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Adjoint perturbations and their applications to the design of vacuum RF sources

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It is often required to estimate the effect of small perturbations of design parameters on various performance metrics of RF sources as a part of optimization and sensitivity analysis. The direct approach, assuming an accurate simulation code is available, is to change slightly the value of an input variable of interest; a simple example is a calculation of how a small change in klystron cavity spacing would affect output power. The trouble with this approach is that, when there are many, N, design parameters of interest, for example cavity spacing, cavity dimensions, magnetic field, beam voltage, current, then N+1 runs of the simulation code are required to compute all the partial derivatives. N can be very large when considering the detailed design of RF sources for accelerators (*(), ()*. *By computing the solution of the adjoint of the perturbed equations governing the beam-wave interaction, we have shown* (**) that all N partial derivatives might be computed with only three runs of the simulation code, no matter how large N is. Once known, these partial derivatives may be used to specify manufacturing tolerances and/or used in a design optimization calculation. Example of the latter include (3) for a traveling wave tube. We will discuss an application of adjoint perturbations to klystron design in our presentation.

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Footnotes

() G. Cariotakis, IEEE Trans. on P.S, 22, 693-691, 1994.
() A.Y. Baykov, et al., IEEE Trans. on ED, 62, 3406-3412, 2015.
(**) A.N. Vlasov, et al., IEEE Trans. PS, 50, 2568-2577, 2022

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