Background

Electronic devices are becoming more important in people’s daily lives. From a simple light bulb lighting our life to CPUs powering our smartphone, electronic devices are becoming more complex. These devices require strict management of voltages and current in their circuits. With a well-designed power distribution board, electronic devices can have a longer working lifespan and work stably. Therefore power distribution boards are used widely in electronic devices such as drones.

This project will design a functional modular power distribution board that can deliver the power from batteries to an avionic aircraft’s onboard system. To improve the stability, the design of power distribution board will be divided into five different modules:

1. 12V to 3.3V converter
2. 12V to 5V converter
3. 12V to 8V converter
4. 12V to 24V converter
5. Voltage selector

Objective & Goals

(i) Design a modular power distribution system that provides 3.3V, 5V, 8V, and 24V to unmanned aircraft subsystems
(ii) Voltage Selector that prioritizes auxiliary input over battery input and supplies power to voltage converters
(iii) Optional: Include a voltage and current sensing capabilities for each voltage converter
(iv) Required specifications of the voltage converters are listed in the following table 1

<table>
<thead>
<tr>
<th>Specification</th>
<th>12V to 3.3V</th>
<th>12V to 5V</th>
<th>12V to 8V</th>
<th>12V to 24V</th>
<th>Voltage Selector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (V)</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
<td>95%</td>
</tr>
<tr>
<td>Ripple Voltage (V)</td>
<td>80mV</td>
<td>80mV</td>
<td>80mV</td>
<td>80mV</td>
<td>80mV</td>
</tr>
<tr>
<td>Transient Under shoot</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Transient overshoot</td>
<td>80mV</td>
<td>80mV</td>
<td>80mV</td>
<td>80mV</td>
<td>80mV</td>
</tr>
<tr>
<td>Voltage in (V)</td>
<td>3.322V</td>
<td>4.98V</td>
<td>24.15V</td>
<td>6-36V</td>
<td>8.04V</td>
</tr>
<tr>
<td>Full load current (A)</td>
<td>2.5A</td>
<td>4A</td>
<td>2A</td>
<td>6-36A</td>
<td>10-24A</td>
</tr>
</tbody>
</table>

Methods

The design is split up into 5 boards:

- Voltage selector board
- 4 Voltage converters with a integrated hall-effect sensor for current measurement

Voltage Selector:

- Designed using the LTC4416 as MOSFET Controller
- Uses two PMOS MOSFETs for switching states
- Selection ability between 2 inputs
- Able to supply up combined 40A to 4 outputs

Voltage Converters:

- Buck or boost converter used to convert 12V input to 3.3V, 5V, 8V, or 24V output
- Used Webench to generate schematics for voltage converters
- Output current maximum of 2-4Amps

Hall Effect Sensor:

- Uses ACS722LCTR-10A8 to measure output current using the Hall effect
- Has one output to measure current and one output to measure voltage
- Produces 132mV per A from output so current can be read by a microcontroller

Results

The voltage converters were simulated using Webench and the specifications achieved can be found in table 2:

The PCB boards were designed:

- Voltage selector board
  180mm x 60mm
  4.2mm mounting holes at corners 4mm offset from the edges
  60mm x 60mm
  2 inputs
  4 outputs

Voltage Converters

- 60mm x 60mm
- 4.2mm mounting holes at corners 4mm offset from the edges
- 1 input
- 1 output

The finalized PCB designs can be seen below in figure 2 to 6.

Conclusions

Project Creation Results:

- Voltage Selector created and simulated successfully
- Voltage Converters created and simulated successfully
- Hall Effect Sensor created and simulated successfully

Project Statements:

- Design objectives for each board were all met
- Each project component was thoroughly simulated
- No physical prototype were made for the project

Table 2: Simulated results of converters and selector

<table>
<thead>
<tr>
<th>Specification</th>
<th>12V to 3.3V</th>
<th>12V to 5V</th>
<th>12V to 8V</th>
<th>12V to 24V</th>
<th>Voltage Selector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency (V)</td>
<td>87.5%</td>
<td>96.5%</td>
<td>95.7%</td>
<td>96.0%</td>
<td>95.5%</td>
</tr>
<tr>
<td>Ripple Voltage (V)</td>
<td>21.76mV</td>
<td>20mV</td>
<td>300mV</td>
<td>200mV</td>
<td>260mV</td>
</tr>
<tr>
<td>Transient Under shoot</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
<td>3%</td>
</tr>
<tr>
<td>Transient overshoot</td>
<td>300mV</td>
<td>400mV</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Voltage in (V)</td>
<td>3.322V</td>
<td>8.04V</td>
<td>24.15V</td>
<td>N/A</td>
<td>21.76V</td>
</tr>
<tr>
<td>Full load current (A)</td>
<td>2.5A</td>
<td>9A</td>
<td>2A</td>
<td>N/A</td>
<td>12A</td>
</tr>
</tbody>
</table>

Figure 1: Block diagram of the overall design layout

Figure 2: Voltage Selector

Figure 3: 3.3V Converter

Figure 4: 5V Converter

Figure 5: 8V Converter

Figure 6: 24V Converter