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## Analysis and Design of a Lumped-Element Hybrid Coupler Using Limited Quality Factor of Components

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### Abstract

This paper presents the analysis and design of a hybrid lumped-element coupler in which the loss of components is considered. First, only the loss of each capacitor is considered and it is shown that return loss or isolation can be significantly improved by a controlled reduction in capacitors quality factors. Then, the corresponding expressions for these parameters by considering both the inductors and capacitors quality factors are derived. Based on these analyses, a design procedure and a design example at 3 GHz are presented to achieve an integrated coupler with minimized  $S_{11}$  by adjusting the components quality factors while the other S-parameters are approximately preserved in comparison to ideal lossless case. So, the optimum values for components and also for their quality factors are determined, resulting in the most significant improvement in  $S_{11}$ . Also, a design is presented to improve  $S_{41}$ . Finally to demonstrate the feasibility of the given method, as a proof of concept a prototype coupler is fabricated and tested on a Rogers 4003 PCB at 500 MHz. The measurement results show that by adjusting the capacitors quality factors through placing an appropriate series resistor with each one,  $S_{11}$  improves by 26 dB and reaches -56 dB.

**Keywords:** lumped-element coupler, limited quality factor, optimum values for quality factor, return loss, isolation.

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