, wire diameters are specified according to the American Wire Gauge (AWG). There are 40 different sizes, ranging from 36 (smallest) to 0000 (largest, also written “4/0”): 36, 35, 34, . . . , 2, 1, 0, 00, 000, 0000.

The diameter $D_{36}$ of 36 AWG wire is 0.005" (= 0.127 mm). The ratio of each diameter to the previous one is $92^{1/39} = 1.1229322$ (I am not joking—you can’t make this stuff up). Therefore, the diameter of $n$ AWG wire is

$$D_n = D_{36} 92^{\frac{36-n}{39}},$$

where $n$ must be negative for sizes 00 and larger. For example,

$$D_{22} = D_{36} 92^{14/39} = (0.127 \text{ mm}) \times 5.06931731 = 0.6438 \text{ mm}.$$  

Some common sizes:

<table>
<thead>
<tr>
<th>AWG</th>
<th>Diameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>2.588 mm = 0.1019&quot;</td>
</tr>
<tr>
<td>12</td>
<td>2.053 mm = 0.0808&quot;</td>
</tr>
<tr>
<td>14</td>
<td>1.628 mm = 0.0641&quot;</td>
</tr>
<tr>
<td>18</td>
<td>1.024 mm = 0.0403&quot;</td>
</tr>
<tr>
<td>22</td>
<td>0.644 mm = 0.0253&quot;</td>
</tr>
<tr>
<td>24</td>
<td>0.511 mm = 0.0201&quot;</td>
</tr>
</tbody>
</table>

What is the resistance of a length $L$ of $n$ AWG copper wire? The resistivity of copper is $\rho_{Cu} = 1.678 \times 10^{-8} \text{ \Omega \cdot m}$ at 20 °C.

$$R = \frac{\rho_{Cu} L}{A},$$

where $A$ is the cross-sectional area of the wire. So

$$R = \frac{4\rho_{Cu} L}{\pi D_n^2} = \frac{4\rho_{Cu} L}{\pi D_{36}^2 92^{\frac{2(36-n)}{39}}},$$

Working in SI units, $D_{36} = 1.27 \times 10^{-4} \text{ m}$, so

$$\frac{4\rho_{Cu}}{\pi D_{36}^2} = 1.3246 \text{ \Omega/m}.$$  

Then

$$R = \frac{1.3246L}{92^{\frac{2(36-n)}{39}}} = 1.3246 \cdot 92^{\frac{2n-72}{39}} L \text{ \Omega},$$

where $L$ is in meters.

Example: for $n = 22$ and $L = 0.3 \text{ m}$, $R = 1.55 \times 10^{-2} \text{ \Omega}$. 