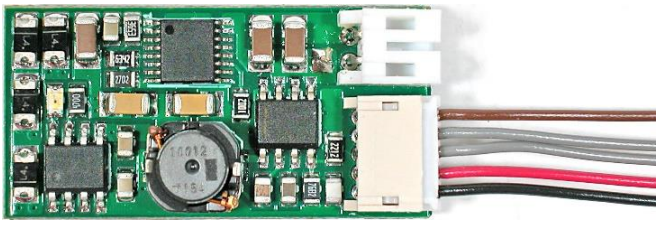
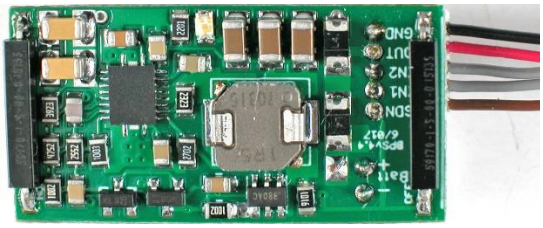
BPS-v4 Technical Reference

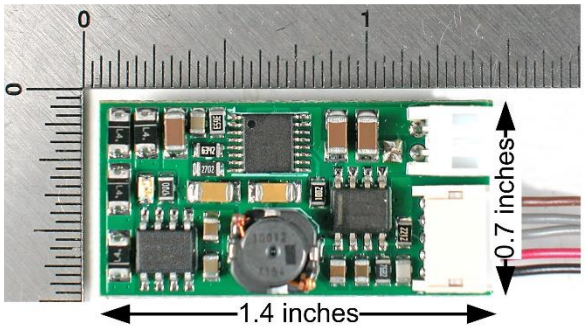
S-CAB 11 volt, 1 amp battery power supply

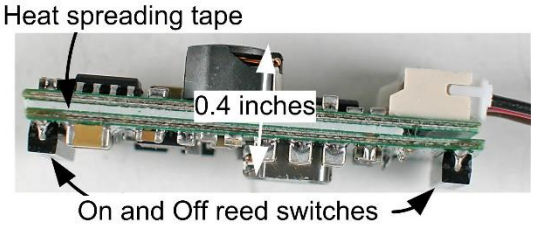




This fourth generation BPS battery power supply is intended for applications requiring up to 1 amp from a small package. Conceptually, there is no change from previous designs. Energy is provided by one or more lithium polymer (LiPo) cells connected in parallel and higher voltage output is produced electronically using a step-up converter. Battery charging, protection and switching are included within the design.

Dimensions





Connections

Battery: 2-pin JST connector for BPS-compatible battery.

- Red is battery positive.
- Black is negative. Connects to BPS ground.

Output:

- Red is output positive. 11.1 volts +/-0.1 volts
- Black is output negative. Connects to BPS ground

Input: Gray wires, any polarity.

Shutdown: Brown wire; turns off step-up converter.

Ratings

- Maximum continuous output: 1 amp.
- Maximum 1-minute output: 1.2 amps.
- Thermal shutdown: depends on battery voltage. Approx. 1.5 amps
- High input voltage shutdown: 20 volts
- Low input voltage shutdown: 6.4 volts
- Battery low voltage shutdown: 3 volts.
- High input current limit: 1.2 amps.
- Charging current: 200 mA when BPS input is 12 volts
- Battery charge rate: 450 mA
- Maximum battery voltage: 4.2 volts

Heat Dissipation

When heavily loaded, the BPS circuit board becomes quite hot and heat dissipation becomes the practical limit to higher output. The board is designed for assembly with a heat-sink, but standard package uses thermal transfer tape to distribute heat to the overall surface area of back-to-back circuit boards.

- At a continuous load of 1 amp, BPS can be held or touched without discomfort. Heat dissipation increases as battery voltage drops.
- With continuous overload of 1.2 amps, BPS becomes too hot to hold. Somewhere in the range of 70 to 80 degrees C.

Input Power Source

In order prevent reverse flow and support alternative power sources, input connects to a bridge rectifier. Rectifier diodes are rated 2 amps.

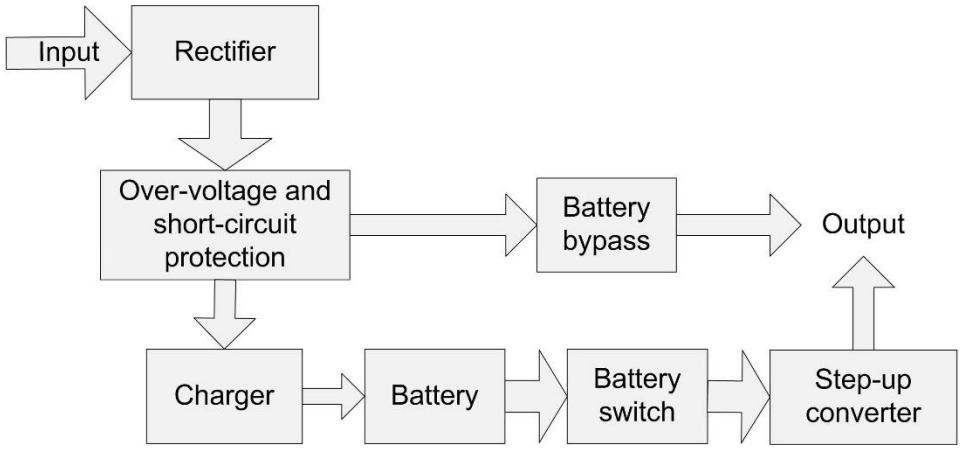
Acceptable input sources:

- Well-filtered DC. Recommended not to exceed 16 volts
- DCC from quality equipment. Recommended not to exceed 16 volts
- AC: Sinusoidal supply. Recommended not to exceed 12 volts RMS

Not recommended:

Avoid hobby type DC power packs/controllers, especially products described with phrases such as "pulse output" and similar. One extreme example is antique controllers that use high voltage spikes to break through track dirt. These are guaranteed decoder busters.

BPS-v4 Block Diagram



Battery Bypass

Power can flow from input to output though battery bypass. It can also flow from battery via battery switch to step-up converter.

The path that delivers higher output voltage supplies most (or all) output power.

- No input: battery provides all output.
- No battery: input must supply all output.

Since the step-up converter produces 11 volts, output is supplied by the battery when bypass voltage drops below this value.

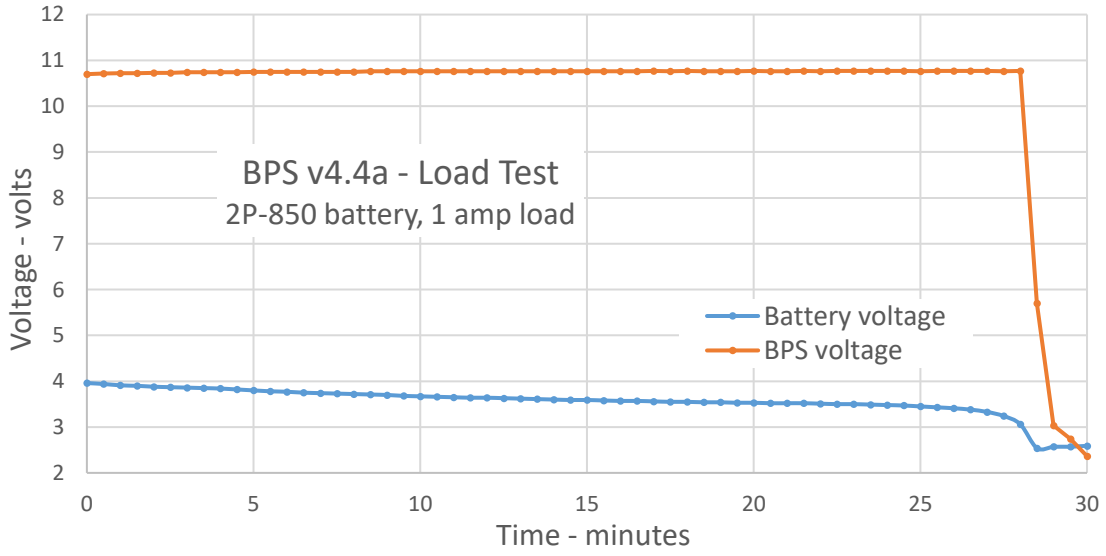
If track voltage is high enough (12 or more volts), bypass voltage exceeds 11 volts and track power supplies output while simultaneously charging the battery. Battery energy is consumed only when needed to substitute for track power.

Battery load

If we assume BPS voltage conversion is perfectly efficient, power provided by battery must equal power delivered by BPS. (Power = volt x amps). The heaviest battery current occurs at lowest battery voltage. Assume 3 volts for battery and BPS output of 1 amp at 11 volts. Since power in equals power out, battery must provide 11 watts to balance power output, which requires a battery current of 3.67 amps (11/3 = 3.67 amps). Allowing for losses and rounding for convenience, we use 4 to 1 as the ratio between battery and output current. That is, 1 amp out requires 4 amps from battery. For short overload periods, BPS can output 1.5 amps, corresponding to battery current of 6 amps.

Performance data

The following chart graphs BPS v4.4 performance with a 2-cell 850 mAh (1.7 Ah) battery and 1 amp resistive load. Full output was sustained for 28 minutes until BPS dropped load at 3.06 battery voltage. At full charge and no load, battery measured 4.2 volts. This dropped immediately to 3.96 volts with 1 amp load, then steadily declined during discharge. BPS output voltage is constant at 10.75 (+/- 0.03) volts over the full operating range of battery voltage.



Battery voltage was 2.54 volts when BPS dropped output voltage. With resistive load, current continued to flow at a much lower level and graph shows a slight transient recovery of battery voltage. BPS ultimately shut down at approximately 2.5 volts.

Since a motor would likely stall or a decoder turn off at 2.5 volts, loco operation will stop immediately without lingering drain on the battery. Attempts to restart will not be successful and should be avoided.

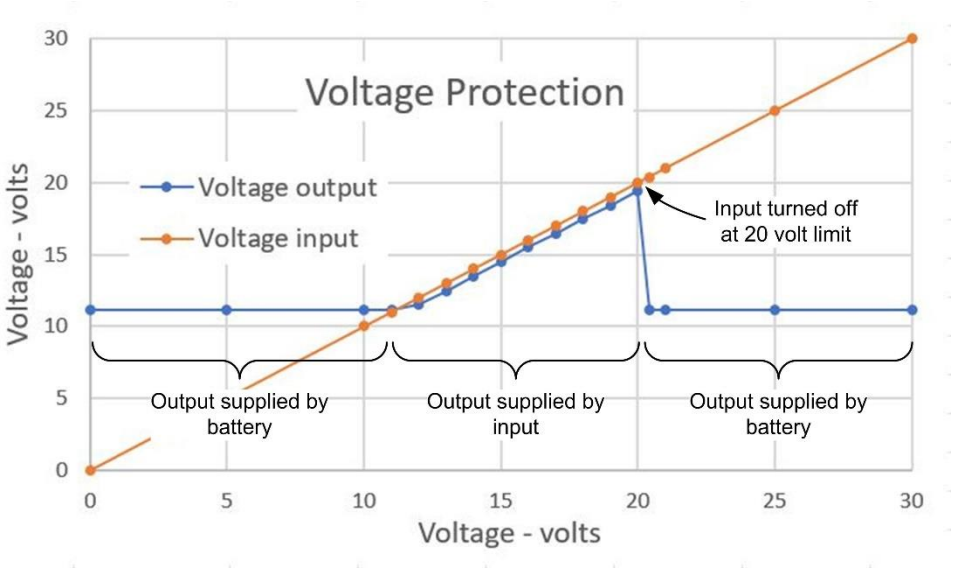
Protection

Protection and thermal behavior are the most complicated aspects of version 4 design. Since, from experience with version 3, we know the risks of unregulated hobby-style power supplies, v4 includes input voltage protection.

Voltage protection: Since most legacy DC power packs do not output DC, a "DC" voltage measurement or manufacturer's specification provides no indication of peak voltage relative to DC value. Peak voltage is often twice or even 3 times "DC" value.

To protect electronic equipment, BPS v4.4 includes voltage limiting as illustrated in the following diagram. Rectified input, which flows through a diode to BPS output, behaves as shown by the blue graph while input (orange graph) varies from zero to 30 volts.

When input is less than 12 volts, battery supplies output. Between 12 and 20 volts, input supplies BPS output and follows magnitude of input voltage minus diode voltage drop. The protective circuit turns off input at 20 volts and battery resumes output supply. Since input is restored when voltage drops below 18 volts, protection is fast enough to block voltage spikes without noticeable effect on average voltage.



Most decoders can handle input voltage up to 20 volts, but best performance requires track voltage between 11 and 13 volts. Otherwise, there will be noticeable speed variations as BPS output switches between battery and track power.

Overload protection: There are two current paths through the BPS and both have overload and short-circuit protection.

- Input current can flow to output through battery bypass.
- Battery energy can flow to output through voltage step-up.

Input: To prevent over-heating input rectifier diodes, input current turns off at 1.2 amps. This shuts down battery charging and battery bypass. It does not turn off battery power. Input short-circuit shut-down is instantaneous with periodic retry.

Step-up Converter: The step-up converter includes both current limiting and thermal protection.

The following figure illustrates BPS performance in normal and overloaded conditions. Loading of the step-up converter increases as battery voltage drops. Each test began with the same fully charged 1.7 Ah battery and continued until load was dropped due to either thermal or current limits. Testing was performed on workbench (not in a model) at ambient temperature using a BPS without heat sink.

- 1 amp is the recommended maximum continuous load for BPS v4.4 and can be maintained with moderate temperature rise from battery full charge (4.2V) to discharge level (3V). No heat sink is required.
- 1.2 amp is safe, but not recommended, for continuous operation without a heat sink due to high operating temperature. Since heat accumulates slowly, there is no problem with temporary 1.2 amp loading. This level will not be sustained as battery approaches discharge voltage.
- Absolute Maximum: 1.5 amps was a stress test, which caused thermal shutdown (150°C) in 5 minutes with no damage to the BPS.