Approximate upper and lower bounds on the VSWR of a 3-port circulator with nonideal loads

The upper and lower bounds on the voltage standing wave ratio (VSWR) at port 1 of a 3-port circulator with a complex load under any phase conditions at port 2 and a nonideal termination at port 3 is of some interest in microwave engineering. The purpose of this letter is to give a solution to this problem under some simplifying conditions. The lower bound obtained here is in keeping with the definition of the complex gyrator circuit of this sort of junction when either port 2 or port 3 is terminated in its complex conjugate load.

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