Financial Comparative Analysis of Substation EMP Mitigation Approaches

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***Abstract*—**The effective mitigation of high-level fields from EMPs requires mitigation of both radiated and conducted energy. Cost concerns are always central to the mitigation debate. This paper examines the financial costs of achieving various levels of shielding effectiveness (SE) from a range of implementation methods as compared to a module-based design [1]; using quantitative methods for costs and qualitative methods for mitigation effectiveness.

I. Mitigating EMP effects in power substations

The environments considered in this paper are HEMP (100 MHz to 1 GHz) and IEMI (up to 10 GHz). Radiated fields should be addressed using hardened enclosures, shielded control cables and addressing POEs. Conducted energy should be mitigated with surge suppression devices as well as high frequency grounding and bonding. Device power protection is accomplished with HEMP filtering. Below is an evaluation framework for assessing effectiveness versus costs in mitigation decisions.

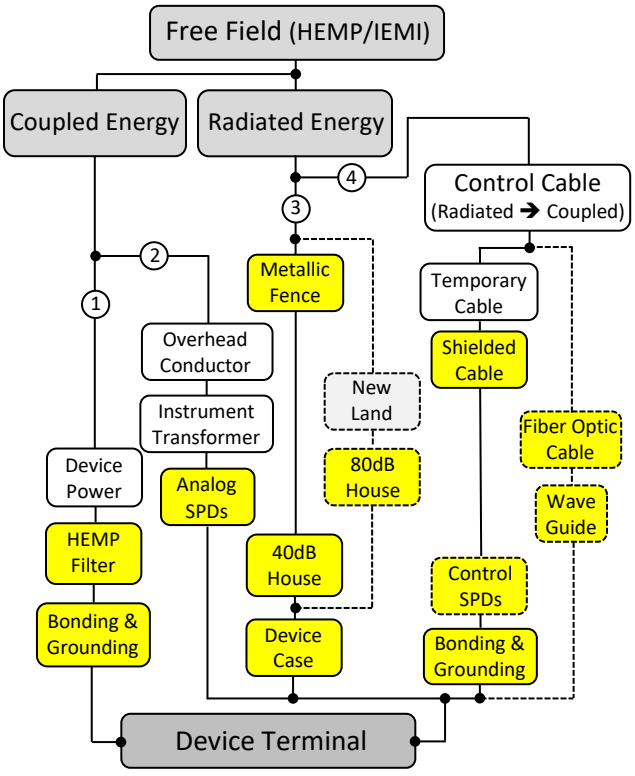

Figure 1: HEMP/IEMI Protection Diagram

II. HEMP/IEMI Protection Alternativities

Figure 1 represents four paths of mitigation including (1) device power, (2) overhead power conductor coupling, (3) direct radiation and (4) coupled energy resulting from radiated fields on metallic control cable. Based on Figure 1, ten configurations were identified for comparison to the module design. Initial implementation costs range from $0.5 M to $2.5M. Figure 2 represents the initial installation costs and qualitative assessment of mitigation effectiveness.

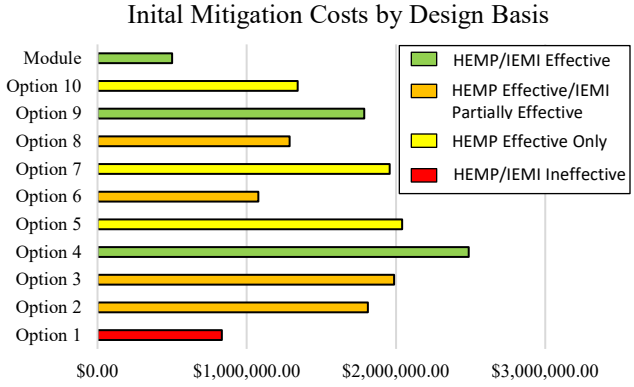

Figure 2: Quantitative Costs/Qualitative SE

Life-cycle costs associated with maintenance and inspection for SE were also considered. Maintenance associated with SPDs is assumed to be proportional to the number of SPDs installed. Door maintenance costs would be based on expected open/close cycles and SE testing costs proportional to enclosure size. Assumptions included an SPD failure rate of 1%, annual SE testing and a 20-year asset life.

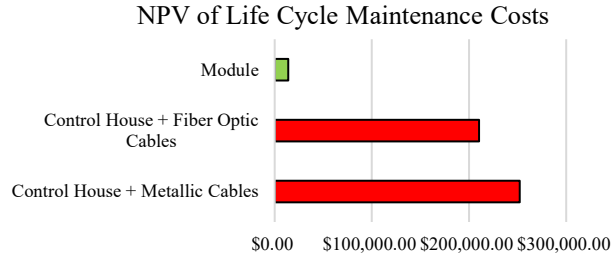

Figure 3: Maintenance Cost Comparison

[1] E. Easton, K. Bryant and W. Radasky, "Design Approach for HPEM Mitigation for Electrical Substations," in press for APEMC 2020, Sydney Australia, May 2020.