**Universal Power Bank**

**System Overview**



**Design notes:**

* The battery pack is detachable and can be charged Independently, allowing users to swap depleted batteries for fresh ones and get an instant full charge.
* The universal charging station provides a one-stop solution for all charging needs.
* Apple Add-On is focused on apple users catering to their specific requirements.

**Detailed System Architecture**

**Battery Pack**

****

**Batteries**

20,4000 mAh battery pack with 6x 3,400mAh Li-ion NCR18650B cells in **3S2P** configuration.

**BMS**

* The battery management system is capable of monitoring battery current and voltages in real-time for fault protection.
* Primary and Secondary level protection systems to cut of batteries during a fault.
* Record and log Battery SOC through gas gauging and make available the same information to control subsystem through I2C/SMBUS Comm interfaces.
* Cell voltage balancing during charging and discharging to increase battery longevity.

**Prospective BMS ICs**

* **BQ4050 -** [**http://www.ti.com/product/bq4050**](http://www.ti.com/product/bq4050)
  + BMS IC with fuel gauge and cell balancing.
  + USD 1.1
* **BQ2947 -** [**http://www.ti.com/product/BQ2947**](http://www.ti.com/product/BQ2947)
  + Secondary level protection IC paired with BMS for added protection.
  + USB 0.26

**Charging Controller**

* **CC-CV Charging -** controller for charging the Li-ion battery pack at optimum current and voltage levels.
* **Pass through charging -** Control flow of input power between system and battery charging. With priority to system loads (Devices connected to the charging station to be charged.)

**Prospective Charging Controller ICs**

* **BQ24773 -** [**http://www.ti.com/product/BQ24773/description**](http://www.ti.com/product/BQ24773/description)
  + Dynamic Power Management. I2C controlled input current setting. This can be used to prioritize attached device charging before charging batteries. If max input current from source is known, input current setting can be altered to prioritize system power.
  + USD 1.71
* **BQ24133 -** [**http://www.ti.com/product/bq24133**](http://www.ti.com/product/bq24133)

**Alternative Charging Controller ICs**

* **LTC4162-L -** [**https://www.analog.com/en/products/ltc4162-l.html#product-overview**](https://www.analog.com/en/products/ltc4162-l.html#product-overview)

**Universal Charging Station**

****

**System power supply Input**

* Supply from the Battery pack to the universal charging station.
* **The 3S2P** pack can supply **12.6V** - **10.8V** with peak current rating of **12.8 Amps**
* Input power available - **160W** - **138W**

**22V - 24V Boost Converter**

* Battery voltage boosted to 22V - 24V System bus rail for supplying power to charging subsystems.

**Prospective Boost ICs**

* **TPS43061 -** [**http://www.ti.com/product/TPS43061**](http://www.ti.com/product/TPS43061)
  + Boost controller IC with 95%- 90% efficiency.
  + MOSFET currents are as high as **14Amps.** High currents lead to increased MOSFET losses, need better power dissipation and need larger power planes and power lines to handle very high current.

**Alternate IC**

* **LM5122 -** [**http://www.ti.com/lit/ds/symlink/lm5122.pdf**](http://www.ti.com/lit/ds/symlink/lm5122.pdf)
  + Boost controller IC with 95%- 90% efficiency.
  + MOSFET currents are as high as **14Amps.** High currents lead to increased MOSFET losses, need better power dissipation and need larger power planes and power lines to handle very high current.

**Output Charging Sub - Systems**

* **1x 10W Qi-compatible wireless charging**
  + 10W Qi-compatible wireless charging that supports apple 7.5W and Qi 10W devices.
  + 5V and 9V inputs
  + Needs Buck system to step down battery voltage to 9v or 5v
  + **Prospective ICs**
    - **Modules sourced Directly**
* **2x USB A 24W Smartphone Fast charging ports**
  + Multiprotocol fast charging port ( QC 3.0, QC 2.0, MT PE 1, 2, AFC, SCP, FCP, SFCP, BC 1.2, Apple)
  + **Prospective ICs**
    - **IP6505 -** [**https://lcsc.com/product-detail/Others\_INJOINIC-IP6505\_C188335.html**](https://lcsc.com/product-detail/Others_INJOINIC-IP6505_C188335.html)
* **1x USB Type-C PD 45W Smartphone Fast Charging port**
  + Supports USB PD 3.0 Protocol for fast charging PD compatible smartphones and low power PCs.
  + Multiprotocol fast charging port ( QC 3.0, QC 2.0, MT PE 1, 2, AFC, SCP, FCP, SFCP, BC 1.2, Apple)
  + **Prospective ICs**
    - **IP6518 -** [**https://lcsc.com/product-detail/PMIC-Battery-Management\_IP6518\_C181688.html**](https://lcsc.com/product-detail/PMIC-Battery-Management_IP6518_C181688.html)
* **1x USB Type-C 100W Laptop Charging port**
  + 100W USB PD Charging port to power any USB PD compatible devices.
  + **Prospective ICs**
    - **STUSB4700 -** [**https://www.st.com/content/st\_com/en/products/interfaces-and-transceivers/usb/usb-type-c-and-power-delivery/stusb4700.html#samplebuy-scroll**](https://www.st.com/content/st_com/en/products/interfaces-and-transceivers/usb/usb-type-c-and-power-delivery/stusb4700.html#samplebuy-scroll)
    - **TPS25740 -** [**http://www.ti.com/product/TPS25740A**](http://www.ti.com/product/TPS25740A)
      * **End of Life component**
    - **TPS65987D -** [**http://www.ti.com/product/TPS65987D/description**](http://www.ti.com/product/TPS65987D/description)
      * Expensive at 2$ even though it has integrated FETs
      * Can be used for both In/Out
    - **Other option available at 0.3$ cheaper cost but require Micro controller support.**
* **1x 120W Pure Sine wave AC (110V US or 230V European)**
  + A universal AC port with a Pure Sine wave inverter output can power any AC equipment under 120W power rating.
  + With pure sine wave output, additional noise generating higher harmonics are not generated. This makes it compatible with noise sensitive equipment.
  + **Prospective ICs**
    - **TMS320F280270 -** [**http://www.ti.com/product/TMS320F280270**](http://www.ti.com/product/TMS320F280270)
      * Microcontroller designed for time-critical operations. Has sufficient processing capacity to handle control operations for the complete powerbank including display and buttons.
    - **SM72295 -** [**http://www.ti.com/product/SM72295/description**](http://www.ti.com/product/SM72295/description)

**Battery Charging Input Sub - Systems**

* **15V - 30V DC/Solar Panel Input port**
  + DC input for charging battery inputs with compatible DC power adaptor
  + DC input for Solar panel charging with compatible Solar power panel (15V-30V) for outdoor charging. Equipped with MPPT for Solar provides the Maximum Input power from Solar Panel.
  + **Prospective Port Connectors**
    - **IP6**
* **1x USB Type-C PD 100W Input**
  + 100W USB PD input for charging the batteries and powering the charging station.
  + **Prospective ICs**
    - **STUSB4500 -** [**https://www.st.com/content/st\_com/en/products/interfaces-and-transceivers/usb/usb-type-c-and-power-delivery/stusb4500.html**](https://www.st.com/content/st_com/en/products/interfaces-and-transceivers/usb/usb-type-c-and-power-delivery/stusb4500.html)
* **Supply OR-ing**
  + OR-ing systems or Ideal diode systems to ensure safe supply port selection.
  + **Prospective ICs**
    - **LM5050-1 -** [**http://www.ti.com/product/LM5050-1**](http://www.ti.com/product/LM5050-1)
      * Supply load sharing might be possible with the alternate architecture of Stepping down both supplies to similar voltage first and then OR-ing the supplies. (Unlikely scenario where solar and type c PD input present)
    - **LTC4370F -** [**https://www.analog.com/media/en/technical-documentation/data-sheets/4370f.pdf**](https://www.analog.com/media/en/technical-documentation/data-sheets/4370f.pdf)
      * Supply load sharing supported taking advantage of two input sources
* **15V Buck Converter with MPPT**
  + 100W USB PD input for charging the batteries and powering the charging station.
  + **Prospective ICs**
    - **STUSB4500 -** [**https://www.st.com/content/st\_com/en/products/interfaces-and-transceivers/usb/usb-type-c-and-power-delivery/stusb4500.html**](https://www.st.com/content/st_com/en/products/interfaces-and-transceivers/usb/usb-type-c-and-power-delivery/stusb4500.html)

**Control System**

* **OLED Display with Push button controls**
  + Real-time capacity, charging, power and fault information
  + Push buttons to configure charging settings and turn on/off high power output systems.
    - Configure backup/emergency battery capacity limit
    - Configure battery utilization scheme to prolong battery life (0% - 100% - 500 cycles, 5% - 95% - 1000 cycles, 10% - 90% - 2000 cycles)
    - Turn on/off AC
    - Turn on/off low power charging for earphones etc
    - System reset
* **Microcontroller for logic and control**
  + Monitoring current and voltage during charging and discharging operations.
  + Implement control logic for implementing power bank features.
  + Control Display and take user input through push buttons
  + Communicate with BMS for charge and fault information
  + Control BMS charging controller for input load balancing or system load prioritizing.
  + **Prospective ICs**
    - **TMS320F280270 -** [**http://www.ti.com/product/TMS320F280270**](http://www.ti.com/product/TMS320F280270)
      * Microcontroller designed for time critical operations. Has sufficient processing capacity to handle control operations for the complete powerbank including display and buttons.

**Apple Hub**

****

**7 in 1 Hub**

* **1x USB Type-C port with 100W USB PD pass-through charging.**
* **1x HDMI Port 4K@30Hz**
* **2x USB A 3.1 ports**
* **1x SD Card**
* **1x Micro SD Card**

**Apple watch Wireless charging**

* 5W Apple watch wireless charger integrated

**Airpods Charging Dock**

* Charge Airpods through Docking slot and built in Lightning connector. Compatible with Apple 10W-12W fast charging protocols.

**PCB Architecture**

**BMS**

* **BMS PCB**
  + BMS **1**
  + Second level Protection and Fuses (Pushed to phase 2)
  + 2 days

**Charging Station**

* **Battery Connector PCB** 
  + Battery Connectors **1**
  + Battery Power Bus **1**
  + 28v boost converter **1**
  + 9V buck converter **1**
  + Battery supply BUS IV monitoring **1 (Use BMS and get values through SMBus)**
  + 2 days
* **OLED Display**
* **Button PCB**
* **Bottom ports PCB** 
  + 100W USB C Input controller - 20v 5A **1**
  + 15V-30V 100W DC Input/ Solar MPPT **1**
  + Supply OR-ing **1**
  + 15V Buck with MPPT (MPPT can be implemented in software later) **2**
  + QC 3.0 USB A **1**
  + 45W PD **1**
  + 2 days
* **Top Ports PCB**
  + QC 3.0 USB A **1**
  + 100W USB PD output **1**
  + Microcontroller and display power buck system **1**
  + Microcontroller **1**
  + 120W Pure Sine AC **2(can do modified sine wave for first proto)**
  + Charging controller **1**
  + Buttons **1**
  + 3 days
* **Wireless Power PCB**
  + TBD
* **Wireless Module**
* **Hub Power Connector**
  + Female Pogo Pin Contacts **1**
  + 2 hrs

**HUB**

* **7 in 1 Hub**
* **Ports shift PCB**
  + Ports Shifting **1**
  + USB PD Controller **1**
  + 5v buck converter 3 Amps
  + 5W-12W USB A controller for Airpods and watch Chargers **1**
  + 1 day

**Firmware Development**

* 5 days



|  |  |  |
| --- | --- | --- |
|  |  |  |
|  |  |  |
|  |  |  |