PLUGABLE USB-C MULTIPORT CHARGER

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Problem Statement

Current USB-C multiport chargers work as a current distributor with a microcontroller, where the charging rate decreases as more devices are connected. The project's goal is to provide an alternative to existing products with a more compact, fully analog design charging up to 5 devices with fast charging capabilities.

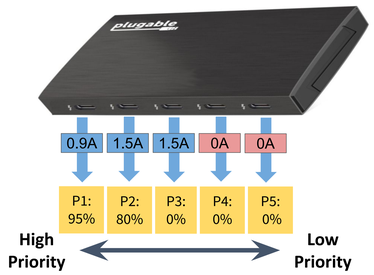
System Requirements

- Use standard 5V 4A power supply to charge all 5 devices overnight
- Follow the standard USB-C power delivery protocol [1]
- Implement Plugable's patented *"Priority Charging" algorithm*
- Design with fully analog components (no microcontrollers)

"Priority Charging" Algorithm

Device Battery Level	Advertised Charging Rate
0 - 80 %	3.0 A
80 - 90 %	1.5 A
90 - 100 %	0.9 A
100 %	0 A

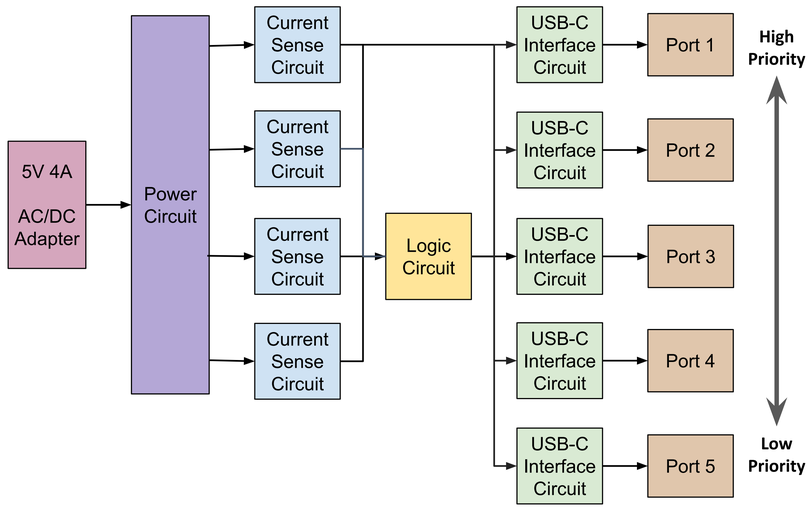
[Table 1] Different charging rates



[Fig 1] Sample Multiport Charger

- Charges each port up to 15W 3A [2] starting at the highest priority port
- Power dynamically shifts to the lower priority ports as each device completes charging in succession

Implementation



[Fig 2] High-level block diagram

- **AC/DC Adapter:** Provides constant 5V 4A to the system
- **Power circuit:** Generates -5V DC power for other components
- **Current Sense Circuit:** Measures the current drawn from the device in voltage readings
- **Logic Circuit:** Controls the priority charging function that triggers the USB-C interface circuit
- **USB-C Interface Circuit:** Chooses the resistance value (Rp) for the USB-C CC line to limit the charging rate of the connected device

Test Results

V_Rd	Advertised Charging Rate
0 - 0.15 V	0 A
0.25 - 0.61 V	0.9 A
0.7 - 1.16 V	1.5 A
1.31 V or above	3.0 A

[Table 2] V_Rd range that corresponds to different max (advertised) charging rate [2]

- The voltage drop across resistor Rd (V_Rd) determines the device charging rate
- For testing, a 3 port USB-C circuit was built on the breadboard before expanding it to 5 ports for the PCB design
- Devices may draw less current than the advertised current

Port #	Device Battery Level	V_Rd	Advertised Charging Rate
Port 1	0 %	1.67 V	3.0 A*
Port 2	0 %	1.67 V	3.0 A*
Port 3	0 %	0.42 V	0.9 A*

[Table 3] Test result of a 3 port USB-C charger. The test result shows the charging rate of 3 different devices with a battery level of 0%.

[*] The advertised charging rate is different from the actual charging rate, which depends on how much current the device wants to draw.

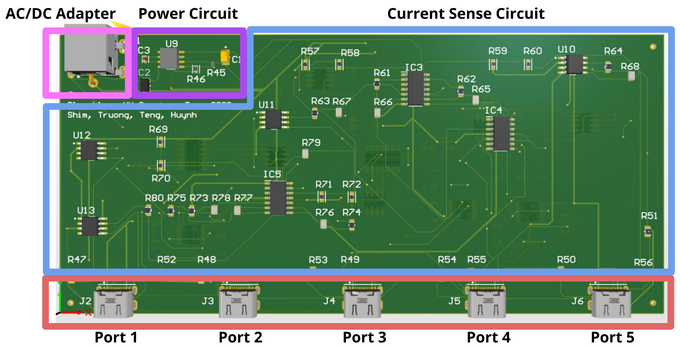
Conclusion

The team successfully designed a fully analog USB-C multiport charger that outputs the desired Rp resistor values according to the Plugable's patented "Priority Charging" algorithm, which charges up to 5 devices using a standard 5V 4A power supply.

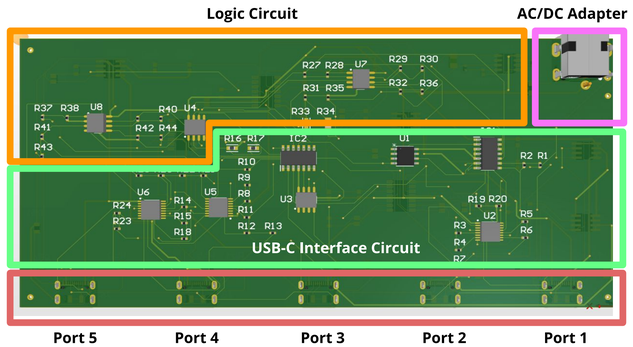
Future Work

- Optimize circuit components to follow the patented algorithm more efficiently
- Further research to validate the Power Delivery protocol on USB-C connectors
- Integration of AC-DC adapter into the circuit
- Circuit protection and heat sink

Final Product Design



[Fig 3] Top View of the PCB. The design includes the power circuit, the current sense circuit, and the USB-C circuit.



[Fig 4] Bottom View of the PCB. The design includes the logic circuit and the USB-C circuit.

References and Acknowledgments

[1] "USB-C – A new version of the well-known wired communication interface," Masters Creative Technology, 12-May-2021. [Online]. Available: https://masters.com.pl/en/usb-c-a-new-version-of-the-well-known-wired-communication-interface/. [Accessed: 14-Mar-2022].

[2] "Technical article – TA0357 – overview of USB Type-C," STMicroelectronics. [Online]. Available: https://www.st.com/resource/en/technical_article/dm00496853-overview-of-usb-typec-and-power-delivery-technologies-stmicroelectronics.pdf. [Accessed: 14-Mar-2022].

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