

Build UPS

Low-Temperature 12V DC UPS for Cable Modem

A native, low-loss 12V DC Uninterruptible Power Supply (UPS) system designed for unconditioned, ventilated enclosures subject to freeze-thaw cycles (down to sub-freezing winter temperatures) and elevated summer heat.

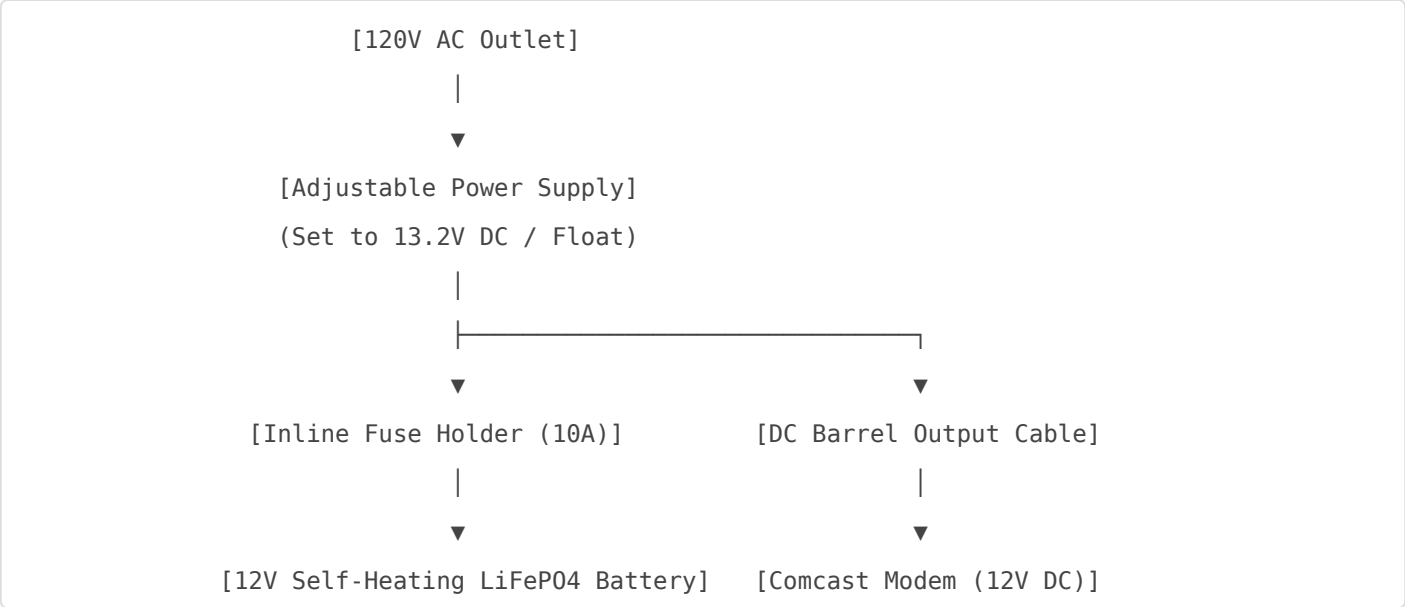
Design Strategy: Unlike standard AC UPS units—which convert AC wall power to DC for the battery, then invert back to AC, only for the modem's power adapter to step it down to 12V DC again—this design operates on **native 12V DC power**, eliminating inverter idle draw and conversion losses.

1. System Overview & Strategy

Key Advantages:

- **Zero Conversion Loss:** Eliminates inverter idle draw, extending backup runtime by 3x–4x compared to AC UPS equivalents.
- **0ms Switchover:** Zero-delay battery takeover prevents modem reboots during brownouts or transient drops.
- **Freeze Protection:** Utilizes a self-heating LiFePO_4 battery whose internal BMS diverts incoming charge current to internal heating pads when temperatures fall below 0°C (32°F).
- **Extended Calendar Life via Voltage Tuning:** Instead of keeping the battery floating at 100% State of Charge (SOC) at 14.4V (which accelerates calendar aging in warm weather), the charging supply voltage is tuned to **13.2V** , holding the battery at a comfortable **50%–60% SOC** during normal operation while retaining ample backup capacity.

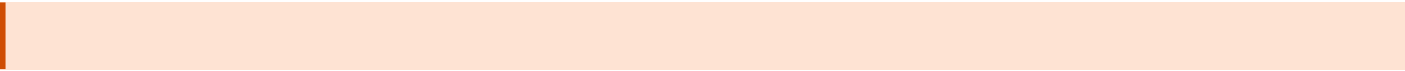
2. Wiring Schematic



3. Recommended Parts List

Component	Function	Notes / Links
Heated 12V LiFePO_4 Battery	Energy storage with sub-zero freeze protection	TimeUSB 12V 12Ah Self-Heating or Dakota Lithium 12V 10Ah Heated
Adjustable 12V Power Supply	Powers load & floats battery at tuned voltage	Mean Well NDR-75-12 or Mean Well DRC-100A
Fuse & Holder	Protection on battery positive terminal	10A Blade Fuse + Waterproof Inline Holder
DC Cable Harness	Connects supply/battery to modem power jack	18AWG 5.5mm × 2.1mm / 2.5mm DC Barrel Cable

4. Voltage Tuning & SOC Management



Voltage Tuning Note: Standard drop-in LiFePO_4 BMS units do not support software-defined SOC limits. The output voltage must be calibrated using the power supply's potentiometer before connecting the battery.

Calibration Steps:

1. Connect a multimeter across the power supply output terminals before attaching the battery.
2. Turn the supply's voltage adjustment potentiometer (`SVR1`) until the output reads 13.2V .
3. At 13.2V , the LiFePO_4 chemistry naturally rests between **50% and 60% SOC**. Current flow stops automatically once battery potential equals charger voltage.

Voltage & SOC Operating Profiles:

Voltage Setting	Target State of Charge (SOC)	Operating Profile
14.4V - 14.6V	100%	Full capacity; accelerated calendar aging in high ambient heat
13.4V - 13.6V	80% - 90%	High backup capacity; low stress
13.2V	50% - 60%	Optimal longevity for standby float service (Recommended)

5. Assembly & Installation Instructions

Step 1: Pre-charge & Voltage Matching

1. Fully charge the battery indoors using a standard 12V LiFePO_4 charger.
2. Discharge the battery down to $\sim 13.2\text{V}$ using a test load or let it sit idle until settled.

Step 2: Wiring Assembly

1. Connect the inline fuse holder directly to the positive (+) battery terminal. **Do not insert the 10A fuse yet.**
2. Join the positive output lead of the power supply and the positive conductor of the DC barrel cable to the fused line.
3. Connect the negative (-) output lead of the power supply, the negative conductor of the DC cable, and the battery negative terminal together.

Step 3: Voltage Verification

1. Plug the power supply into wall AC.
2. Verify the DC output voltage is set to **13.2V**.
3. Insert the 10A fuse into the inline holder.

Step 4: Final Connection

1. Plug the 5.5mm DC barrel connector into the 12V input on the Comcast modem.
2. Confirm modem powers on normally. Test grid failure by disconnecting the AC plug; the modem should remain online without rebooting.

6. Cold Weather & Emergency Behavior

Sub-Zero Recovery ($<0^{\circ}\text{C}$ / 32°F): If grid power returns while the enclosure is frozen below 0°C , the internal battery BMS automatically diverts incoming charge power to internal heating elements until cells reach safe charging temperature.

- **Normal Operation:** Wall power supplies 13.2V directly to the modem and keeps the battery sitting at 50%–60% SOC.
- **Grid Outage:** The battery instantly supplies full 12V power to the modem with zero delay.
- **Thermal Protection:** Internal BMS prevents cold-temperature lithium plating during sub-freezing conditions.

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