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Structural support considerations for the launching lens

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Abstract

Initial considerations for a feed and mechanical support structure for the final experimental realization, high power and high pressure, of the PSIRA system are outlined.

1 Introduction

In the final, experimental realization of the T4FASC-CSS-SPVSHC and T4FASC-CSS-CPVCHC designs [1, 2], the (truncated) feed-arms are charged, to a few 100 kV, and then discharged through the switch cones. The hydrogen chamber is filled with high-pressure gas to avoid breakdown at lower voltages (cf. Paschen's law). The pressure vessel prevents the system from blowing apart due to the high pressure in the hydrogen chamber. External support structures are typically used to hold the pressure vessel together. Capacitors are used in series with the feed-arms to provide desired rise times in the input voltage. This paper presents some preliminary considerations for the design of such mechanical support structures and capacitors.

2 Feed

Voltages of the order of a few 100 kV will ultimately be delivered to the switch by charging capacitors placed on the feed arms as shown in Fig. 1(a). The hollow (elliptical) capacitors might be made of a material like glass and have a capacitance (for a 100 ps pulse width) of

$$C > \frac{t_r}{Z} = 100^{-12}/100 = 1.0 \text{ pF (several times this).} \tag{2.1}$$

A resistive feed could be guided through a hollow fiber-glass cylindrical structure as shown in Fig. 1(a). The cylinder is placed in the region of minimum electric field, i.e., between the switch and feed arms, to minimize perturbation. Note that capacitance of the truncated feed arms alone may be sufficient to provide the necessary rise times. This must be determined experimentally.

3 Disperser

A disperser is placed behind the feed arms, in the region away from the reflector, to dissipate the prepulse. This region typically consists of highly lossy dielectric material.

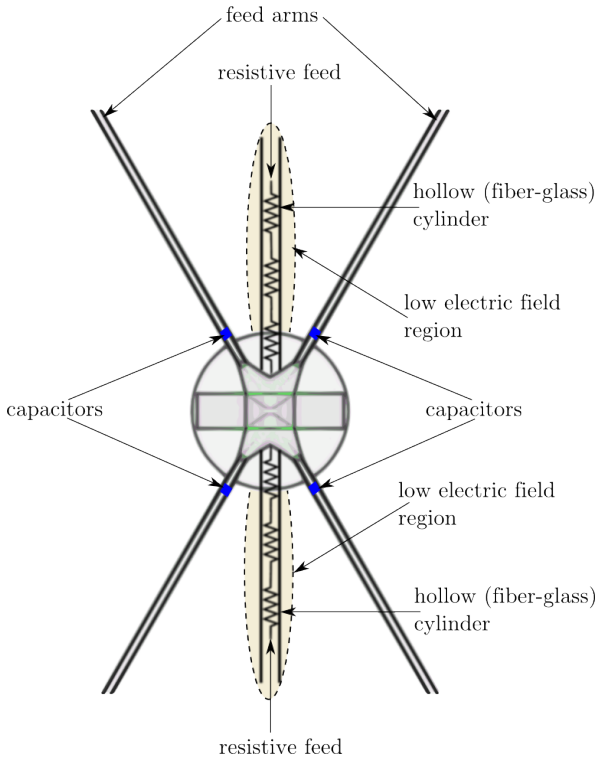
4 Mechanical support

For voltages of the order of a few 100 kV, the pressure vessel would be subject to pressures of the order of 10.13 MPa (100 atm). Therefore, an external force of the same amount (or greater) must be applied to maintain structural integrity and avoid mechanical failure. The amount of force to be applied can be roughly estimated since the area of the switch cone base is known ($\pi r_{sw}^2 = \pi r_{hc}^2 \approx \pi(0.51)$ cm^2)

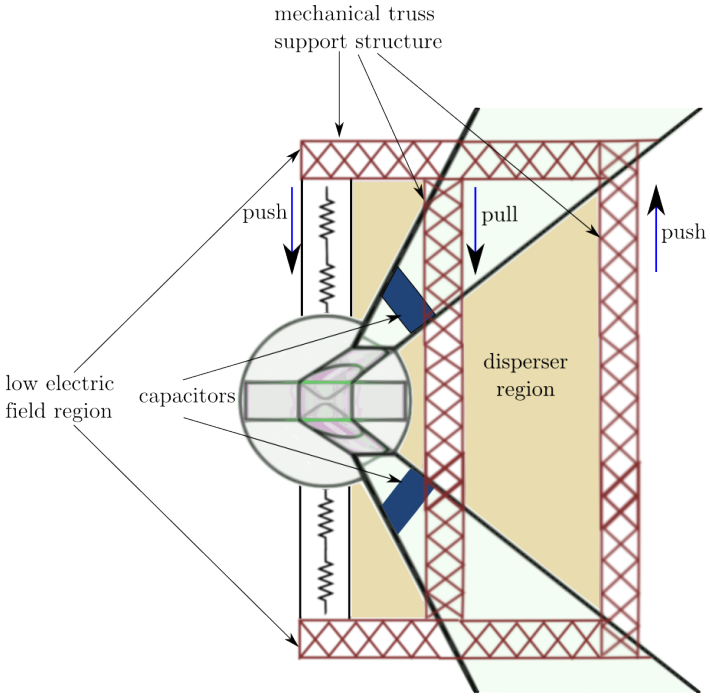
$$100 \text{ atm} = (100)(14.7 \text{ psi}) = 10.14 \text{ MPa (1470 psi)}, \tag{4.1}$$

$$\therefore \text{ Force} = (1470 \text{ psi})(\pi(0.51 \text{ cm})^2) = (1470 \text{ psi})(\pi(0.2 \text{ in})^2) = 821.72 \text{ N (184.73 lbf)} \tag{4.2}$$

A mechanical truss support structure that might be used is shown in Fig. 1(b). The directions of the forces on the various beams (push or pull) are shown in the figure. The fiber-glass feed system described above could form an integral part of this support structure. The whole structure is essentially a C-clamp. Additional supports (for e.g., cross beams) can be provided if necessary.



(a) Front view of switch system with truss support structure.



(b) Side view of switch system with C-clamp like truss support structure.

Figure 4.1: Front and side view of switch system and support structure.[a]

[a]These figures are rough sketches. They are not to scale and are only used to illustrate the concepts. The T4FASC-CSS-CPVCHC configuration is used as an example.

The whole system is in the disperser region so as not to interfere with waves propagating toward the reflector. Of course, reducing the overall size of the structure may prove beneficial (minimal perturbation of the outgoing wave). Detailed mechanical calculations are required to determine the final configuration of the support structure for practical use. Note that the T4FASC-CSS-CPVCHC configuration is easier to support and is therefore practically more preferable to the T4FASC-CSS-SPVSHC design.

5 Conclusion

Initial considerations for a feed and mechanical support structure for the final experimental realization, high power (few 100 kV) and high pressure ($\approx$ 100 atm), of the system have been outlined. The required force and capacitance of such a system have also been roughly estimated. Detailed calculations and experiments are required to tailor the design.

References

[1] Prashanth Kumar, Carl E. Baum, Serhat Altunc, Christos G. Christodoulou and Edl Schamiloglu, "The truncated four feed-arm configuration with switch cones (T4FASC) and a spherical pressure vessel." EM Implosion Memo 42, May 2010.

[2] Prashanth Kumar, Carl E. Baum, Serhat Altunc, Christos G. Christodoulou and Edl Schamiloglu, "The truncated four feed-arm configuration with switch cones (T4FASC) and a cylindrical pressure vessel." EM Implosion Memo 43, May 2010.