CLIMB Electrical Power Concept:

# Assumptions:

1. Solar Cells: Spectrolab XTJ, Vmp=2.348V, Voc=2.633V, Imp=453mA, Pmp=1.06W
2. Dimensions: 2U + 4 foldable arrays = 12.72Wp
3. Batteries: 4x 18650 INR18650HG2, 3Ah, Vnom=3.6V, Vmax=4.2V, Idcmax=20A
4. Outputs: 3.3V/3W, 5V/5W, 12V/40W

# Concepts:

1. Single Step-up:  
   One solar cell + one battery with MPPT step-up charging circuit, subsystems reused from Pegasus with max. 4.2V input
2. 3/2 Redesign:  
   3 solar cells + 2 batteries in series, solar cells directly connected to batteries, all subsystems redesigned to allow for 8.4V input
3. 3/2 Hybrid:

3 solar cells + 2 batteries in series, solar cells directly connected to batteries, step-down stage to interface with subsystems, subsystems reused from Pegasus with max. 4.2V input

1. 4/3 Redesign:  
   4 solar cells + 3 batteries in series, MPPT step-up charging circuit, all subsystems redesigned to allow for 8.4V input
2. 4/3 Hybrid:  
   4 solar cells + 3 batteries in series, MPPT step-up charging circuit, subsystems reused from Pegasus with max. 4.2V input

# Comparison:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Single Step-up** | **3/2 Redesign** | **3/2 Hybrid** | **4/3 Redesign** | **4/3 Hybrid** |
| Solar voltage | 2.348-2.633V | 7.044-7.899V | 7.044-7.899V | 9.392-10.532V | 9.392-10.532V |
| Battery voltage | 3.0-4.2V | 6.0-8.4V | 6.0-8.4V | 9.0-12.6V | 9.0-12.6V |
| Power bus voltage | 3.0-4.2V | 6.0-8.4V | 4.2V | 9.0-12.6V | 4.2V |
| Solar to battery topology | Step-up | Diode | Diode | Step-up | Step-up |
| Solar to battery efficiency | 80% | 93% | 93% | 80% | 80% |
| Solar to battery development effort | 0% | 50% | 50% | 100% | 100% |
| Solar to battery reliability | 90% | 90% | 90% | 80% | 80% |
| Power bus topology | Unregulated | Unregulated | Step-down | Unregulated | Step-down |
| Power bus efficiency | 98% | 98% | 90% | 98% | 90% |
| Power bus development effort | 0% | 100% | 50% | 100% | 50% |
| Power bus reliability | 99% | 90% | 80% | 90% | 80% |
| Power bus total reliability | 89% | 81% | 72% | 72% | 64% |
| 12V topology | Step-up | Step-up | Step-up | Unregulated  (Step-up) | Unregulated  (Step-up) |
| 12V connection | Battery | Battery | Battery | Battery | Battery |
| 12V efficiency | 85% | 85% | 85% | 85%-98% | 85%-98% |
| 12V total efficiency | 68% | 79% | 79% | 68-78% | 68-78% |
| 12V battery current | 16.3A | 7A | 7A | 4.7-5A | 4.7-5A |
| 12V duty-cycle | 11% | 11% | 11% | 11% | 11% |
| 12V total losses (avg.) | 1.42W | 0.93W | 0.93W | 0.98-1.42W | 0.98-1.42W |
| 12V total losses (peak) | 12.8W | 8.4W | 8.4W | 8.8-12.8W | 8.8-12.8W |
| 12V development effort | 100% | 100% | 100% | 100% | 100% |
| 12V reliability | 80% | 80% | 80% | 80-90% | 80-90% |
| 12V total reliability | 72% | 72% | 72% | 64-72% | 64-72% |
| 3.3V topology | Step-up/step-down | Step-down | Step-down | Step-down | Step-up/step-down |
| 3.3V connection | Power bus | Power bus | Power bus | Power bus | Power bus |
| 3.3V efficiency | 90% | 90% | 90% | 88% | 90% |
| 3.3V total efficiency | 70% | 82% | 75% | 70% | 65% |
| 3.3V battery current | 1.2A | 0.51A | 0.55A | 0.4A | 0.43A |
| 3.3V duty-cycle | 100% | 100% | 100% | 100% | 100% |
| 3.3V total losses | 0.9W | 0.54W | 0.75W | 0.9W | 1.05W |
| 3.3V development effort | 0% | 50% | 0% | 100% | 0% |
| 3.3V reliability | 90% | 80% | 90% | 80% | 90% |
| 3.3V total reliability | 80% | 64% | 64% | 57% | 57% |
| 5V topology | Step-up | Step-down | Step-up | Step-down | Step-up |
| 5V connection | Power bus | Power bus | Power bus | Power bus | Power bus |
| 5V efficiency | 90% | 90% | 90% | 90% | 90% |
| 5V total efficiency | 70% | 82% | 75% | 70% | 65% |
| 5V battery current | 2A | 0.85A | 0.93A | 0.67A | 0.72A |
| 5V duty-cycle | 100% | 100% | 100% | 100% | 100% |
| 5V total losses | 1.5W | 0.9W | 1.25W | 1.5W | 1.75W |
| 5V development effort | 0% | 50% | 0% | 100% | 0% |
| 5V reliability | 90% | 80% | 90% | 80% | 90% |
| 5V total reliability | 80% | 64% | 64% | 57% | 57% |
| **Total battery current** | **19.5A** | **8.36A** | **8.48A** | **5.77-6.07A** | **5.85-6.15A** |
| **Total losses (avg.)** | **3.82W** | **2.37W** | **2.93W** | **3.38-3.82W** | **3.78-4.22W** |
| **Total losses (peak.)** | **15.2W** | **9.84W** | **9.84W** | **11.2-15.2W** | **11.2-15.2W** |
| **Total development effort** | **100%** | **350%** | **200%** | **500%** | **250%** |
| **Total reliability** | **41%** | **23%** | **21%** | **14-16%** | **13-14%** |