

# Petawatt Laser EMP Mitigation Strategy for Controls Systems - MarBox: an EMP Mitigation Device

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## Background - MarBox is a mitigation strategy to prevent EMP/EMI from frying PLCs

Existing MEC facility, MEC-U, and other laser facilities around the world have proven that high-intensity laser interaction with target material generates a strong electromagnetic pulse (EMP). This EMP can disrupt electrical system performance, completely damage electronics, and result in the loss of experimental data. This poses as a significant risk to the reliability of facilities that hold petawatt lasers, hence the creation of the Marshall Box (MarBox).

Fig. 1 - Proposed implementation diagram of the MarBox

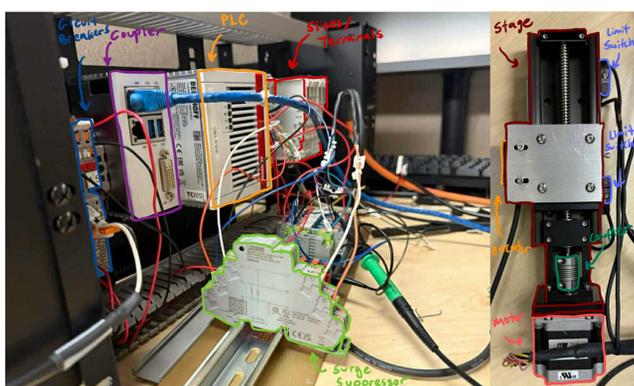
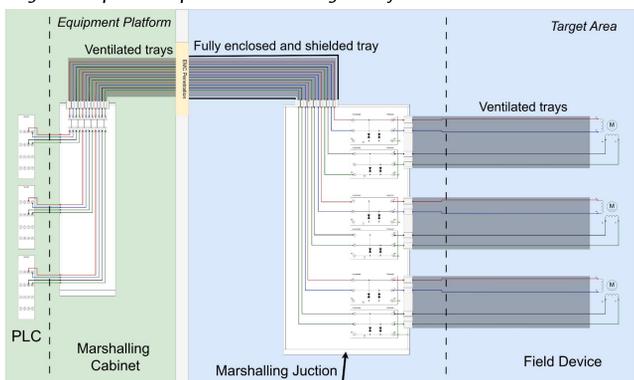


Fig. 2 - Implementation of the interconnect diagram from Figure 3

## Results

Fig. 7 is the waveform of the signal with the surge suppressor connected to the PLC and motor. The red arrow is pointing to the surge suppressor preventing the voltage from going over 36.4V, which triggers the circuit breaker causing the voltage to drop immediately. The overcurrent tripping is a sign that the surge suppressor is delivering excess voltage to the grounding system.

Fig. 8 is the waveform of the signal without the surge suppressor connected. The red arrows are pointing to the voltage spikes at 48.8V, caused by external power that was provided to the motor. Since there is no surge suppressor to protect the motor, there is a pattern of the voltage hitting 48.8V, and then going back down to 0V, which is shown as a PWM Wave (Pulse Width Modulation Wave).

## Project Objective and Design Process

To prepare for future EMP threats from facilities like the upcoming MEC-U system, the objective is to research and identify the necessary parts to create an EMP mitigation device (MarBox). After identifying the parts necessary, the next steps are to test them and design the MarBox.

As seen in Fig. 3, this interconnect diagram is how the basic proof of concept for the MarBox was constructed. Out of all the the parts researched and tested (Surge Suppressors, Opto-isolators, Low-pass filters, Brickwall-Filters), the TTC-6-2XTVSD-24DC-PT Surge Suppressor was chosen. This surge suppressor was chosen since no power is needed for it to reduce the EMP, and it utilizes TVS Diodes, which are extremely effective at protecting circuits from high voltage spikes.

After this surge suppressor was chosen, it was connected to the PLC and Motor, as seen in Fig. 2 AND Fig. 3. The surge suppressor is connected to the A+, A-, B+, and B- signals of the motor.

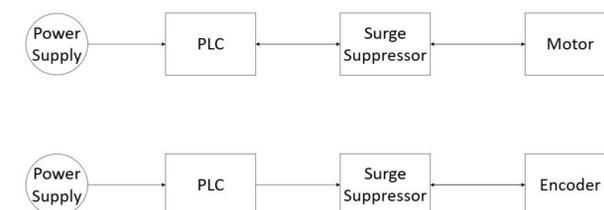


Fig. 3 - Interconnect diagram of MarBox testing



Fig. 7 - Voltage with Surge Suppressor

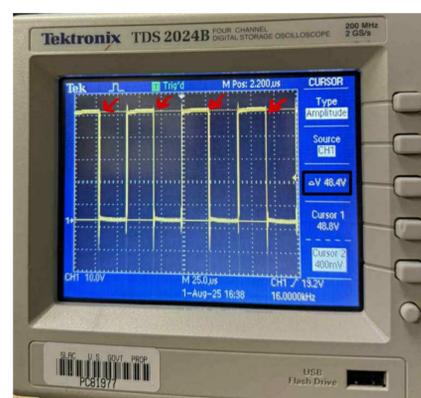


Fig. 8 - Voltage without Surge Suppressor

## Implementation and Testing

At the start of testing, it was imperative to make sure that motor performance was not compromised by the Surge Suppressor. Fig. 4 is the position difference, tested at 3 mm/s, 12 mm/s, and 24 mm/s, of motor motion without the surge suppressor connected.

Fig. 4 - Line Graph of Motor Motion at 3,12, and 24 mm/s without the Surge Suppressor

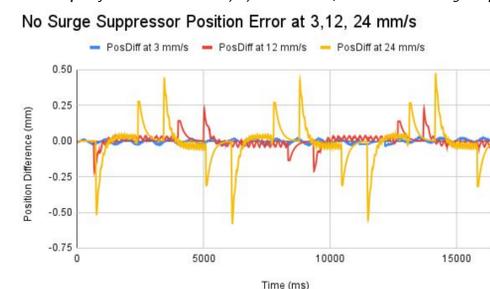
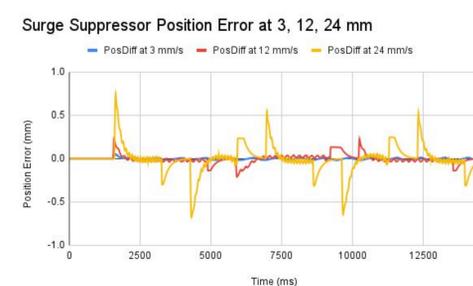
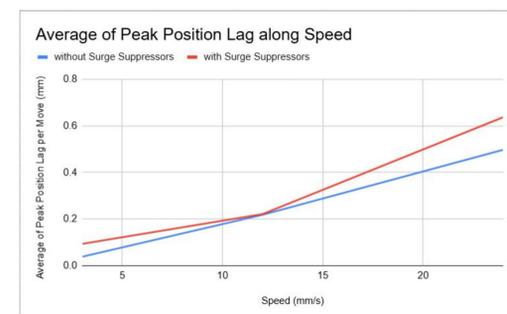


Fig. 5 is the position difference, tested at 3 mm/s, 12 mm/s, and 24 mm/s, of motor performance with the surge suppressor connected.

Fig. 5 - Line Graph of Motor Motion at 3,12, and 24 mm/s with the Surge Suppressor



Finally, Fig. 6 is the Average of Peak Position Lag between Fig. 4 and Fig. 5  
Fig. 6 - Avg Peak Position Lag of Fig. 4 and Fig. 5 compared



## Future Plans

Future plans would include doing more research on upscaling the circuit and test environment to match the size of a facility like MEC-U. Also, researching what part would be an upgrade from the surge suppressors being used. Another future plan would be to test the MarBox with actual EMPs, which would require it to be put in a facility like MEC at SLAC.

## ACKNOWLEDGEMENTS

Thank you to my mentors, Nicholas Lentz and Mitchell Cabral, for guiding me through the engineering process, providing me with learning experiences, and supporting me throughout this project.

## REFERENCES

A. Fry, G. Dyer, M. Martinez, K. LaFortune, A. Conder, "MEC-U EMP Risk Technical Note," MECU-EN-0025-R0, June 7, 2022.