MILLSWOOD engineering

250W PMU V2

VERSION 2 PRODUCT UPDATE BULLETIN

1 Reason for update

A new high-voltage board has been developed for the 250W PMU, providing improved performance and reliability. This bulletin describes the changes made and the benefits that these changes provide. PMUs that contain the new HV board are referred to as Version 2 PMUs.

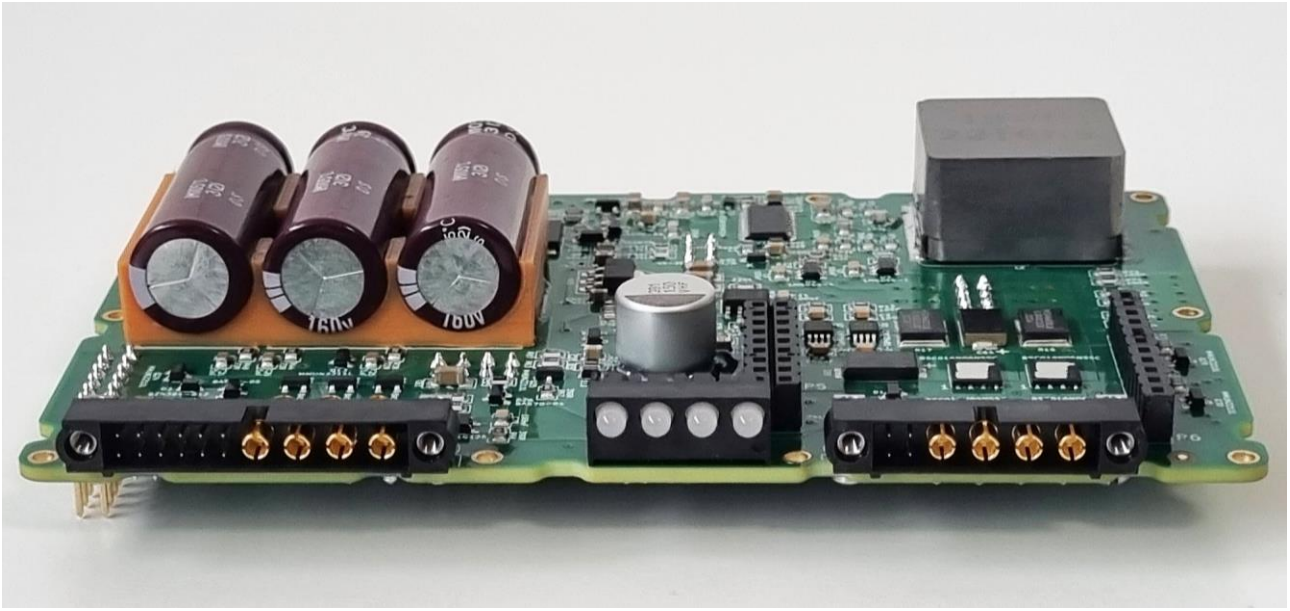
The main motivation for updating the HV board was to increase its reliability, but many other improvements have been made at the same time, including:

- Increasing the output power of the main Buck-Boost converter, especially at low RPM.
- Improving the efficiency and thermal management of the main Buck-Boost converter.
- Increasing the 3-phase input voltage rating.
- Reducing the likelihood and severity of electromechanical instability.
- Improving the accuracy of reported voltages, currents and temperature.
- Improving battery management by implementing a charge termination algorithm.
- Adding a master shut-down input.
- Updating the external temperature sensors from the obsolete KTY83 to 10k NTC.

2 Scope and Compatibility

2.1 Hardware

The high-voltage board has been updated to Revision 5.



There are no changes to the distribution board. This means that the output specifications for the Avionics, Servo, Payload and Battery chargers remain unchanged.

There are no changes to the enclosure. Fitment of a fan is still required to achieve the maximum possible power.

2.2 Embedded firmware

The firmware has been updated to Version 2.02. This firmware is ***not*** backwardly compatible with previous hardware, and should ***not*** be loaded onto Version 1 PMUs.

2.3 PC software

The configuration utility has been updated to version 2.0.0.1. This software is compatible with all PMUs, but if writing settings to a Version 1 PMU there are some things to be aware of:

- "Detect battery disconnection" will always be set to enabled.
- "Manage safe operating area" will always be set to enabled.
- The Thermal "Offset calibration value (T0)" will not be modified.
- The "Upper Temperature Limit (Tu)" will always be set to 85°C.

These 4 settings are ignored by Version 2 PMUs.

Previous versions of the configuration software are not compatible with Version 2 PMUs. It is recommended that the latest PC software be used for all PMUs.

2.4 RS232 communications

Some bit flags have changed in meaning, and some fields have slightly different ranges, but the format and content are largely very similar. An updated RS232 protocol document has been created which describes all the changes made.

2.5 CAN communications

Some bit flags have changed in meaning, some fields have slightly different ranges, and some commands have been deleted, but the format and content are largely very similar. An updated CAN protocol document has been created which describes all the changes made.

3 Changes in detail

3.1 3-Phase and Umbilical input voltage ratings

The maximum recommended input voltage for the 3-phase inputs has increased from 72V to 130V. The maximum recommended input voltage for the Umbilical input has increased from 48V to 65V.

3.2 Main Buck-boost DC-DC converter

The main Buck-boost DC-DC converter has been upgraded from a 2-switch design to a synchronous 4-switch design. This allows greater power handling capability and improved efficiency.

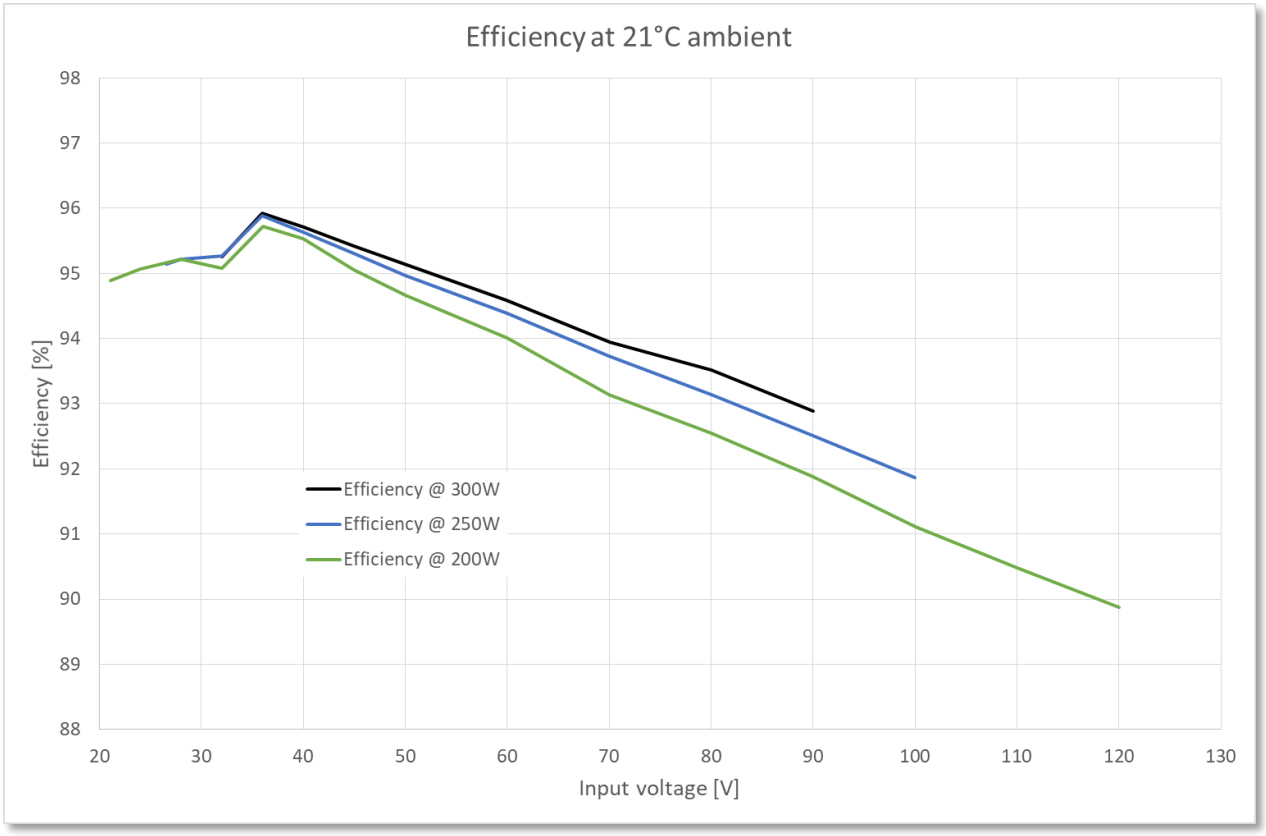
3.2.1 Input voltage range

The minimum input voltage for the converter to start operating is 21.5V. Once operating it tolerates input voltages down to 18.5V. This is similar to the previous converter.

The maximum recommended input voltage has increased from 72V to 130V. When the input voltage exceeds 130V the converter shuts down to protect itself and outputs are sustained using battery power. The converter comes back on automatically when the input voltage falls below 130V.

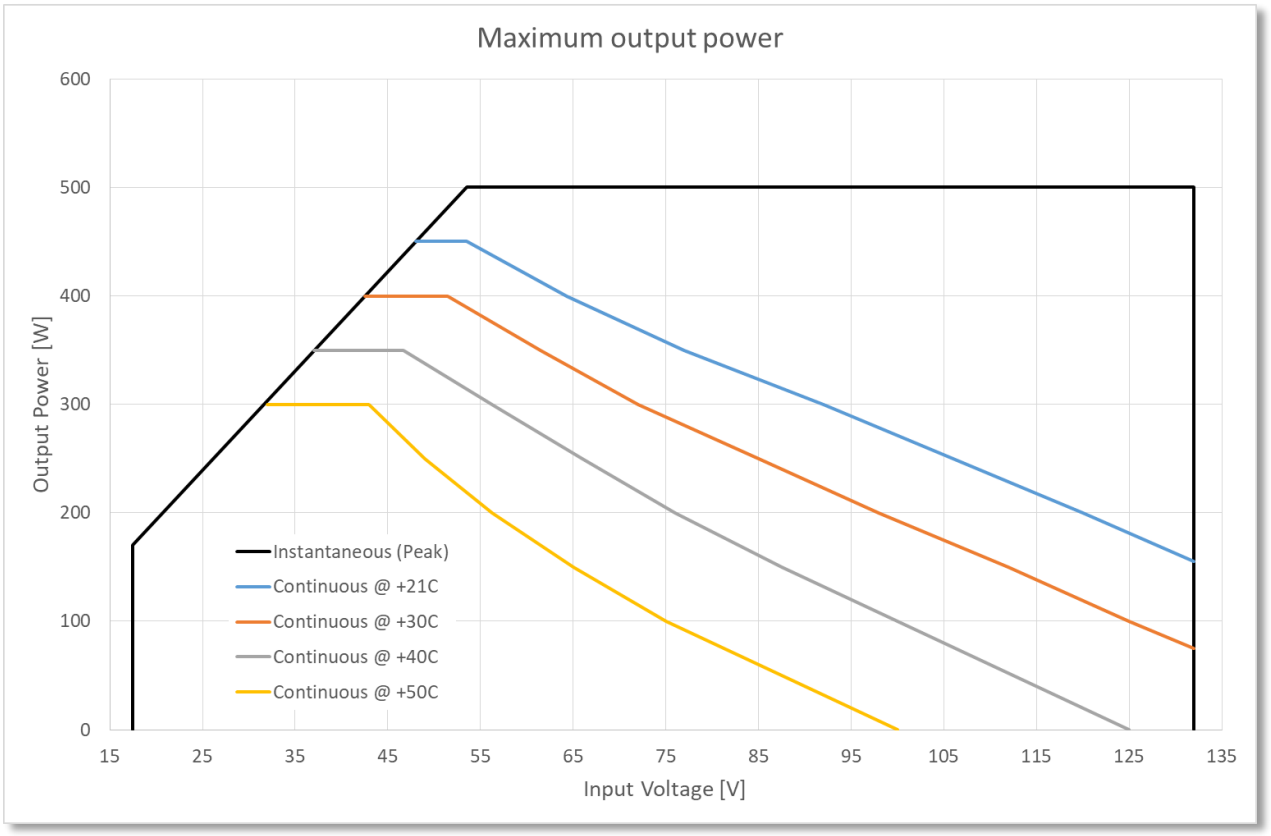
Although the PMU tolerates voltages to 140V without damage, be aware that there is a TVS diode (PN: 5.0SMDJ130A) across the HV bus which will start conducting above 140V. Sustained voltages above 140V may damage the PMU.

3.2.2 Efficiency at 21°C ambient



Graph 1 – Efficiency at 21°C ambient

3.2.3 Maximum output power



Graph 2 – Maximum output power

Maximum output power can only be achieved when the fan is fitted and running.

At low input voltages the maximum output power is intentionally reduced to prevent electro-mechanical instability. If additional power is demanded from the PMU at low RPM, the shortfall is supplied from battery power.

At higher input voltages, the continuous output power is limited by converter temperature rise. Exceeding the maximum continuous power envelopes is not catastrophic – the converter will protect itself by shutting down until its temperature falls to within normal limits before restarting. Whilst in thermal shutdown, outputs are sustained using battery power.

Peak power is limited to 1 second maximum at 10% duty cycle maximum. The temperature of the PMU should be monitored if peak power is drawn frequently. At least 15°C of headroom is recommended (i.e. maintain the internal temperature below 70°C when drawing peak power).

3.2.4 Thermal shutdown

If the internal temperature rises above 85°C, thermal shutdown of the main converter occurs and the outputs are sustained using battery power. The main converter comes back on automatically when it has cooled below 75°C.

3.2.5 Input current limiter

The new converter includes an input current limiter which is set to approximately 10 Amps. The main purpose of the input current limiter is to avoid excessive mechanical loading of the engine at low RPM, thereby reducing the risk of electro-mechanical instability. The input current limiter is implemented in hardware, and works by reducing the output power in order to maintain the input current at or below 10 Amps. The output voltage reduces only as far as the battery voltage, at which point the batteries provide the shortfall in power required to maintain the 28V bus (although at a slightly reduced voltage).

3.2.6 Safe Operating Area

Previously a "Safe Operating Area" management feature was implemented in firmware to protect the main converter from damage if too much power was drawn from it at low RPM. Because of the increased power handling capability of the new converter and the protection offered by the input current limiter, this is no longer necessary and has been deleted.

3.2.7 External temperature sensor type

Version 1 PMUs support the connection of KTY83 type temperature sensors to monitor battery and BLDC alternator temperatures. These sensors are now obsolete, and so the type of sensor has been updated to the 10k NTC type. Because the hardware has changed to suit 10k NTC sensors, KTY83 sensors are no longer supported.

3.3 Firmware version 2.02

The main changes made to the firmware are as follows:

- T0 (temp. calibration) no longer used, EEPROM read/write left in-situ.
- Tu (upper temp. limit) no longer used, EEPROM read/write left in-situ.
- T (internal PMU temp.) now derived from temperature sensor on HV PCB.
- Over-temperature hysteresis changed to 10°C.
- Over-temperature shutdown threshold now fixed internally.
- Te (engine starter temp.) no longer supported, reports 0/-128 (CAN/RS232).
- Vg rescaled (HV sensing range increased to 140V).
- Safe Operating Area (SOA) management deleted.
- Overvoltage flag added.
- Headroom protection for servo and payload switchers deleted.
- Vba, Vbb, Va, Vp, Vs, Ip, Is, I28 recalibrated to improve accuracy.
- Battery charge termination implemented and flags added.
- Battery disconnect detection parameter deleted.
- Battery charger output voltage offset corrected.
- Battery current accumulation (Coulomb counter) recalibrated.
- External temperature sensor type changed from KTY83 to 10k NTC.

3.3.1 Battery management

Battery management has been improved significantly.

A charge termination algorithm has been implemented. Charging occurs when the battery voltage is less than the configured battery voltage minus 1V and greater than 64% of the configured battery voltage. Batteries with less than 64% of their configured voltage will not be charged.

Charging ceases when the battery voltage has risen to within 0.5V of the configured battery voltage and the charging current is less than 0.2A, and these 2 conditions have been maintained for 25 seconds. There is a 5 second guard time before charging can recommence, to prevent rapid charger cycling with high-ESR batteries.

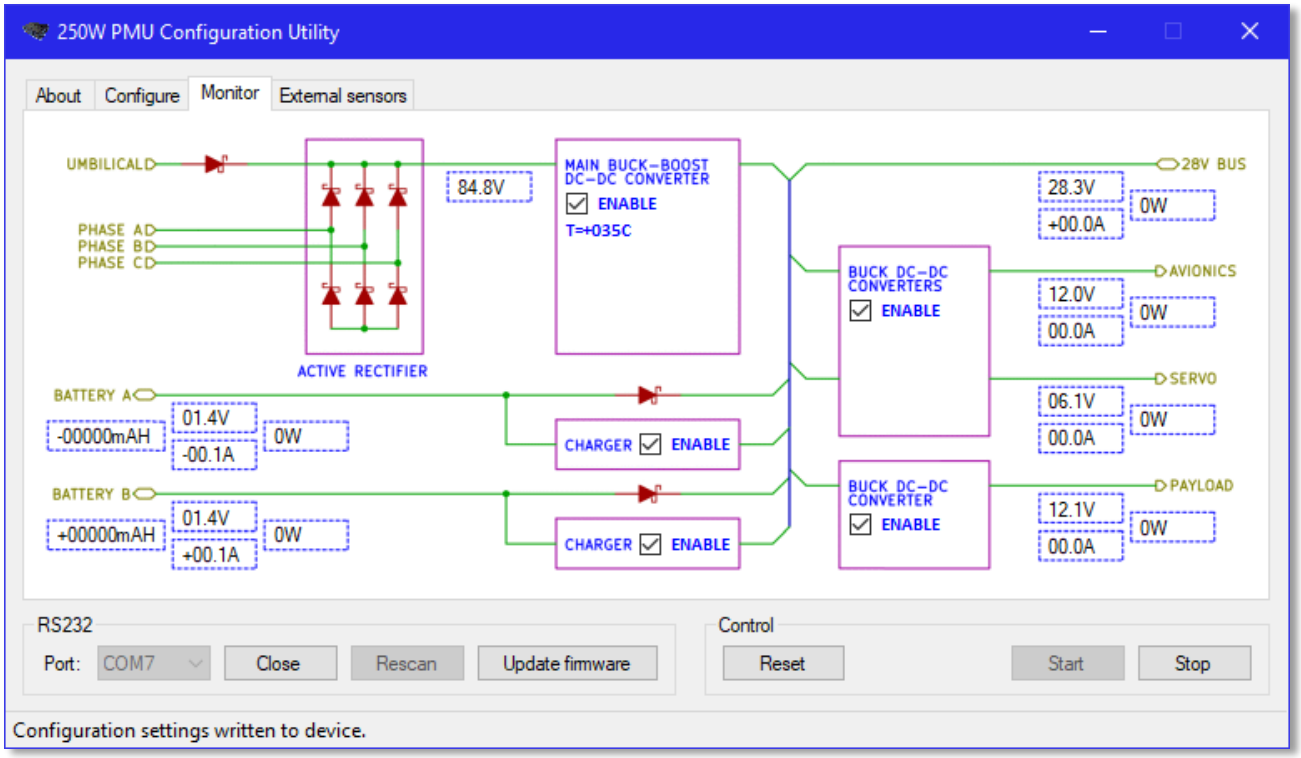
Batteries are managed independently. Charge termination is flagged in a status register, one bit per battery.

Implementation of a charge termination algorithm means that battery disconnection is detected automatically, and so the "Detect battery disconnection" parameter has been deleted.

And finally, a long-standing offset in the battery charging voltage has been corrected.

3.4 Configuration utility version 2.0.0.1

The updated software includes a new graphical display of measured data from the PMU. This is located on the "Monitor" tab as shown below:



This provides a much more intuitive representation of the internal state of the PMU. Voltages, currents, power flows, temperatures, etc. are shown where they occur, and are updated in real-time. Various blocks may be turned on and off using the checkboxes.