In this paper, a novel methodology for cost-efficient microwave design optimization in the frequency domain is proposed. Our technique, referred to as adaptive response scaling (ARS), has been developed for constructing a fast replacement model (surrogate) of the high-fidelity electromagnetic-simulated model of the microwave structure under design using its equivalent circuit (low-fidelity model). The basic principle of ARS is a nonlinear frequency and amplitude response scaling aimed at accommodating the discrepancies between the low- and high-fidelity models at the reference design and, subsequently, at tracking the low-fidelity model changes that occur during the optimization run. The surrogate model prediction is obtained by applying appropriately composed scaling functions to the high-fidelity model at the reference design. ARS is a parameterless and simple-to-implement method that can be applied to a wide range of microwave structures. The ARS surrogate features excellent generalization capability that translates into improved reliability and reduced design cost. It is demonstrated using an eighth-order microstrip bandpass filter and a miniaturized rat-race coupler. Comparison with several space mapping algorithms is provided. The numerical results are supplemented by measurements of the fabricated optimum designs of the considered structures.