

# Fan-Out Circuit Board Design for Reduced Voltage

## Soft Starter Eaton Corporation



### PROBLEM STATEMENT

Eaton's current medium-voltage AC Soft Starter systems requires one or more power electronics assemblies and rely on multiple 1:2 fiber-optic fan-out boards to distribute light pulse signals across these power electronic assemblies. This multi-board configuration increases production costs, assembly time, and system complexity especially in higher-current applications such as the 800A, 7.2KV RVSS system which requires four power electronics assemblies.

To address this, Eaton proposed a consolidated, single-board solution that maintains signal integrity and performance while reducing cost and complexity. This capstone project aims to design and implement such a solution using Altium Designer, Eaton's and industry preferred PCB design software.

### OBJECTIVES

- Fan-Out Requirement: Convert each fiber-optic input into multiple outputs (1:4) to drive parallel/series power electronics assemblies.
- Power Supply Upgrade: Replace the onboard switched-mode power supply to accept a 48V DC input—matching the soft starter's available voltage—and step it down to 5V.
- DC Improved Diagnostics: Incorporate additional LEDs for power and signal monitoring.

### REQUIREMENTS

#	Description
1	The switched mode power supply needs to accept a 48VDC input voltage
2	Add LED diagnostics for PS rail, each input
3	Use existing 1:2 fiber-optic fan-out board to develop new fan-out of 2:8 per phase using Altium Designer
4	Create new part number for the new PCB
5	Integrate with existing control box and PE assemblies
6	The PCB should be a 4-layer board

### CONCEPT

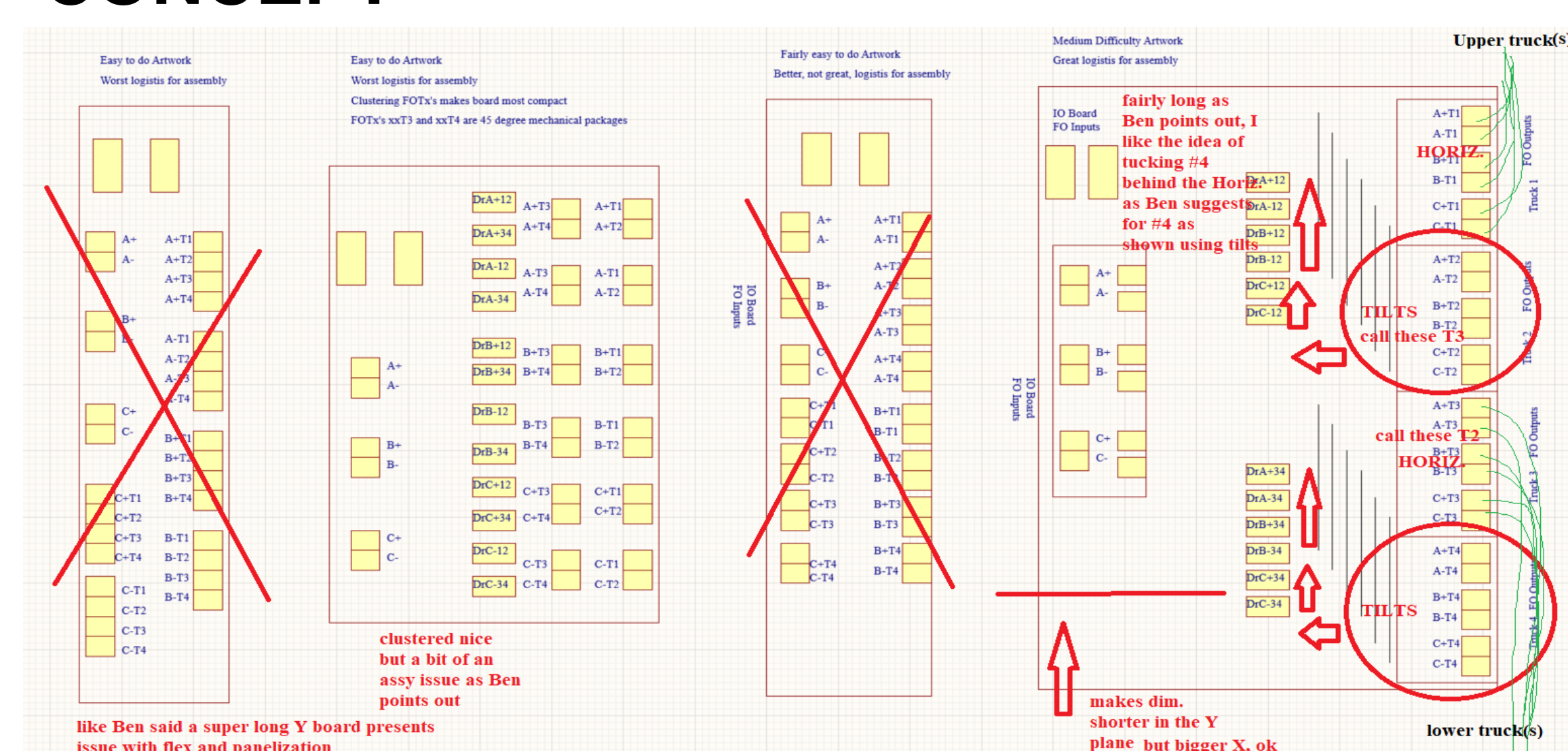


Photo Caption: Artwork concept design drawings

### FINAL DESIGN, APPROACH, PLAN

The team designed a 4-layer circuit board, with top and bottom layers as signal paths and the internal layers allowing for a dedicated ground plane and power plane. This arrangement supports signal integrity for high-speed signals and to reduce EMI susceptibility.

The fiber optic components, buck converter and ICs are mounted on the top layer, with the signal routing on the top and bottom layer to provide more routing space.

Heat was a major concern due to the high-power levels involved. Strategic placement of thermal vias, copper pours, and heatsinks are used to ensure effective heat dissipation. Also, given the high-voltage nature of the system, proper clearance distances were maintained between traces and components.

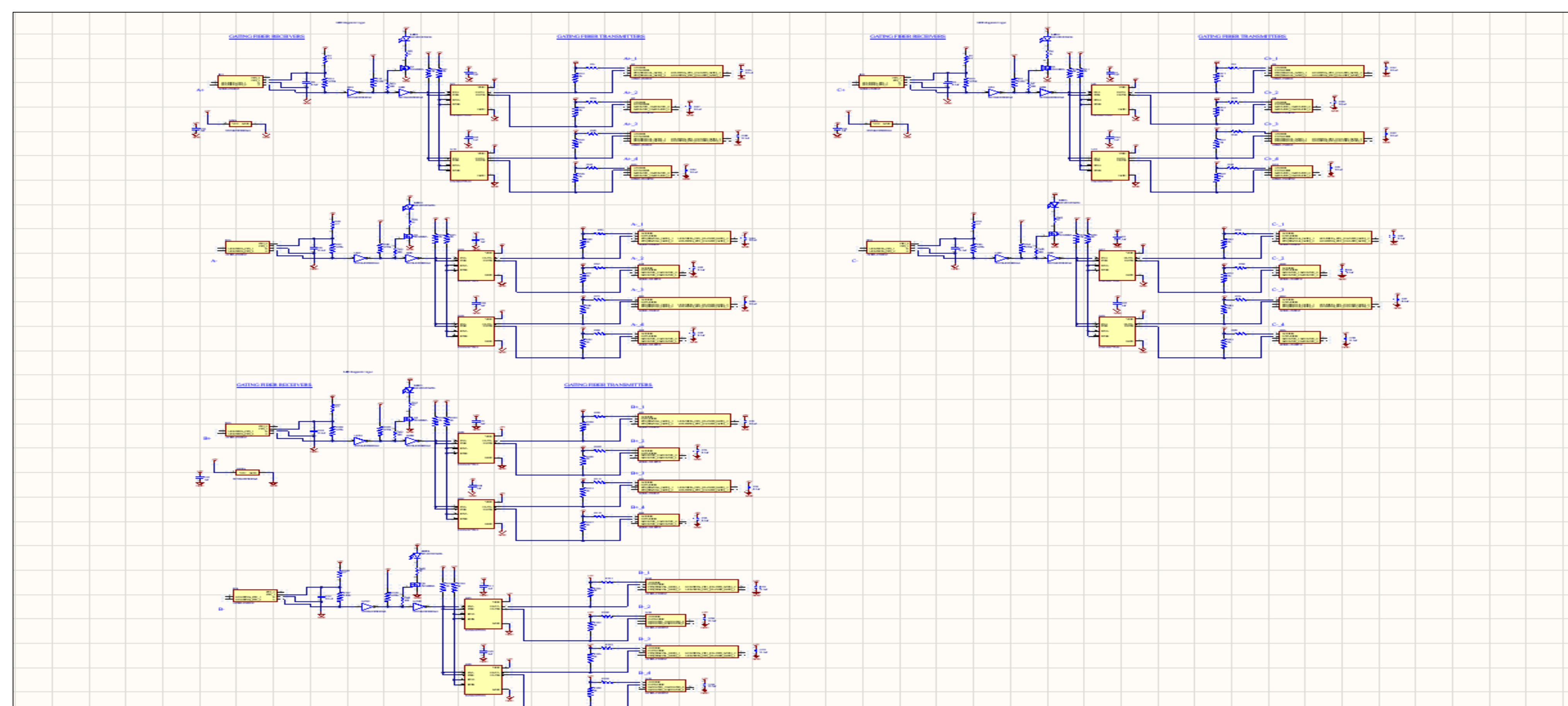


Photo Caption: Complete fiber-optic circuit schematic diagram

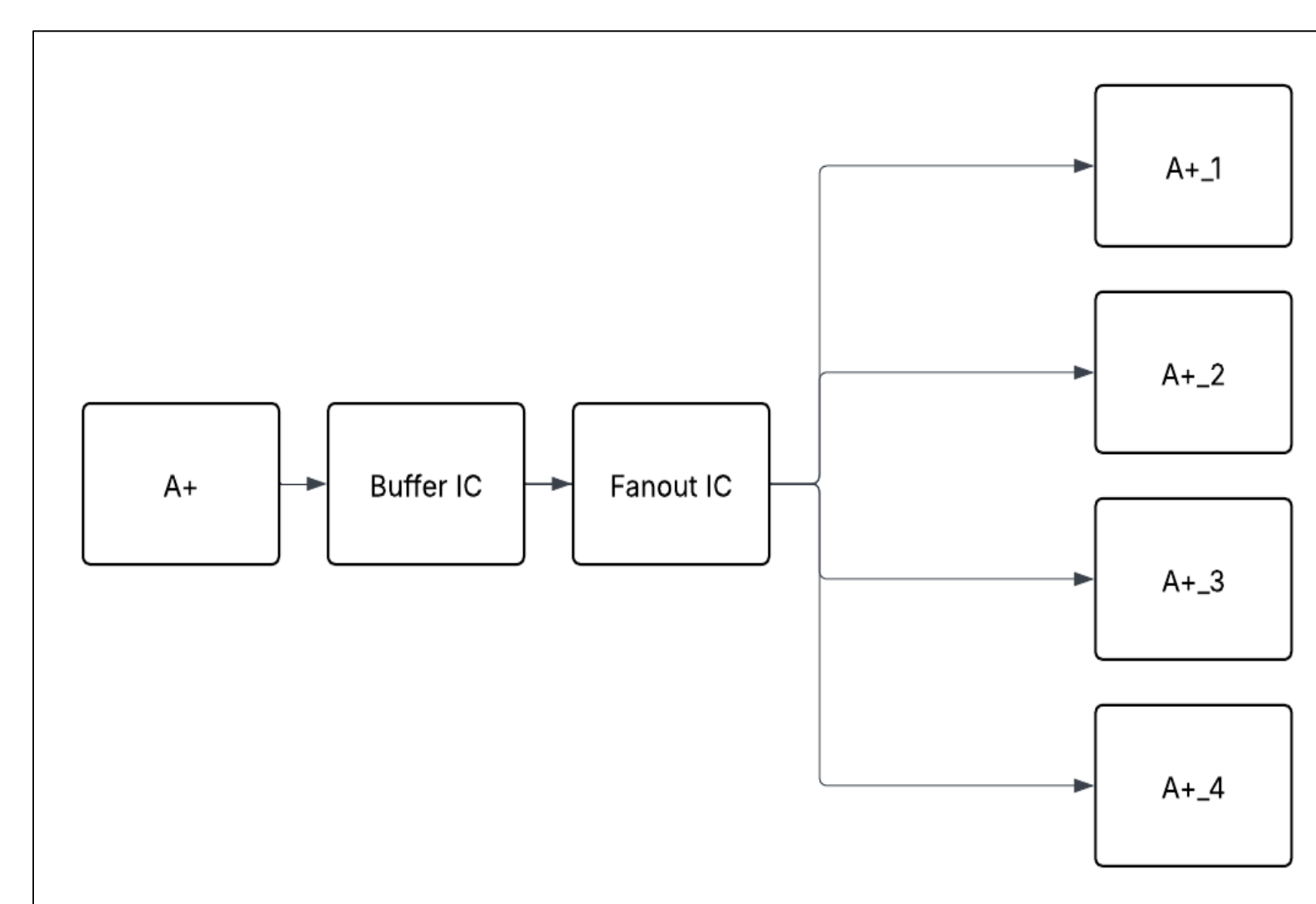


Photo Caption: Fiber-optic data reception, fan-out and transmission block diagram for A+ phase pulse

#	Name	Material	Type	Weight	Thickness	Dk	Df
	Top Overlay		Overlay				
	Top Solder	Solder Resist	Solder Mask		0.4mil	3.5	
1	Signal Layer (Top)		Signal	1oz	1.4mil		
	Dielectric 2	PP-006	Prepreg		8mil	4.1	0.02
2	GND Plane (Layer 2)	CF-004	Plane	1oz	1.4mil		
	Dielectric 1	FR-4	Dielectric		12.6mil	4.8	
3	SV Plane (Layer 3)	CF-004	Plane	1oz	1.4mil		
	Dielectric 3	PP-006	Prepreg		8mil	4.1	0.02
4	Signal Layer (Bottom)		Signal	1oz	1.4mil		
	Bottom Solder	Solder Resist	Solder Mask		0.4mil	3.5	
	Bottom Overlay		Overlay				

Photo Caption: PCB layer stack-up arrangement, copper weights and thicknesses

### RESULTS

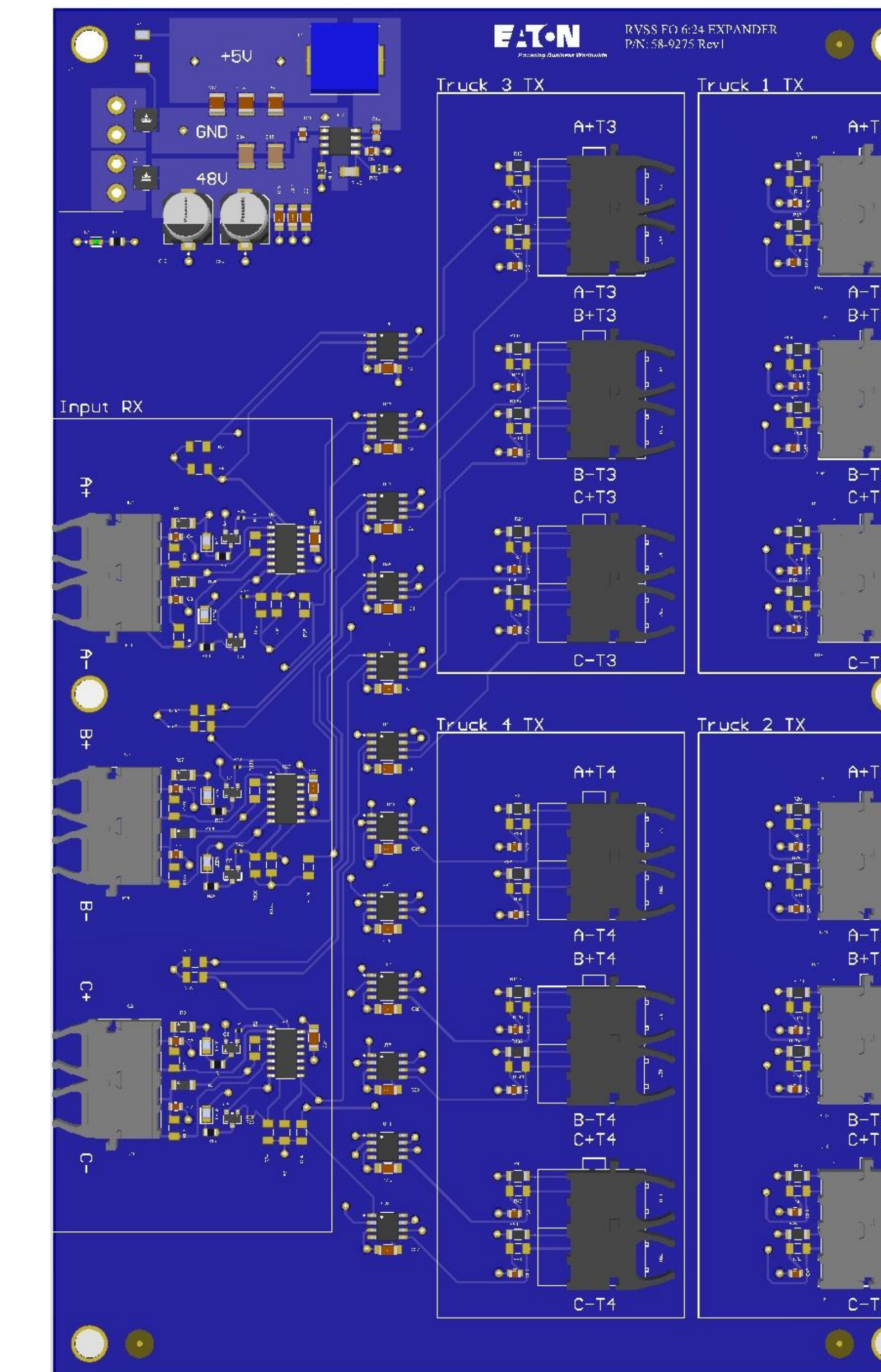


Photo Caption: 3D representation of the final design PCB

### SUMMARY AND CONCLUSIONS

This capstone project focuses on redesigning Eaton's Reduced Voltage Soft Starter (RVSS) printed circuit board (PCB) to improve efficiency, reduce costs, and simplify manufacturing of the overall system. The team was successful in constructing the foundational circuit and component layout that is described in our design plan, and with careful considerations and planning, the team was able to complete all project objectives.

### TEAM & ACKNOWLEDGEMENTS

- Chibuike Okere – ECET
- Fernando Gonzalez – ECET
- Peyton Chester - EE
- Stan Simms – EATON Sponsor Contact
- Ben Wells – EATON Design Engineer
- Dr. Tarek Kandil – Faculty Mentor

### References

[1] Eaton, "Ampgard RVSS Reduced Voltage Starter User Manual," Eaton Technical Documentation, 2025. [Online]. Available: <https://www.eaton.com/content/dam/eaton/products/low-voltage-power-distribution-controls-systems/mcc-aftermarket/ampgard-rvss-reduced-voltage-starter-user-manual-ib020003en.pdf>

[2] "High-Voltage PCB Design," Altium. [Online]. Available: [https://files.resources.altium.com/sites/default/files/uberflip\\_docs/file\\_707.pdf](https://files.resources.altium.com/sites/default/files/uberflip_docs/file_707.pdf)