MILLSWOOD engineering

Generator PMU

PRODUCT MANUAL

General Description

The Millswood Engineering Generator Power Management Unit provides up to 500 Watts of on-board electrical power generation for small to medium-sized UAVs. The Generator PMU includes active rectification technology for cooler, more efficient operation, as well as several other innovative features not found on competing products.

Figure 1 - Generator PMU

The PMU connects to a suitable brushless DC electric motor, which is in turn driven by the aircraft's primary power plant, usually an internal combustion engine.

Features

- Active rectification avoids the diode losses with traditional passive rectifiers, resulting in superior low voltage performance and higher efficiency.
- Buck-boost converter keeps the output voltage on target and the battery being charged even when the input voltage is less than the output voltage.
- Programmable main output voltage can be set to any voltage from 10 to 30VDC in 0.1V steps. Rated at 15A continuous.
- Auxiliary power output provides 6V at 5A continuous.
- Built-in universal (CCCV) battery charger with charging current programmable up to 5A in 0.1A steps.
- Programmable input current and input power limits prevent overloading the internal combustion engine and BLDC motor.
- RS232 or CAN control and monitoring interface.
- Main 3-phase input voltage range of 10 to 70Vpp.
- External DC input voltage range of 12 to 70VDC.
- Inputs and outputs protected from reverse polarity, over-voltage, ESD and short-circuits.
- Extensive monitoring and reporting of voltages, currents, battery charge status, temperature.

Contents

Absolute Maximum Ratings[Note 1]

Symbol	Parameter	Min	Max	Unit
V_{BLDC}	BLDC motor voltage, phase-to-phase[Note 2]	-75	+75	V
V_{BAT}	Battery voltage[Note 3]	-0.5	+35	V
V_{EXT_DC}	External DC input voltage[Note 4]	-75	+75	V
V_{MAIN}	Main output voltage[Note 5]	-1	+35	V
V_{AUX}	Auxiliary output voltage[Note 6]	-1	+7.5	V
V_{RS232_I}	RS232 input voltage	-25	+25	V
V_{RS232_O}	RS232 output voltage	-13.2	+13.2	V
V_{CAN}	CAN L, CAN H voltage	-42	+42	V
T_{ST}	Storage temperature range	-55	+85	°C

Note 1: Absolute maximum ratings are those values beyond which damage to the product may occur. Functional operation under these conditions is not implied (or recommended).

Note 2: The BLDC motor inputs are indirectly protected by a 70V Transient Voltage Suppressor (TVS) diode. Overvoltage will be clamped, potentially resulting in large current flows.

Note 3: The Battery terminals have limited protected from reverse polarity. ***DO NOT*** *connect a battery with incorrect polarity.*

Note 4: The External DC input is protected by a blocking diode as well as a 70V TVS diode. Overvoltage will be clamped, potentially resulting in large current flows.

Note 5: The Main output is protected by a 30V TVS diode. Reverse polarity or overvoltage will be clamped, potentially resulting in large current flows.

Note 6: The Auxiliary output is protected by a 6.0V TVS diode. Reverse polarity or overvoltage will be clamped, potentially resulting in large current flows.

Recommended Operating Conditions

Symbol	Parameter	Min	Max	Unit
V_{BLDC}	BLDC motor voltage, phase-to-phase	10	70	V_{PP}
V_{BAT}, V_{MAIN}	Battery voltage, Main output voltage	+10	+30	V
V_{EXT_DC}	External DC voltage	+12	+70	V
T_{OP}	Operational temperature range	-40	+70	°C
Alt	Altitude[Note]		80,000	feet

Note: The aluminium electrolytic capacitors used in the PMU are Cornell-Dubilier MLP type. Conventional aluminium electrolytic capacitors are often considered unsuitable for use at high-altitude, but MLP type capacitors are able to tolerate high-altitudes reliably, and are in widespread use in military avionics. The PMU has not been tested at 80,000 feet; this is a theoretical value.

Electrical Characteristics

Test conditions are 10<=V_{BLDC}<=70V, 10<=V_{BAT}<=30V, 10<=V_{MAIN}<=30V, -40<=T_{OP}<=+70°C unless stated otherwise.
Where given, typical values apply to operation at +21°C unless stated otherwise.

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
I_{QB}	Quiescent battery current *Note 1*	V_{BLDC}=V_{EXT_DC}=0V, I_{MAIN}=I_{AUX}=0A			80	mA
$V_{DROPOUT}$	Dropout voltage from battery input to main output *Note 2*	V_{BLDC}=V_{EXT_DC}=0V, I_{AUX}=0A I_{MAIN}=5A I_{MAIN}=15A			 0.5 0.8	V
H	Cascaded efficiency from BLDC input to main output *Note 3*	12V<=V_{MAIN}<=28V, T_{op}=+21°C I_{MAIN}=5A I_{MAIN}=10A I_{MAIN}=15A	 79 86 87.5	 90 90 90	 95 93.5 92.5	%
$θ_{CA}$	Thermal resistance case to ambient *Note 4*	Case horizontal, still air Fan-forced air to rear panel at 49cfm		2.4 0.75		°C/W
Main output						
V_{MAIN}	Programmable voltage range (0.1V increments)		8.0		32.0	V
V_{MAIN}	Programmed voltage accuracy	I_{MAIN}=0A		±0.1	±0.2	V
$ΔV_{MAIN}$	Line regulation (at I_{MAIN}=2.5A)	V_{MAIN}=12V, V_{BLDC}=10V to 70V V_{MAIN}=21V, V_{BLDC}=15V to 70V V_{MAIN}=28V, V_{BLDC}=20V to 70V		0.5 3 3.5	1 4 5	%
$ΔV_{MAIN}$	Load regulation (0<=I_{MAIN}<=15A)	V_{MAIN}=12V, V_{BLDC}=30V V_{MAIN}=21V, V_{BLDC}=45V V_{MAIN}=28V, V_{BLDC}=60V		1 2.5 2.7	2 3 4	%
I_{MAIN}	Continuous current *Note 5*	V_{MAIN}=12V, V_{BLDC}>10V V_{MAIN}=21V, V_{BLDC}>15V V_{MAIN}=28V, V_{BLDC}>20V V_{MAIN}=12V, V_{BLDC}>20V V_{MAIN}=21V, V_{BLDC}>30V V_{MAIN}=28V, V_{BLDC}>40V V_{MAIN}=12V, V_{BLDC}>25V V_{MAIN}=21V, V_{BLDC}>40V V_{MAIN}=28V, V_{BLDC}>55V	5 5 5 10 10 10 15 15 15			A
I_{MAIN}	Peak current (10 seconds per minute) *Note 5*	V_{MAIN}=12V, V_{BLDC}>28V V_{MAIN}=21V, V_{BLDC}>45V V_{MAIN}=28V, V_{BLDC}>62V		18 18 18		A
$V_{MAINp-p}$	Peak-to-peak voltage ripple			200		mV

Main output (continued)						
H_{MAIN}	Efficiency	$12V<V_{MAIN}<28V$, $T_{op}=+21°C$ $I_{MAIN}=5A$ $I_{MAIN}=10A$ $I_{MAIN}=15A$	 79 86 87.5	 90 90 90	 95 93.5 92.5	 %
Auxiliary output						
V_{AUX}	Voltage		5.8	6.0	6.2	V
ΔV_{AUX}	Line regulation		Unmeasurable			mV
ΔV_{AUX}	Load regulation ($0<=I_{AUX}<=5A$)			20	50	mV
I_{AUX}	Continuous current		5.0			A
I_{AUX}	Peak current (10 seconds per minute)			7.5		A
V_{AUXp-p}	Peak-to-peak voltage ripple			30	100	mV
H_{AUX}	Efficiency	$1A<I_{AUX}<5A$, $T_{op}=+21°C$	90	95		%
Battery charger						
I_{BAT}	Programmable current range (0.1A increments)		2.0		5.0	A
I_{BAT}	Programmed current accuracy			±1	±5	%
RS232 interface						
V_{RS232_IL}	Input logic low	$T_{op}=+21°C$	-25		0.8	V
V_{RS232_IH}	Input logic high	$T_{op}=+21°C$	2.4		25	V
R_{RS232_I}	Input resistance	$T_{op}=+21°C$	3	5	7	kΩ
V_{RS232_OS}	Output voltage swing	$R_L=3k\Omega$ to ground	±5.0			V
V_{RS232_OSCC}	Output short circuit current			±35	±60	mA

Note 1: See the quiescent current graph (figure 2) in the Typical Performance Characteristics section.
Note 2: See the dropout voltage graph (figure 3) in the Typical Performance Characteristics section. The Auxiliary output maintains 6V whenever Main output voltage is present, regardless of how the PMU is powered (BLDC, External DC or Battery).
Note 3: See the efficiency graphs (figures 4, 5 and 6) in the Typical Performance Characteristics section.
Note 4: Power in this instance refers to the power being dissipated by the PMU, not the output power. See figure 10 in the Thermal Management section.
Note 5: See the operating area graphs (figures 7, 8 and 9) in the Typical Performance Characteristics section.

Typical Performance Characteristics

Test conditions are 10<=V_{BLDC}<=70V, 10<=V_{BAT}<=30V, 10<=V_{MAIN}<=30V, T_{OP}=21°C unless stated otherwise.

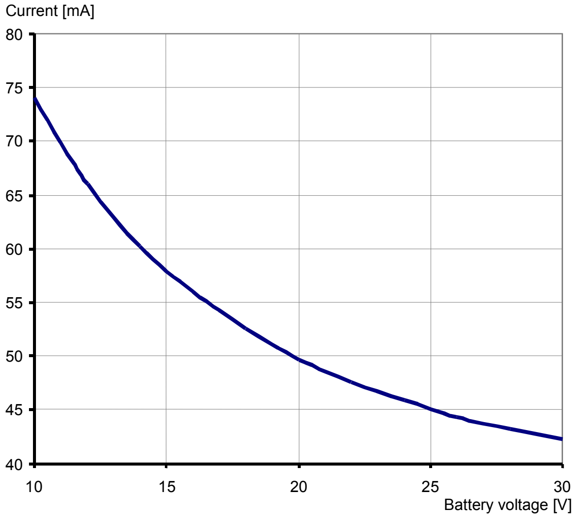


Figure 2 - Quiescent current drain (backup battery operation)

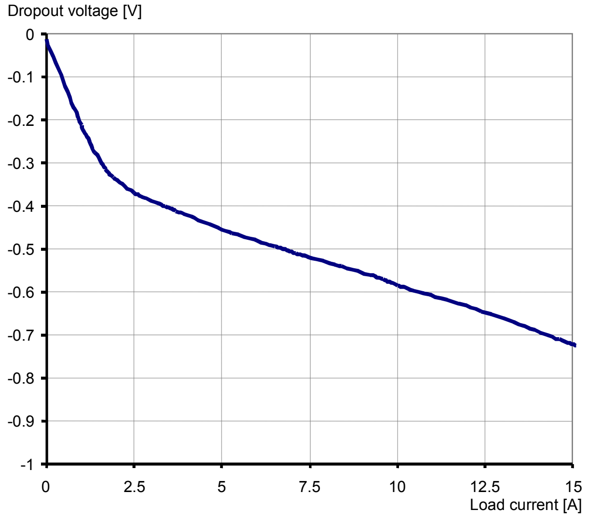


Figure 3 - Dropout voltage from battery input to main output (battery backup operation)

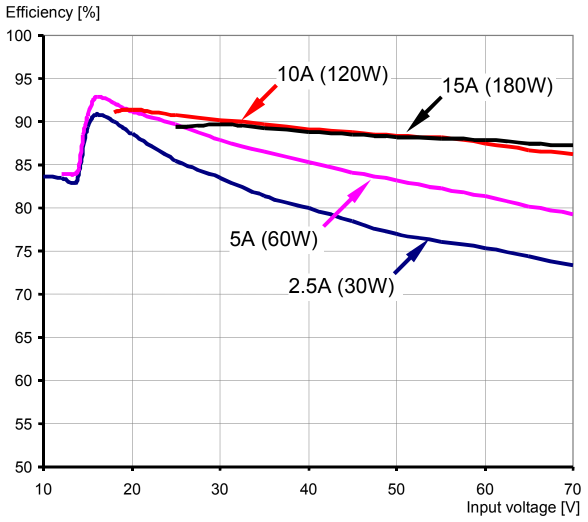


Figure 4 – Cascaded efficiency from BLDC input to main output at 12V

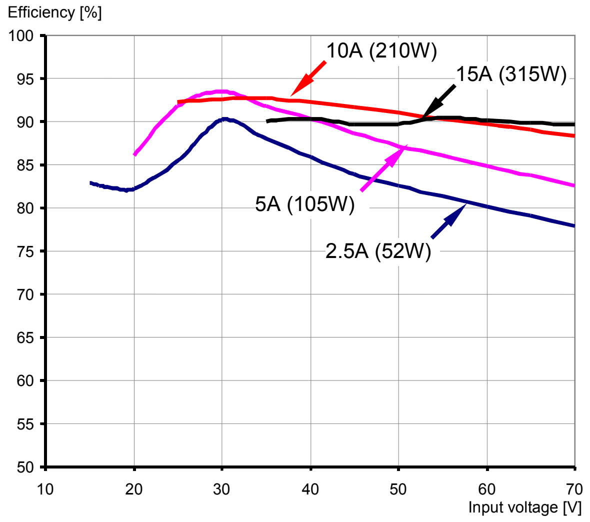


Figure 5 - Cascaded efficiency from BLDC input to main output at 21V

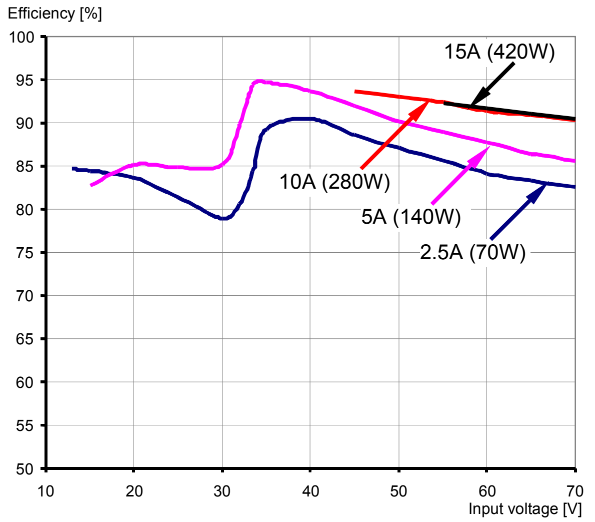


Figure 6 - Cascaded efficiency from BLDC input to main output at 28V

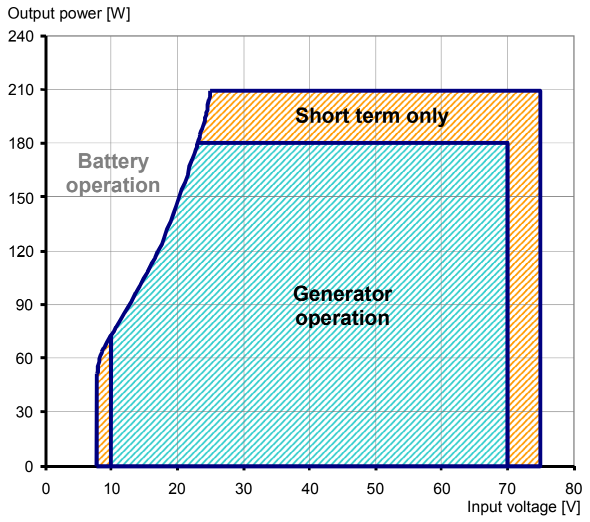


Figure 7 - Power available from the main output at 12V

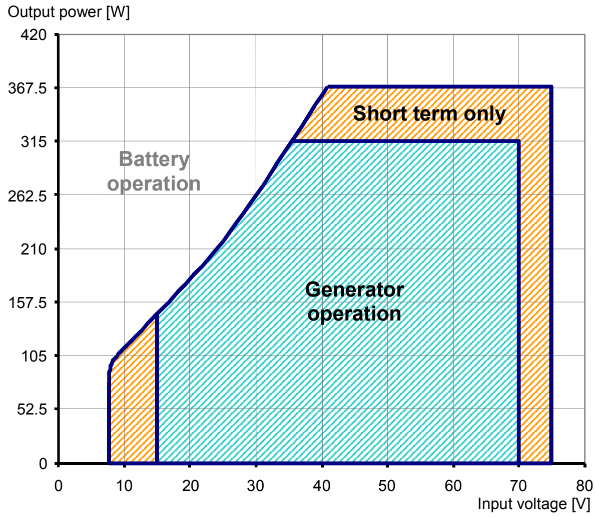


Figure 8 - Power available from the main output at 21V

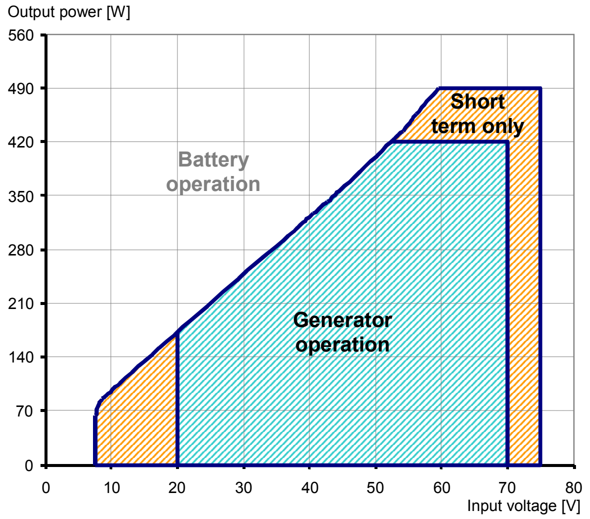


Figure 9 - Power available from the main output at 28V

The "missing" areas in the top left hand corners of the operating area graphs (marked "Battery operation") are due to PMU input current limiting.

For example, with an input voltage of 10V and an output voltage of 30V, more than 45A input current would be required to generate an output current of 15A. Clearly this is an impossible situation – for both the BLDC motor as well as the PMU.

There is both a "hard" input current limit – which is fixed internally and cannot be changed – as well as a "soft" input current limit that is user programmable. The graphs show the fixed current limit.

There is also a user programmable input power limit.

Thermal management

All power conversion devices generate heat, and getting rid of this unwanted heat is one of the main factors limiting maximum continuous output power. Operation at elevated temperatures for extended periods of time also impacts negatively on reliability and service life. For these reasons it is worth taking some time to ensure that the PMU is operated at the lowest possible internal temperature.

Most devices quote a maximum ambient operating temperature, but this figure is of little practical value. A more useful measure of thermal performance is thermal resistance – this figure is given in degrees per Watt and allows calculation of the device temperature under different operating conditions. Note that the power used in thermal resistance calculations is the dissipated power, not the output power. To calculate the dissipated power the following formula is used:

$$P_{DISSIPATED} = P_{OUTPUT} \times (1-\eta) / \eta$$

where η is the efficiency ranging from 0 to 1

The dissipated power is then multiplied by the thermal resistance to give temperature rise above ambient. The PMU has a worst-case thermal resistance of 2.4 C°/W (mounted horizontally in still air). This can be improved to 0.75 C°/W with sufficient airflow.

Figure 10 shows the internal temperatures reached for a range of operating conditions, all measured with an ambient air temperature of 21°C.

The upper 3 traces were measured with the PMU mounted horizontally in still air.

The lower 3 traces were measured with a fan attached to the rear of the bulkhead to which the PMU was mounted. The fan delivered ambient air at 49cfm to the rear panel of the PMU through a 90mm circular cutout.

Input voltages were 25, 40 and 55V for output voltages of 12, 21 and 28V respectively.

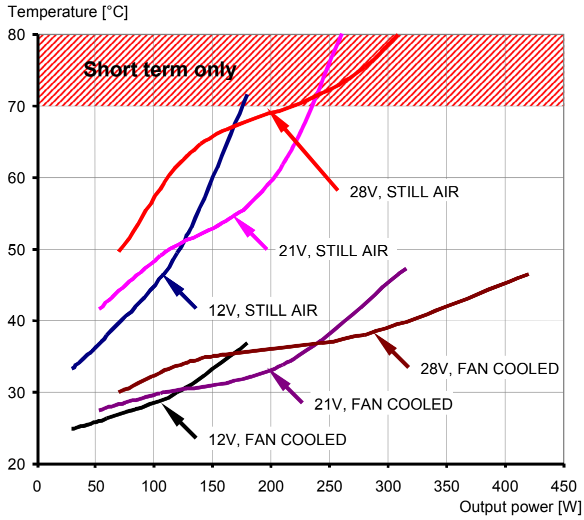


Figure 10 - Internal temperature versus output power at 21°C ambient

Recommendations

The goal of thermal design should be to maintain the PMU's internal temperature below +70°C. Operation between +70 and +85°C is permitted but not recommended for extended periods of time. Internal temperature is reported in the telemetry data stream, and there is a user-programmable thermal cutout that is set to +85°C by default.

- If no fan is to be used and the PMU is installed in a stagnant environment, the PMU should be mounted such that the rear panel is oriented vertically. This promotes the formation of natural convection currents.
- If possible the PMU should be installed such that natural airflow is able to pass across the rear panel. PMU orientation is less important when airflow is present. All of the heat-generating components within the PMU are in intimate thermal contact with the rear panel, and this is where airflow will have the most benefit.
- If high power is to be drawn from the PMU and natural airflow is limited, then a fan should be installed. PMU orientation is irrelevant if a fan is present. EBM-Papst 8414N, 3414NM, and 8414NH are all reasonable choices for 28V operation, although obviously many other possibilities exist. Airflow should be directed at the rear panel of the PMU through a suitable cutout in the bulkhead.

Communications

The communications interface has 3 main functions:

1. To provide status information during flight.
2. To allow user configuration of the PMU's programmable parameters.
3. To allow the PMU's firmware to be updated in the field.

The PMU may be ordered with either an RS232 or CAN interface. In the case of RS232, all that is required to communicate with the PMU on the ground is a terminal program and an RS232 port. During flight, status information can be directed to a datalogger or fed to a telemetry downlink for real-time display and analysis.

The RS232 interface operates at 9600 baud, with 8 data bits and no parity (9600 8N1). The RS232 communications protocol is described in detail in the following sections. CAN is more complex and is only described briefly here – a complete description is available separately.

RS232 commands

The PMU supports a number of commands via its RS232 interface. The command processor is not case sensitive, but commands must be entered exactly as shown below, with the correct number of digits and no extraneous spaces. A carriage return or linefeed character is required to terminate each command. A confirmation string is issued if the command is successful. Programmed values are stored in non-volatile memory.

Show displays the current values of V_M, I_B, I_G, P_G, P_P, I_0, T_0 and T_U.

Set Vm=XX.X where XX.X is the desired main output voltage in Volts
V_M may be set to any value from 10.0 to 30.0 inclusive (default: 12.0)

V_M MUST BE SAME AS THE FULLY-CHARGED NO-LOAD BATTERY VOLTAGE;
V_M IS USED BY THE BATTERY CHARGER TO CONTROL CHARGE TERMINATION.

Set Ib=X.X where X.X is the desired maximum battery charge current in Amps.
I_B may be set to any value from 2.0 to 5.0 inclusive (default: 2.0). Setting I_B to 0.0 disables the battery charger.

Set Ig=XX.X where XX.X is the desired PMU input current limit in Amps.
I_G may be set to any value from 00.0 to 25.5 inclusive (default: 12.0). Values greater than 15.0 are not recommended.

Set Pg=XXX where XXX is the desired PMU input power limit in Watts.
P_G may be set to any value from 000 to 999 inclusive (default: 500).

Set Pp=XX.X where XX.X is the desired packet period in seconds (the interval of time between successive status reports).
P_P may be set to any value from 00.2 to 25.5 inclusive (default: 01.0).

Set I0=XXX where XXX is the battery current offset calibration value.
I_0 may be set to any value from 000 to 255 inclusive. I_0 is set at the factory and should not normally need changing.

Set T0=XXX where XXX is the temperature offset calibration value.
T_0 may be set to any value from 000 to 255 inclusive. T_0 is set at the factory and should not normally need changing.

Set Tu=XXX where XXX is the upper temperature limit in degrees Celsius.
T_U may be set to any value from 000 to 255 inclusive (default: 85). There is approximately 10% hysteresis. Setting T_U to 0 will turn the main converter off, and setting T_U to 255 will disable thermal shutdown. Note that thermal shutdown **DOES NOT** affect the main and auxiliary outputs as long as a

	battery is connected; it merely shuts down power generation from the BLDC inputs.
Set V0	factory use only – do not use.

RS232 monitoring

The PMU measures and reports a number of quantities via its RS232 interface. The measured data is formatted into a human-readable plain text string, and is transmitted regularly at a user-defined rate. The string contains the following fields:

Vg=XX.X V	Generator voltage *Note 1*
Ig=±XX.X A	Generator current *Note 1, 2*
Vm=XX.X V	Main output voltage
Im=±XX.X A	Main output current *Note 2*
Va=X.XX V	Auxiliary output voltage
Ia=±X.XX A	Auxiliary output current *Note 2*
Vb=XX.X V	Battery voltage
Ib=±XX.X A	Battery current *Note 3*
Eb=±XXXXX mAH	Battery energy *Note 4*
T=±XXX C	Temperature

Note 1: These are DC quantities. Generator voltage and current are measured after the active rectification process.
Note 2: Positive current is defined as flowing from the BLDC motor towards the load. Under normal circumstances (when power generation is occurring) all currents are positive.
Note 3: Positive current is defined as flowing into the battery, i.e. the battery is being charged.
Note 4: Eb is similar to a fuel gauge, except that it represents the change in energy stored (since power-up), rather than the total amount of energy stored. A positive value means that the battery has had a net gain in energy since power-up (i.e. it has been charged). Battery energy is a more faithful measure of the state of charge than battery voltage.

Measurements are fixed width, i.e. leading zeros are always included. Measurements are separated from each other by a pair of spaces, and a complete set of measurements is terminated by a carriage return and linefeed. Including these two control characters, one complete set of measurements occupies 107 bytes.

An example of a typical string is as follows:

V	g	=	5	7	.	8	V			I	g	=	+	0	2	.	9	A			V	m	=	1	3	.	8	V			I	m	=	+	0	8
.	5	A			V	a	=	6	.	0	1	V			I	a	=	+	3	.	8	5	A			V	b	=	1	2	.	7	V			I
b	=	+	0	2	.	5	A			E	b	=	+	0	0	0	1	5	m	A	H			T	=	+	0	4	2	C	CR	LF				

RS232 firmware updates

Firmware updates can be performed in the field at any time. There is no limit on the number of updates that can be performed, and loss of power during a firmware update is not a problem as the bootloader code is stored in a locked sector of the flash memory and cannot be corrupted.

If a power failure occurs during the firmware update process, it should simply be repeated.

To update the firmware a terminal program that supports the Xmodem file transfer protocol is required. Simply connect the PMU to your computer's RS232 port, load the relevant .BIN file, initiate an Xmodem file transfer and power up the PMU. The firmware will be uploaded, error-checked and written to flash memory without further user intervention. Once the update has finished, the PMU will report its new firmware version and run as normal.

Previously programmed parameters are left unchanged by the firmware update process.

CAN interface

CAN offers faster and more reliable communication than is possible with RS232. The PMU's default CAN protocol operates at 1Mbit/s and is compatible with Cloud Cap Technology CAN devices. A detailed description is available separately. Custom CAN protocols can also be developed if required; please contact us to discus your requirements.

Firmware updates are also supported via the CAN interface. Insert a grounded probe into the small access hole on the underside of the PMU, apply power, and the PMU will power up in firmware update mode. Download Atmel's FLIP application (http://www.atmel.com/dyn/products/tools_card.asp?tool_id=3886) and connect the PMU to your computer with a suitable CAN interface. FLIP is available in Windows and Linux versions.

LED Indicators

There are 4 LED indicators on the front panel of the PMU. They should be interpreted as follows:

Aux	● (green)	The Auxiliary output is on.
	● (off)	The Auxiliary output is off or short-circuited to ground.
Main	● (green)	The Main output is on.
	● (off)	The Main output is off or short-circuited to ground.*Note 1*
Gen	● (green)	Power generation is occurring or external DC power is present.
	● (red)	Power generation is not occurring and no external DC is present; the battery is being depleted to maintain the Main and Auxiliary outputs.
	●● (green/red)	Current (or power) limiting is occurring.
	● (off)	The PMU is off.
Chg	● (green)	The battery is being charged.
	● (off)	The battery is not being charged.

Note 1: The Main LED will also extinguish if the Auxiliary voltage is not present for any reason. This does not mean that the Main output has failed.

Interfacing

All power inputs to the PMU are on connector X1, and all power outputs are on connector X2. Although the battery connection is both an input and an output, it is allocated to X1 to avoid the possibility of exposed live pins. All ground pins are connected together internally.

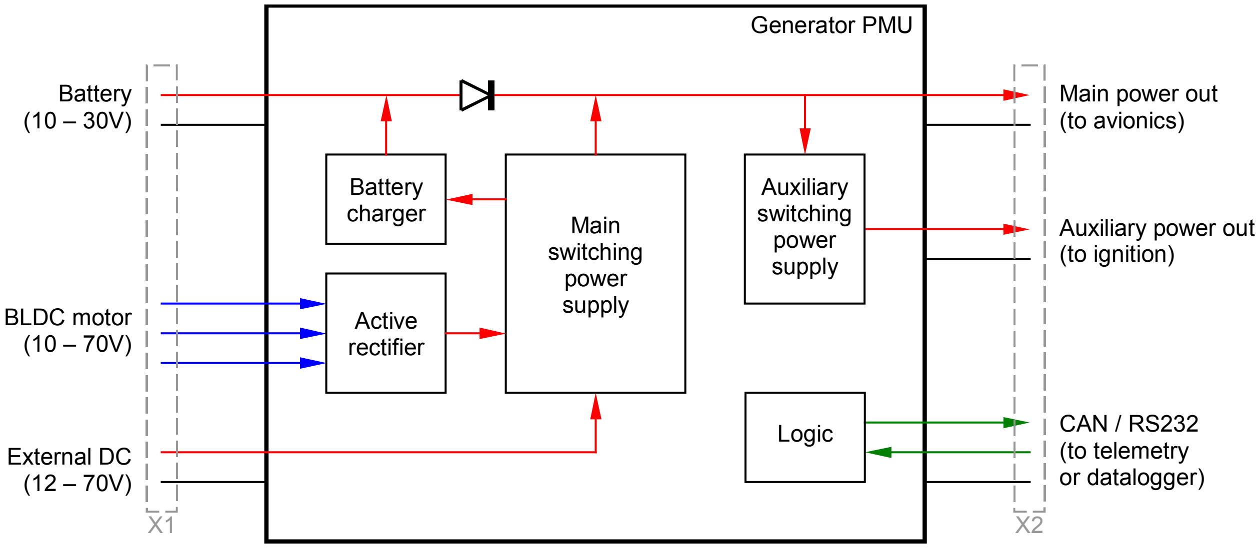


Figure 11 - Block diagram

X1 – Battery

DO NOT CONNECT THE BATTERY WITH THE WRONG POLARITY; THE GENERATOR WILL BE DAMAGED.

Connect the avionics battery here. The nominal no-load fully-charged battery voltage must be in the range 10 to 30V, and the programmable parameter V_M must be set to this value. The battery charger will charge the battery up to this value. Program the I_B parameter to the maximum charging current permissible for your particular battery.

The PMU will be on (i.e. Main and Auxiliary outputs active) whenever a charged battery is connected. It is therefore recommended to have a switch in series with one of the battery leads in order to be able to turn the PMU off.

Connecting loads directly across the battery is not recommended, as it will load the battery charger. Although small loads (< 1A) will do no harm, be aware that the current drawn subtracts from the programmed maximum charging current I_B. Loads connected across the battery will also make the calculated battery charge state "Eb" inaccurate.

X1 – BLDC motor

Connect the 3 terminals of a suitable brushless DC motor. Over the operating rpm range that generation is desired, the peak voltage must be in the range 10 to 70V. This voltage can be calculated using the following formula:

$$Vp = rpm / Kv$$

For example, a brushless motor with a Kv of 240rpm/V rotating at 3000rpm will generate 3000 / 240 = 12.5V peak. Note that this formula neglects losses and gives an upper bound on the peak voltage. Under load, the voltage will be significantly less.

X1 – External DC input

Also known as “umbilical power”, this input is used to power the aircraft whilst it is on the ground. When power is applied to this input, the Main and Auxiliary outputs are active and the battery charger is operational. It is recommended that the applied voltage be at least 33% higher than the programmed Main output voltage V_M; this will result in the coolest and most efficient operation. Voltages down to 12V will always work, but the PMU must work harder to step up the voltage, and will draw more current doing so.

X2 – Main power output

The Main power output provides an uninterruptible power source for the aircraft’s avionics. It is conservatively rated at 15A continuous.

The Main output voltage V_M can be programmed to any value from 10 to 30V, but it must be the same as the battery voltage. The reason for this restriction is safety: The design of the PMU is such that in the event of PMU failure, the battery will deliver power directly to the Main output – there is no step-up conversion at this point in the circuit. This means that the avionics must be able to operate at battery voltage, and this requirement is enforced by having the Main voltage the same as the battery voltage.

Main power is available whenever power is applied to the BLDC or External DC or Battery connections.

X2 – Auxiliary power output

The Auxiliary power output provides a second uninterruptible power source. It is primarily intended for powering ignition systems, but may be used for any device that requires 6VDC.

The Auxiliary output is rated at 5A continuous, and will eventually hiccup at some point beyond this limit. For this reason it is not recommended to power a servo bus from the Auxiliary output, unless measures are taken to supply peak demands.

The Auxiliary output can be customised to any voltage up to 15VDC. Some higher current options are also available.

Auxiliary power is available whenever power is applied to the BLDC or External DC or Battery connections.

X2 – CAN / RS232

The PMU can have either a CAN or an RS232 communications interface. The RS232 protocol is described in the Communications section of this document, and the CAN protocol is described in a separate document. Custom CAN protocols are also available on request.

The CAN and RS232 interfaces share the same physical pins on connector X2 – these are configured as either CAN or RS232 at the time of manufacture depending on the variant ordered. A 120Ω termination resistor may be fitted to the CAN bus if required, but is not fitted by default.

Connectors

Pin Arrangement

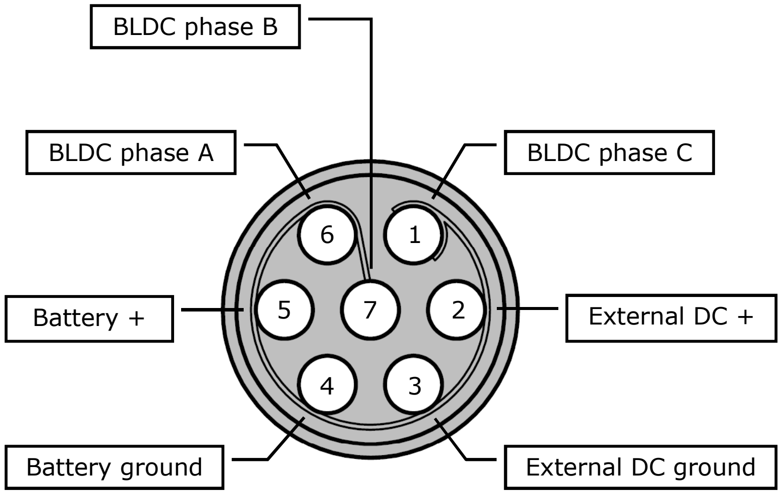


Figure 12 - X1 pin arrangement.
View of rear of mating (female) connector

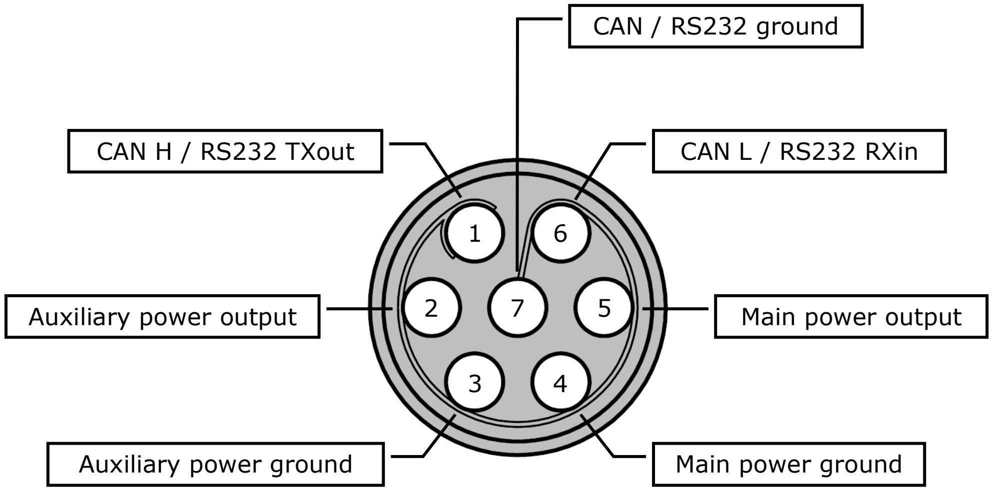


Figure 13 - X2 pin arrangement.
View of rear of mating (male) connector

There are 2 connectors on the front panel of the PMU labelled X1 and X2. X1 is a 7-way male connector and contains all of the power inputs to the PMU. X2 is a 7-way female connector and contains the main and auxiliary power outputs from the PMU plus the communications pins. All ground pins are connected together internally.

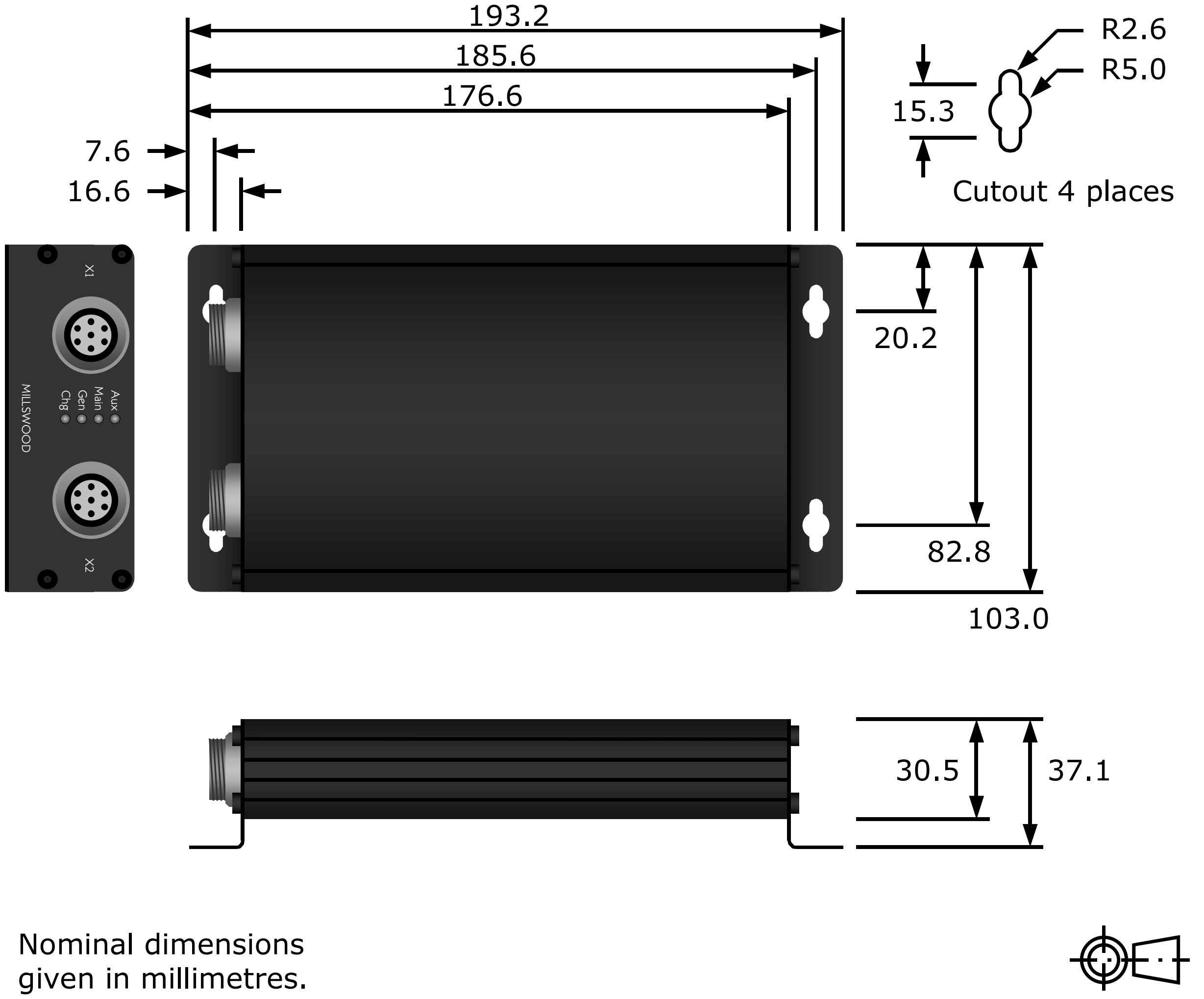
The connectors used are ODU Mini-snap series L, size 3, cylindrical push-pull connectors. These are high-quality connectors and are rated to carry 17 Amps per pin continuously.

Pin Functions

Pin	Name	Description
X1:1	BLDC phase C	Connect to one of the 3 BLDC motor terminals. Must be fully floating, not ground referenced.
X1:2	External DC +	Positive power input intended for powering avionics and recharging battery whilst aircraft is on the ground.
X1:3	External DC ground	Corresponding ground connection for pin 2
X1:4	Battery ground	Corresponding ground connection for pin 5. Connect to negative terminal of battery.
X1:5	Battery +	Connect to positive terminal of battery.
X1:6	BLDC phase A	Connect to one of the 3 BLDC motor terminals. Must be fully floating, not ground referenced.
X1:7	BLDC phase B	Connect to one of the 3 BLDC motor terminals. Must be fully floating, not ground referenced.
X2:1	CAN H / RS232 TXout	CAN H or RS232 TXout depending on the variant ordered.
X2:2	Auxiliary power output	+6V output intended for powering ignition system(s). Output is maintained at +6V even when engine is off. 5 Amps.
X2:3	Auxiliary power ground	Corresponding ground connection for pin 2.
X2:4	Main power ground	Corresponding ground connection for pin 5.
X2:5	Main power output	Positive power supply connection for avionics. Output is maintained even when engine is off. Programmable voltage, 15 Amps.
X2:6	CAN L / RS232 RXin	CAN L or RS232 RXin depending on the variant ordered.
X2:7	CAN / RS232 ground	Corresponding ground connection for pins 1 and 6.

Mechanical Data

Symbol	Parameter	Test conditions	Min	Typ	Max	Unit
M	Mass	Excluding mating connectors		625		g
		Including mating connectors		720		



Nominal dimensions given in millimetres.

Figure 14 - Physical dimensions

Ordering Information

Part number:	MEG50A-X-YYY-Z[Note 1]
Options:	
X (communications standard):	R (RS2332, default); C (CAN)
YYY (Auxiliary output voltage):	060 (6.0VDC, default) to 150 (15.0VDC)
Z (Mating connector pin termination style):[Note 2]	C (Crimp, default); S (Solder); N (None)

Note 1: The standard product is MEG50A-R-060-C.

Note 2: The ODU mating connectors offered have the following part numbers:
- *Crimp terminations: S13L0C-P07PSN0-8200 and S13L0C-P07NSN0-8200*
- *Solder terminations: S13L0C-P07MSN0-8200 and S13L0C-P07LSN0-8200*

These connectors are straight – right-angled connectors could be substituted if desired. The 8200 at the end of the part numbers indicates that the collets are suitable for total cable diameters of 7.0 to 8.2mm.

Further Information

Visit us on the web at www.millswoodeng.com.au

Didn't find what you wanted? Send us an email or give us a call – contact details are on our website.

MILLSWOOD engineering Generator PMU

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Appendix 1 – Choosing a suitable BLDC motor

Types of BLDC motors

BLDC motors are available in two basic configurations, commonly known as "inrunners" and "outrunners". Inrunners have the magnets attached to the central shaft, and this assembly rotates within the surrounding (fixed) windings. Outrunners have the opposite arrangement, with the magnets attached to the external housing which rotates around the inner (fixed) windings.

Outrunners with suitable Kv and power ratings for use in electric power generation are cheap and readily available. They have excellent power density per unit volume and per unit weight. However, outrunners tend to have an open style of construction and this makes them vulnerable to ingesting airborne contaminants.

Inrunners have a non-rotating outer case and can therefore be sealed against the ingress of airborne contaminants. This makes inrunners a better choice for most UAV applications.

Calculating the optimal Kv

In order to maximise power output, the PMU's BLDC input should be operated as near to 70V as possible (without exceeding 70V). In other words, 70V should correspond to the maximum RPM ever expected from the internal combustion engine.

The equation relating these parameters is:

BLDC_voltage = RPM x Gear_ratio / Kv

Where **Gear_ratio = BLDC motor speed / Internal combustion engine speed**

Rearranging the first equation for Kv:

Kv = RPM x Gear_ratio / BLDC_voltage

Example

A system has a maximum engine speed of 6000 RPM and a 2:1 step-up belt drive to the BLDC motor. The equation for Kv is:

Kv = 6000 x 2 / 70
Kv = 171 RPM/V

This Kv will deliver 70V to the PMU at 6000 RPM with 2:1 step-up gearing. It is a ***minimum*** value (i.e. using Kv values less than 171 RPM/V will generate ***more*** than 70V at 6000 RPM). A BLDC motor should be chosen with a Kv as close as possible to 171 RPM/V, but not less than this value.

Pole count

At least 4 poles (2 pole pairs) are recommended. There is no upper limit on the number of poles.

Recommended BLDC motors

For powers up to about 200W, Maxon EC (Externally Commutated) motors have been widely used in UAVs, and have proved to be reliable workhorses.

For powers above 200W, Astro Flight make a range of industrial BLDC motors which are well suited for UAV applications. A suitable motor for the example given above is Astro Flight model 3210 with a 7-turn winding. This device has a Kv of 194 RPM/V.