Wire Selection

Wire Gauge & Material Selection

The wire used to wind an inductor directly affects its DC resistance, current capacity, and Q factor. Proper wire selection is essential for maximizing VIC circuit performance.

Wire Gauge Systems

Wire size is commonly specified using the American Wire Gauge (AWG) system:

AWG	Diameter (mm)	Area (mm²)	Ω/m (Copper)	Max Current (A)
18	1.024	0.823	0.0210	2.3
20	0.812	0.518	0.0333	1.5
22	0.644	0.326	0.0530	0.92
24	0.511	0.205	0.0842	0.58
26	0.405	0.129	0.1339	0.36
28	0.321	0.081	0.2128	0.23
30	0.255	0.051	0.3385	0.14
32	0.202	0.032	0.5383	0.09

Note: AWG follows logarithmic progression. Each 3 AWG steps doubles resistance, halves area.

Wire Materials

Material	Resistivity (×10⁻⁸ Ω·m)	Relative to Copper	Use Case
Copper	1.68	1.0× (reference)	Best for high Q

Material	Resistivity (×10⁻⁸ Ω·m)	Relative to Copper	Use Case
Aluminum	2.65	1.6×	Lightweight applications
SS304	72	~43×	Corrosion resistance
SS316	74	~44×	Better corrosion resistance
SS430 (Ferritic)	~100	~60×	Magnetic, high resistance
Nichrome (80/20)	108	~64×	Heating elements, damping
Kanthal A1	145	~86×	High-temp resistance wire

Effect of Material on Q Factor

Q Factor Relationship:

`Q = 2?fL / R`

Since R is proportional to resistivity, using high-resistivity wire dramatically reduces Q:

Copper wire Q = 100	→ SS316 wire Q ≈ 2.3
Copper wire Q = 50	→ Nichrome wire Q ≈ 0.8

When to Use Resistance Wire

Despite lower Q, resistance wire has valid uses:

- **Current limiting:** Built-in current limit without separate resistor
- **Damping:** Prevents excessive ringing
- **Safety:** Limits power in fault conditions
- **Meyer's designs:** Some original VIC designs used stainless steel wire

Warning: Using resistance wire in a resonant circuit dramatically reduces voltage magnification. A Q of 2 means you only get 2× voltage gain instead of 50× or 100× with copper.

Skin Effect

At high frequencies, current flows primarily near the wire surface:

Skin Depth (?):

```
? = ?(? / (? × f × ?? × ??))
```

For Copper:

```
?(mm) ? 66 / ?f(Hz)
```

> | | |
> |---|---|
> | 1 kHz | δ ≈ 2.1 mm |
> | 10 kHz | δ ≈ 0.66 mm |
> | 100 kHz | δ ≈ 0.21 mm |

Skin Effect Mitigation

- **Litz wire:** Multiple thin insulated strands twisted together
- **Flat/ribbon wire:** More surface area for same cross-section
- **Use finer gauge:** If wire radius ≈ δ, skin effect is minimal

Magnet Wire Types

Insulation Type	Temp Rating	Voltage Rating	Notes
Polyurethane (solderable)	130°C	~100V/layer	Can solder through coating
Polyester-imide	180°C	~200V/layer	Good general purpose
Polyamide-imide	220°C	~300V/layer	High temp applications
Heavy build (HN)	Various	~500V/layer	Thicker insulation
Triple insulated	Various	~3000V	Safety-rated isolation

Wire Selection Guidelines for VIC

For Maximum Q (recommended):

- Use **copper magnet wire**
- Choose gauge based on skin depth at operating frequency
- Use largest gauge that fits the core/bobbin
- Consider Litz wire for frequencies >50 kHz

For Current-Limited Applications:

- Use stainless steel or nichrome
- Calculate required resistance: $R = V_{max}/I_{limit}$
- Accept reduced Q factor as tradeoff

Calculating Wire Length

Wire Length for N Turns:

l_{wire} ? N × ? × d_{coil}

Where d_{coil} is the average coil diameter.

Resulting DCR:

R_{dc} = ? × l_{wire} / A_{wire}

VIC Matrix Calculator: The Choke Design tool automatically calculates DCR based on your wire gauge, material, and number of turns. It shows the resulting Q factor and voltage magnification for your design.

Next: Bifilar Winding Technique →

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