XTRALIS POWER SUPPLY UNITS STYLE E5 APPLICATION NOTE

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Doc. No. 38276_00

Preface

This Application Note provides reference information about the Switch Mode Power Supply (SMPS) PCB assembly of the VPS-215-XX, VPS-220-XX and VPS-250-XX Power Supply Units (PSU).

The information is arranged as a quick reference followed by a more detailed explanation.

A section on batteries provides a more in-depth explanation of potential issues.

Related Products

Xtralis PSUs:

- VPS-215-E5
- VPS-220-E5
- VPS-250-E5
- VPS-220-STX5
- VPS-250-STX5

Safety

Warning!

- Mains voltages are present and safe working practices must be observed.
- Any maintenance or activity outside the normal operating conditions must only be carried out by competent personnel.
- Even when the incoming mains has been disconnected, hazardous voltages may still be present. The red LED (for avoidance of doubt there is only one red LED on the PSU) indicates that hazardous voltage may be present. In normal operation the hazard is inaccessible, being on the underside of the PCB or under the plastic cover.

Warning!

- Batteries can source extremely high current which will heat any conductor such that it will cause severe thermal damage and even combustion.
- Take great care to avoid a direct short circuit between any +V and 0V terminal, on the batteries or on the PCB.
- Do not wear any metal objects on or near your hands, such as rings, bracelets and watches.
- You must cover unused battery terminals to prevent accidental short circuits.

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1 Quick Reference Charts

1.1 VPS-250-XX

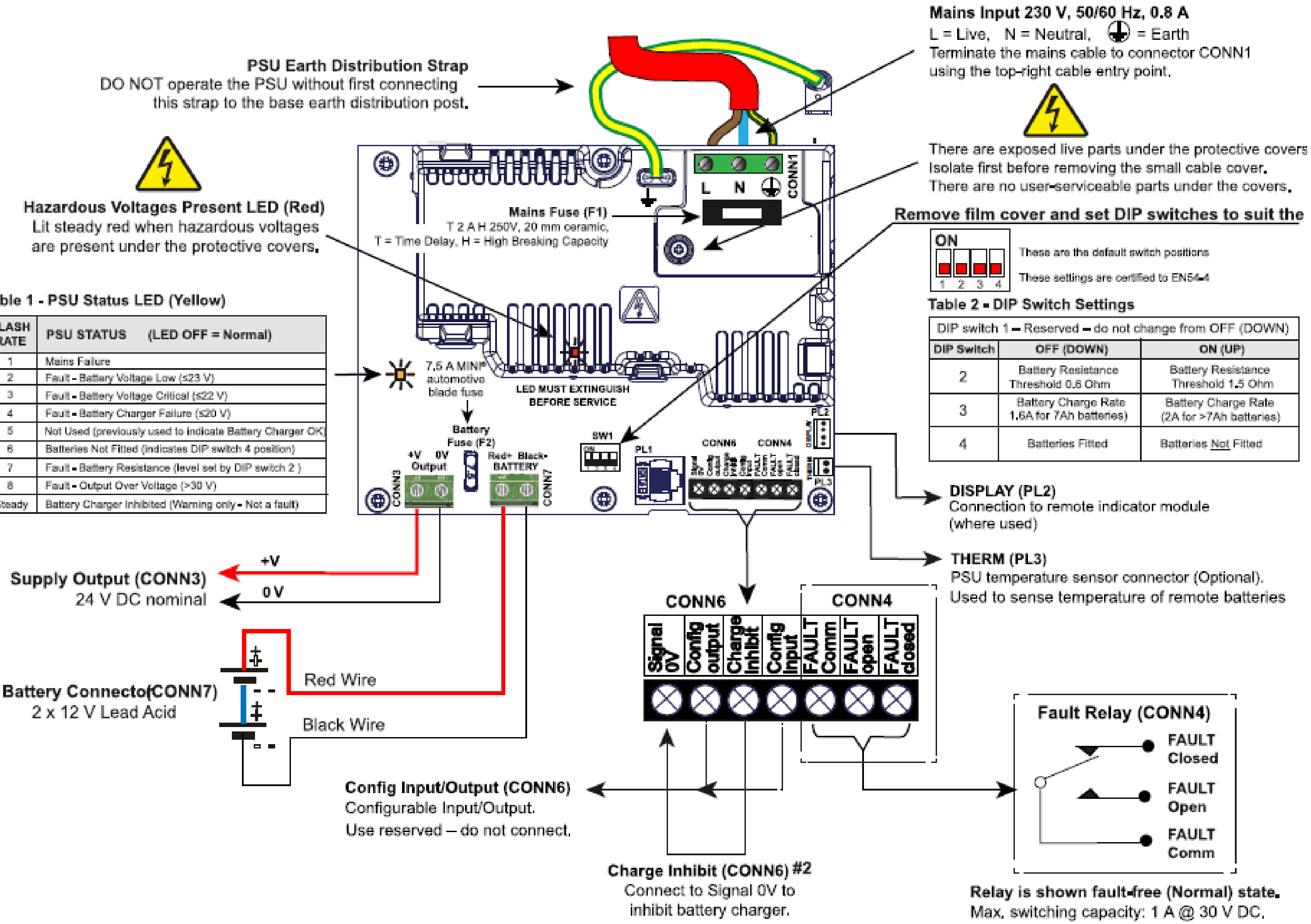

Table 1 - PSU Status LED (Yellow)

FLASH RATE	PSU STATUS (LED OFF = Normal)
1	Mains Failure
2	Fault – Battery Voltage Low (≤23 V)
3	Fault – Battery Voltage Critical (≤22 V)
4	Fault – Battery Charger Failure (≤20 V)
5	Not Used (previously used to indicate Battery Charger OK)
6	Batteries Not Fitted (indicates DIP switch 4 position)
7	Fault – Battery Resistance (level set by DIP switch 2)
8	Fault – Output Over Voltage (>30 V)
Steady	Battery Charger Inhibited (Warning only – Not a fault)

Table 2 – DIP Switch Settings

DIP switch 1 – Reserved – do not change from OFF (DOWN)		
DIP Switch	OFF (DOWN)	ON (UP)
2	Battery Resistance Threshold 0.6 Ohm	Battery Resistance Threshold 1.5 Ohm
3	Battery Charge Rate 1.6A for 7Ah batteries)	Battery Charge Rate (2A for >7Ah batteries)
4	Batteries Fitted	Batteries Not Fitted

1.2 VPS-215-XX and VPS-220-XX

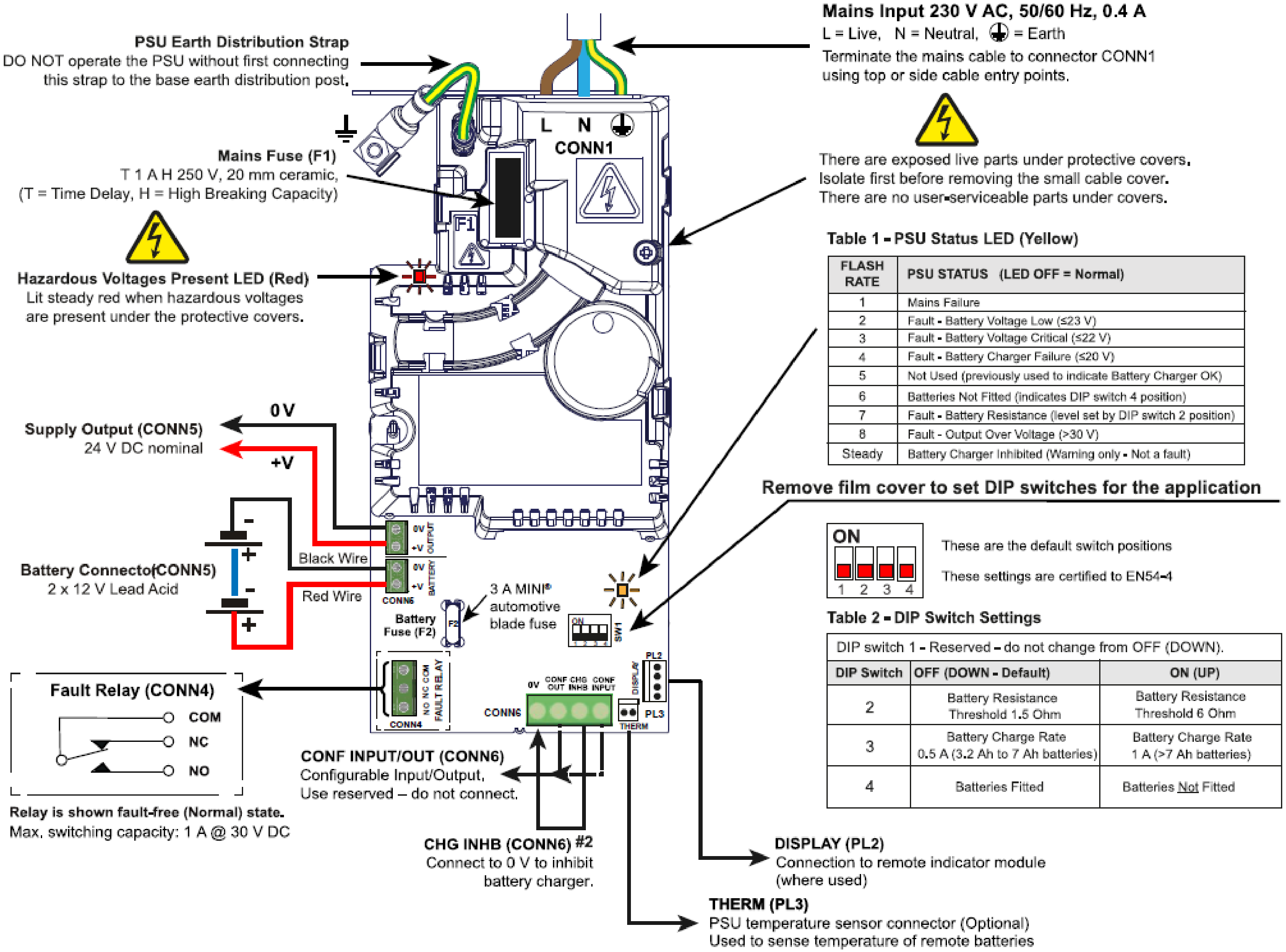

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Table 2 - DIP Switch Settings

DIP switch 1 - Reserved - do not change from OFF (DOWN).

DIP Switch	OFF (DOWN - Default)	ON (UP)
2	Battery Resistance Threshold 1.5 Ohm	Battery Resistance Threshold 6 Ohm
3	Battery Charge Rate 0.5 A (3.2 Ah to 7 Ah batteries)	Battery Charge Rate 1 A (>7 Ah batteries)
4	Batteries Fitted	Batteries Not Fitted

2 Periodic Maintenance Measurements

The PSU is designed to be maintenance free, but batteries do have a finite lifetime. The PSU provides an indication of the health of the battery.

It is acknowledged that some applications require manual measurements to be made to confirm the correct operation of the PSU and the health of the battery.

These measurements usually consist of a measurement of the battery voltage in normal operation, a further measurement of the battery with the mains disconnected and a check that the PSU will support the application load with the battery disconnected

However, VPS-215-XX and VPS-220-XX have some special requirements for the periodic maintenance checks. In this case it is essential that the test is carried out in this order:

1. Disconnect battery
2. Perform load test
3. Reconnect battery
4. Measure battery voltage
5. Disconnect mains
6. Measure battery voltage
7. Reconnect mains

The minimum period between stage 5 and stage 7 must be 10 seconds.

This is because the overload protection in the SMPS controller Integrated Circuit (IC) detects a momentary overload when the battery is reconnected. This protection is latching and requires the mains to be disconnected to reset the IC. By conducting the test procedure in the order above, the required reset is built into the test. This protection is hard coded into the IC and cannot be turned off.

Note!

This does not apply to the VPS-250-XX PSU which uses a different SMPS controller IC.

3 1st Line Troubleshooting

- In the event of a fault occurring, the fault relay will change state. In order to identify the fault that has occurred, it is necessary to attend the PSU while the fault condition exists so that the fault condition can be identified by observing the code indicated by the flashing yellow LED.
- Note that faults are not latching. If the fault condition clears before the LED is observed, it may not be possible to identify the fault. Fault conditions are not logged.
- If the red LED is not illuminated, check the primary fuse and the incoming mains supply. If necessary, replace the fuse with the same type and rating. If the fuse operates again, the PSU is probably defective and must be changed.
- If the yellow LED is flashing, count the number of blinks. Compare this with the table in the quick reference charts in section 1.1 and 1.2 (more information is available in the latter sections).
- If the battery voltage is low, it is likely that the battery is depleted. Has there been a failure of the mains? The fault will clear if the battery voltage increases to greater than 23V. If the battery voltage does not increase, it is likely that the battery is defective and must be replaced.
- Note that if the battery voltage drops below 20V, the charger is disabled to prevent a possible hazard condition created by charging a damaged battery.
- If the battery charge voltage is not present, or the battery does not power the application, check the battery fuse. If this fuse has operated, replace it with the same type and rating of fuse. If the fuse operates again, do not replace it again. Return the PSU for investigation. The probable reason for this fuse to operate is a short circuit on the PSU output or a reversal of the battery leads. Because the battery can supply very large currents within a short time, damage to the PSU circuitry may occur before the fuse can operate.
- If a battery has been disconnected for any reason in a VPS-215-XX or VPS-220-XX PSU, the output may shut down after a few minutes, but the red LED may continue to be illuminated. This is the condition outlined in Section 2 Periodic Maintenance Measurements. This can be rectified by disconnecting the mains supply for at least 10 seconds. This fault can be prevented by disconnecting the mains supply every time a battery is reconnected. This does not apply to VPS-250-XX PSUs.
- In a relatively small number of cases, there have been reports of a battery internal resistance fault occurring intermittently and clearing within a short time. The PSU continues to function correctly, but such a fault is a nuisance because it needs to be investigated, particularly if the fault is latching in the application, which must be attended to clear the fault. If this is suspected, return the PSU for investigation.
- If a PSU is removed from the application because of a suspected fault, it should be marked with the date of and the reason for removal. Give as much information as possible to assist with the analysis of the problem.

4 Detailed Information About the PSU

4.1 General

This document provides information supplementary to the product data sheets. The information in the data sheet is specific to the product; this document attempts additional explanation to assist in understanding how the power supply, the battery, and the application work together as a system.

The VPS series of PSUs are a series of combined PSU and battery charger. 12V (for single 12V battery) and 24V (for 2 x 12V series connected batteries) versions are available with current ratings from 1.5A to 5A.

The VPS PSUs are tested and approved to EN 54-4 for use in fire alarm Control and Indicating Equipment (CIE). Additionally, they are approved to EN 50131-6 for use in intruder alarm systems.

When installed correctly, the PSU complies with the requirements of EN 62368-1 and the Low Voltage Directive. Hazardous voltages are inaccessible under the plastic cover and the underside of the PCB.

The PSU provides the main DC power supply to the application, as well as charging and monitoring a connected Valve Regulated Lead Acid (VRLA) battery which provides a backup DC power supply to the application.

The nominal output voltage is 24V DC. If there is no battery connected, the output voltage is 24.5V ± 2%.

If batteries are fitted, the PSU output follows the battery voltage, which is dependent on the charge state of the battery and is dependent on temperature.

The PSU monitors the mains input, the power supply output voltage, the battery charger status, the battery voltage and the battery internal resistance.

When a deviation from nominal conditions is detected, it is indicated in 2 ways:

1. The fault relay changes state.
2. The specific deviation is indicated by a number of flashes of the yellow LED.

4.2 Indicators

The PSU has 2 indicators LEDs, red and yellow.

The red LED, visible under the plastic cover, indicates that there is high voltage present in the mains input circuit. If the LED is illuminated, hazardous voltage is present. Maintenance activities involving the removal of the plastic cover, the mains connection or the entire PSU must not be carried out while the red LED is illuminated.

The yellow LED indicates a fault or deviation from a nominal condition. A steady illumination of the yellow LED indicates that the battery charge function has been inhibited (see the table below). This is not a fault.

A flashing yellow LED indicates a fault or deviation condition. The number of flashes indicates the specific condition.

Table 1: Summary of Yellow LED Status Indications

Flashes	PSU Status	Indication
1	Mains Fail	The mains power supply has been interrupted. The PSU output is automatically switched over to the battery backup. When the mains power is restored, the PSU output switches back to the main PSU output and the fault indication is removed.
2	Battery Voltage Low (≤23 V)	This is a warning that the battery is becoming depleted and may not be able to sustain the application circuit for much longer.
3	Battery Voltage Critical (≤22 V)	This is a warning that the battery depletion is critical and if mains power is not restored, power to the application circuit will be shut off imminently. If the battery voltage reduces further to ≤21 V, power to the application is disconnected. This is to prevent the battery from suffering damage due to over-discharge. Note that if the battery becomes disconnected, the

Flashes	PSU Status	Indication
		LED flashes twice [battery low] and [pause] 3 times [battery critical]
4	Battery Charge Fail	If battery voltage is ≤20 V, the battery is over discharged and may be damaged. Charging is suppressed to prevent further damage from occurring.
5	Not used	In early versions of the PSU, 5 flashes were used to indicate that the PSU was functioning normally. This was sometimes confused with as a fault indication, so this indication was removed in later releases; normal operation is now indicated by no illumination of the yellow LED.
6	Batteries Not Fitted	This indicates that the batteries are not fitted and DIP switch 4 has been changed to the ON position.
7	Battery Resistance Fault	The PSU monitors the battery internal resistance to provide an indication of battery health. Refer to section 5 Batteries for more details. There are two resistance thresholds which are selected by DIP switch 2. The available settings are dependent on the PSU model. Refer to section 5 Batteries for more details. Typically, the settings consist of a normal setting (sometimes called “approved”) and a higher resistance setting that can be selected in case of nuisance resistance fault events.
8	Output Overvoltage (>30 V)	If the output voltage exceeds 30V, which may happen in the unlikely event of regulation failure in the PSU, the PSU controller is disabled. This is a latching disablement, and the mains power must be switched off to reset the power supply. If the same fault occurs, do not continue to reset the PSU – it must be serviced by a competent person.
Steady	Battery Charger Inhibited	This state occurs when the “Charge Inhibit” terminal is connected to 0V. This facility is provided so that all available power from the PSU can be diverted to the application instead of some of the power being used to charge the battery. Note that when the mains connection to the PSU is made, the yellow LED may illuminate steadily for several seconds until the PSU settles into normal operation.

4.3 Connections

Note that different PSU models may have different connector designations, e.g., CONN3, CONN5, etc. Accordingly, there may be multiple connector designations for the same functions in the descriptions below. In any PSU, only one connector designation will be applicable.

CONN1

Live, Neutral and Earth (terminal block – access controlled)

Installation must be made by a competent person only.

CONN3 or **CONN5** (part)

Output: 0V and +V (terminal block)

This is the DC output of the PSU to the application circuit

CONN7 or CONN5 (part)

Battery: 0V and +V, or Black- and Red+ (terminal block)

This is the connection to the battery. Current can flow into the battery (charging) or it can flow from the battery to the application via the Output connection.

CONN4

Fault Relay: COM, NC, NO, or FAULT Comm, FAULT open, FAULT closed

These connect to a single pole changeover relay which changes state in the event of a fault occurring. In the normally energized, no-fault state, the COM and NC (FAULT Comm and FAULT closed) terminals are connected.

CONN6

Signal 0V [0V]

This is a reference level for the inputs and output on this connector. It is connected internally to the main output 0V on CONN7 or CONN5

Config Output [CONF OUT]

This is an uncommitted configurable open drain output. It is preconfigured for specific OEM applications and is not user programmable. No connection should be made to this terminal.

Charge Inhibit [CHG INHB]

This is a control input used to disable the battery charger. This allows all output power to be diverted to an application if required. The inhibit is activated by connecting the input to Signal 0V [0V] or applying a voltage of less than 0.5V with respect to Signal 0V [0V].

The charge inhibit state is indicated by steady illumination of the yellow LED.

Config Input [CONF INPUT]

This is an uncommitted configurable input. It is preconfigured for specific OEM application and is not user programmable. No connection must be made to this terminal.

PL1

PL1 is an 8-way RJ45 female connector. This is for connection to specific applications only. Some PSU versions are not fitted with this connector

PL2 DISPLAY

PL2 DISPLAY is a polarized locking 4- or 5-way male header. This facilitates connection to a remote indicator PCB for some applications.

PL3 THERM

This is a 2-way locking male header for the connection of a remote battery monitoring thermistor.

VRLA battery voltage is dependent on temperature and to optimize the lifetime of the battery, the battery charger must provide the correct temperature-depending voltage while charging. If PSU and batteries are contained within the same enclosure, the PSU on-board temperature sensor is adequate for the task. If the batteries are separated from the PSU such as in a separate enclosure a remote thermistor must be used to ensure the correct charge voltage is applied.

4.4 Configuration Switches

Switch	Description
SW1	A 4-way DIP switch that is used to configure certain operating modes
SW1.1	Reserved for special applications and must be left in the down [OFF] position
SW1.2	Used to set the battery internal resistance threshold. The up [ON] and down [OFF] settings are specific to PSU model and OEM application
SW1.3	Used to adjust the battery charge current. This is also dependent on PSU model. This allows the charge current to be optimized for the application
SW1.4	Used to set the operating mode of the PSU when there are no batteries connected. If there are no batteries connected, SW1.4 should be in the up [ON] position, otherwise it should be in the down [OFF] position

4.5 Fuses

In the event of a PSU fault or misconnection, it is possible that high currents will flow in the PSU or connected cables. The purpose of a fuse is to interrupt excessively high currents before it can cause excessive heating and a potential fire hazard.

Before any fuse is replaced, the PSU must be disconnected and safely isolated from the mains. This must only be carried out by a competent person.

F1 Mains input fuse

The mains input fuse is a ceramic body 5 x 20mm cartridge fuse. The fuse rating is denoted on the PCB next to the fuse connector as T 1 A H or T 2 A H.

T denotes Time Delay. H denotes High Rupture Capacity. 1 A or 2 A is the fuse rating.

Only replace the fuse with the same type and rating of fuse.

When a fuse has operated (“blown”) and has been replaced, if the new fuse also operates, do not replace it again. The PSU must be replaced and the inoperative PSU returned to the factory for analysis.

The most usual reason for the operation of this fuse is incorrect connection of the mains input.

F2 Battery Protection Fuse

F2 is an automotive ‘mini’ blade fuse. Depending on the PSU model it will be either a 3A fuse or a 7.5A fuse.

As with the mains fuse, if a blown fuse is replaced, only for the replacement to operate, do not replace the fuse again. The PSU must be replaced.

The main reason for the battery fuse to operate is when DC output +V and 0V have been shorted while the battery is connected but the mains power is off. This can happen during installation or maintenance. It is good practice to disconnect the battery and the mains during any maintenance activity.

Another typical cause is if the battery is connected with reverse polarity.

5 Batteries

5.1 Basic Information

The basic constituent of a lead-acid battery is a cell. The cell consists of two electrodes (lead plates) immersed in an electrolyte solution (sulphuric acid)—hence, lead-acid. A lead-acid cell has a charged voltage of approximately 2V.

Early lead-acid batteries did indeed have wet cells, where the plates are literally immersed in an acid solution. Nowadays, we use VRLA batteries in which the electrolyte is held within an absorbent glass mat or is actually a gel. Valve-regulated refers to a pressure relief valve. These can be (and are!) used in any orientation. They are sometimes referred to as gel batteries or sealed, maintenance-free batteries.

Lead-acid batteries are commonly available in 6V or 12V units. We refer to them as ‘6V’ or ‘12V’ batteries. However, it must be noted that this is a nominal figure. In fact, the voltage of a fully charged 12V lead-acid battery is closer to 14V than 12V. We call them 12V batteries because it is a convenient quantity to operate arithmetically.

Connect 6 cells in series to make a 12V battery: 6 × 2V = 12V. Connect 2 × 12V batteries in series to make a 24V battery, or 3 to make 36V, or 4 to make 48V.

However, the actual voltage produced by a lead-acid cell is not exactly 2V. It is more like 2.275V. Moreover, the voltage is dependent on temperature and, to a lesser extent, the special recipe of the battery manufacturer.

VPS PSUs are optimized for operation with YUASA NP series batteries. Batteries from other manufacturers may have slightly different requirements for optimum operation and life.

Figure 1 shows how the voltage of a fully charged 12V battery varies over temperature. This is the voltage that the battery charger must supply. The charge voltage must be maintained within ±100mV of the optimum voltage. Too low, and the battery will never reach full capacity. Too high, and the battery lifespan is compromised because of overcharging.

The fully charged voltage is called the float voltage because the battery is ‘floating’ at equilibrium, neither charging nor discharging.

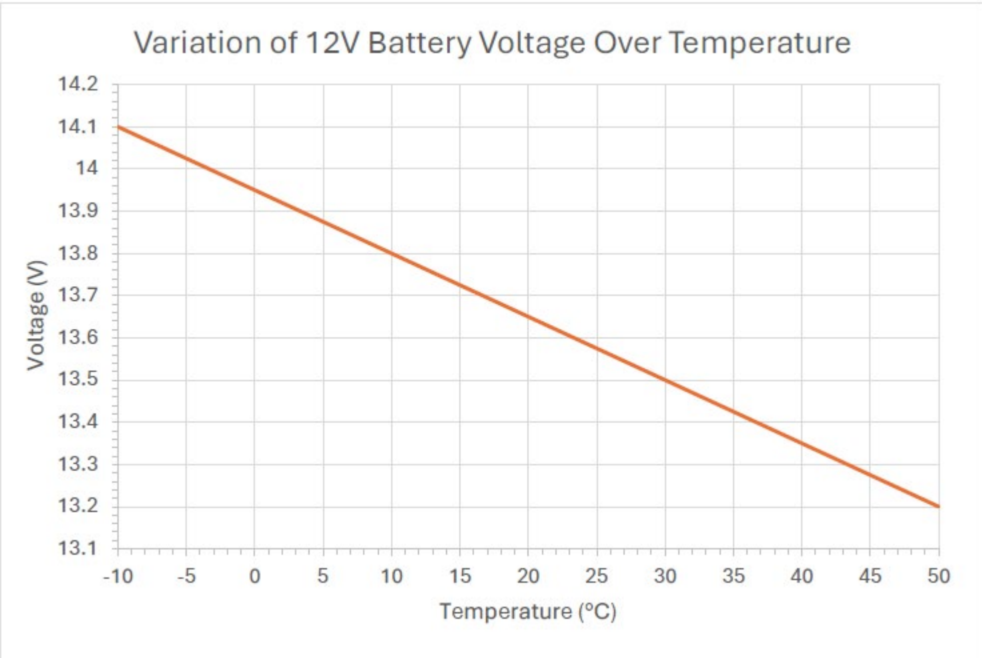

Figure 1: Battery Voltage Over Temperature (Yuasa NP 12V Battery)

5.2 Battery Capacity

Battery capacity is generally determined by the volume of electrolyte. A battery that is physically bigger than another contains more acid and therefore has a greater capacity. A bigger battery can also contain physically larger lead plates which, having a greater surface area, yield a lower internal resistance and therefore a higher current capability. More details in the next sections.

Battery capacity is expressed in amp hours (Ah), e.g., 7Ah, which means that the battery should be able to sustain a current of 7A for 1 hour, or 1A for 7 hours. Unfortunately, it is not quite as simple as that. The relationship between capacity and discharge time does not change linearly with current. Manufacturers specify capacity for a given discharge rate, typically the current that could be sustained for 20 hours. For a 7Ah battery, this means a discharge current of 7Ah / 20h = 0.35A.

> **Note!**
>
> The relationship between current and capacity is not linear. The higher the discharge current, the lower the capacity.

5.3 Battery Chemistry and Internal Resistance

The conversion of chemical energy into electrical energy during discharge takes place in a chemical reaction at the interface between the lead plates and the acid solution.

In simple terms, during discharge, the reaction deposits lead sulphate on the plates, produces water diluting the sulphuric acid and releases free electrons that form the current in the application circuit.

Equally simply, during charging, the reaction is reversed; electrons combine with the sulphate and water to produce sulphuric acid, leaving bare lead on the plates.

The internal resistance is inversely proportional to the area available for the chemical reaction. The bigger the area, the lower the resistance. This is why bigger batteries [higher capacity] have a lower internal resistance.

A battery manufacturer will give a specification for battery internal resistance. This is the internal resistance that can be expected in a brand new, fully charged battery. The internal resistance starts to degrade as soon as the battery has left the production line.

As the battery is discharged, the internal resistance increases because the area of reaction decreases.

Note that a lead acid battery exhibits a property called self-discharge. Even when there is no external circuit connected, the discharge chemical reaction takes place albeit at a low rate. This means that a lead acid battery has a relatively short shelf life. In use, this degradation is avoided by applying a charging voltage at the correct level for the temperature. This charging condition is called trickle charging and the voltage is the float voltage.

During cycles of discharge and charge, the formation and dissolution of lead sulphate on the plates is not perfectly even. Over time this results in areas where the sulphate is not all dissolved back into sulphuric acid. These areas are no longer available for the discharge chemical reaction to take place. Reducing the area increases internal resistance. As some of the sulphate remains on the plates rather than [re]forming sulphuric acid, the capacity of the battery is reduced, too.

The more discharge/charge cycles that the battery experiences, the worse the effect. Moreover, the depth of discharge also affects the uneven buildup of lead sulphate. Manufacturers may give a figure for lifetime expressed in number of cycles for given depth of discharge.

Measuring the internal resistance gives an indication of the health of the battery.

The battery resistance is obtained by measuring the battery voltage with no load and again with a known test load current.

$$(1) \quad R_{int} = \frac{V_{no\_load} - V_{on\_load}}{I_{test}}$$

How much internal resistance is too much internal resistance?

The answer to that depends on the application. The current multiplied by the internal resistance results in a "lost" voltage. If this reduces the effective battery voltage at the PSU battery terminals to 21V or less, the PSU will shut off the battery to prevent it from becoming over-discharged.

$$(2) \quad V_{on\_load} = V_{no\_load} - I_{load} \times R_{int}$$

VPS PSUs are configured with 2 settings for battery resistance alert threshold, which are selected via position 2 of the DIP switch. One of the settings is denoted as "approved." This simply means that this condition was tested by a 3rd party approvals body to make sure that the battery resistance check functions correctly.

That the other case was not tested does not mean that it is somehow less effective. The decision to not test both conditions is due to cost and because the "non-approved" case can be later optimized for a specific application.

In any application, the key figure for internal resistance is that which would cause the battery voltage, Von_load, to fall below 21V as per equation (2).

5.4 Connecting Batteries in Series and Parallel

Batteries can be connected in series to obtain higher battery voltages or in parallel to obtain a greater capacity. Series or parallel connected batteries must be located in close proximity to ensure that they are as near as possible the same temperature. If there is a temperature differential, the optimum float voltage would be different for each battery. This would result in the batteries suffering from a situation where one, or even both, are not optimally charged and suffer from accelerated aging.

If it is necessary to replace series or parallel connected batteries, they must be replaced at the same time. All such connected batteries must be of the same brand and the same capacity. They must also have been manufactured in the same batch to have experienced the same age and be as near identical as possible.

5.5 The Effect of Temperature

Heat kills batteries! This is a strong statement, but it is clear that elevated temperature reduces the life of lead acid batteries, whether on the shelf or in service.

This is best illustrated with some graphs.

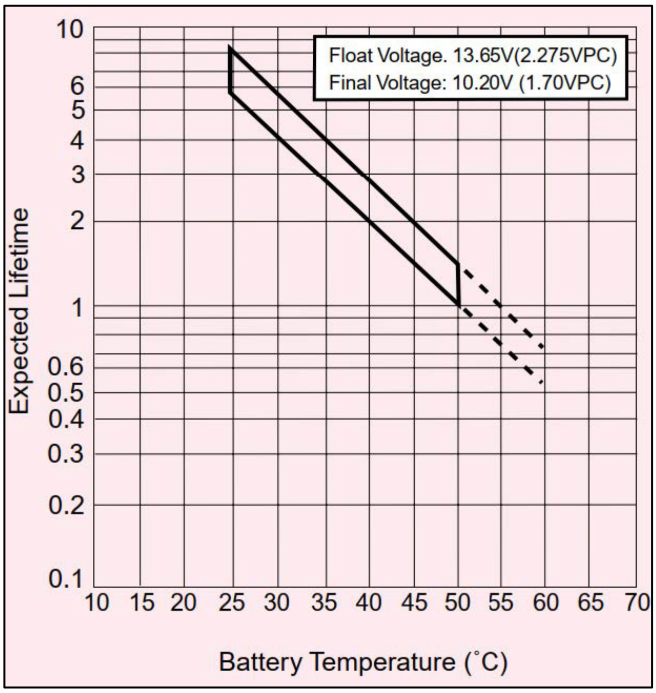

Figure 2: The Effect of Temperature on Service Life (Source: Yuasa)

Figure 2 shows how temperature affects the useful life of a battery that is maintained at the optimum float voltage given in Figure 1.

While the headline endurance of the battery might be 10 years at 25°C, the actual endurance at 50°C could be degraded to 1 year. 50°C is not an unreasonable expectation in some environments.

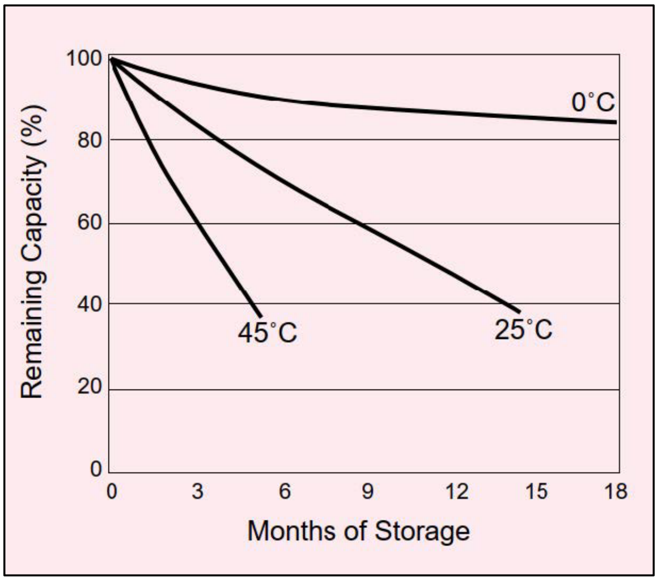

Figure 3: The Effect of Temperature on Self Discharge (Source: Yuasa)

Figure 3 shows how battery capacity is degraded with different temperatures while the battery is sitting on the shelf.

In simple terms, heat promotes the chemical reaction described earlier. This accelerates the deposition of lead sulphate on the plates and makes it more uneven.

It is claimed that a battery with excessively sulphated plates may be recovered by a process called de-sulphation. This involves applying a high charging current, steady or pulsed. This might or might not improve a battery that is so degraded. However, the battery will still be sub-optimal and given that it is a backup power supply for a life critical application, it would be sensible to replace it. The VPS series of PSUs do not have a de-sulphation mode.

If battery life is compromised because of elevated temperature, this must be addressed, or it will be necessary to replace batteries regularly despite that 10-year lifetime claim.

5.6 How Old Is My Battery?

Yuasa NP series batteries have the date of manufacture stamped on the connector surface. Here are some examples.

Figure 4: Manufacturing Date Code on a Yuasa 12V 7Ah Battery

The date code in Figure 4 is 21st June 2019. H7 is a plant / shift code.

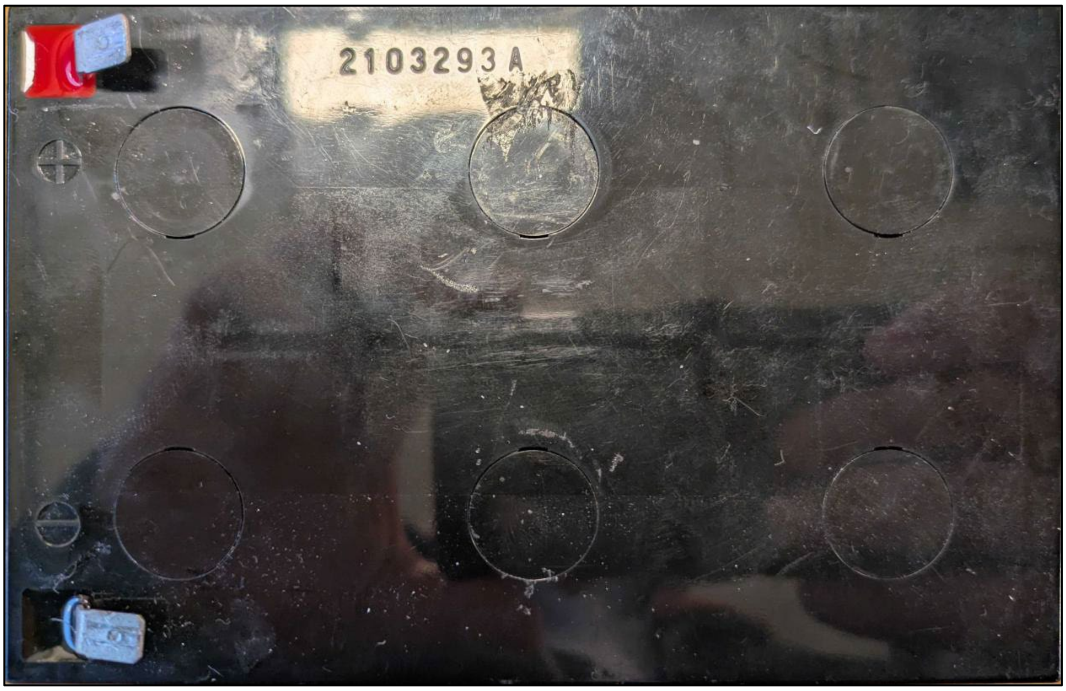

Figure 5: Manufacturing Date Code on a Yuasa 12V 12AH Battery

The date code in Figure 5 is 29th March 2021. 3A is a plant / shift code.

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