Practical Reliability in Motor Drive Electronics

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Background in Electric Car Controllers

Cafe Electric Zilla Z2K
2008, 2000 A 348 V

1994, 1000 A 240 V
Why a controller?

- Regulates power to the motor using throttle or autopilot input.
- Protects batteries, the motor, and itself by limiting voltage and current.
- Provides AC waveform (commutation) for BLDC motors.
Regulates power by Pulse Width Modulation

- 10% Duty Cycle
- 50% Duty Cycle
- 90% Duty Cycle
Common controller types for airplanes

- Brush DC
- Brushless DC (BLDC)
Failures

- Surprisingly common in motor controllers.
- Clearly not welcome, especially in an aircraft.
- High voltage failures cause plasma balls.
- Fire rarely persists long after power is disconnected.
- Most common causes of failure are from Water, Heat, and Voltage.
Water intrusion conducts and corrodes.

- Potting adds weight, but very effective.
- Sealed case can be expensive
- Some cases look sealed, but are not.
Cooling:
Thermal resistance

- Transistor life drops in half for every 10 °C rise in temperature.
- The path from the transistor to cooling is sometimes long.
- Responding to the temperature closer to the transistor better.
Overvoltage Failures

- Transistors have strict limits on voltage.
- Mostly this is a controller design issue.
- Layout and Switching speed directly related to voltage spikes.

Critical Loop distance
## Common Brushed DC Controller Options

<table>
<thead>
<tr>
<th>Brand</th>
<th>Weight (kg)</th>
<th>Voltage</th>
<th>Current* Max/Cont</th>
<th>Power* Max/Cont</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alltrax</td>
<td>3.2</td>
<td>24–72V</td>
<td>450/200A</td>
<td>32.4 kW/14.4 kW</td>
</tr>
<tr>
<td>Curtis</td>
<td>8.3</td>
<td>96–144V</td>
<td>500/225A</td>
<td>72.0 kW/32.4 kW</td>
</tr>
<tr>
<td>Kelly</td>
<td>2.7</td>
<td>24–144V</td>
<td>550/260A</td>
<td>79.2 kW/37.4 kW</td>
</tr>
<tr>
<td>Zilla Z1K</td>
<td>7.5</td>
<td>72–348V</td>
<td>1000/350A</td>
<td>348 kW/121.8 kW</td>
</tr>
</tbody>
</table>

* Some current ratings are pessimistic, while others are very optimistic.
BLDC Options?

- Not many on the public market.
- Generally custom made with each motor.
- Mostly in development

- Antares 20E
  42kW System

- 30kW in dev by Patrick McLaughlin
Review

- Keep controllers cool
- Keep them dry
- Stay within voltage ratings
- Investigate the reputation.
End

More Info: WWW.CafeElectric.com