

Comments on ‘planar wideband in-phase power divider/combiner using modified Gysel structure’

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1 Introduction

A design of a wideband in-phase power divider/combiner has been presented in a recent paper [1]. The authors based their design on the traditional Gysel power divider structure and modified the isolation resistors and the line impedances to obtain the proposed divider. As a matter of fact, it can be shown that the suggested modifications of Gysel power divider can be derived as a special case of the more generalised studies in the literature.

This communication shows how the results of [1] can be reproduced in a more generalised form from the previous studies of the modified Gysel power divider structure. The close relation between the proposed divider and the classical ring coupler is also manifested.

2 The modified Gysel power divider

Fig. 1a shows the configuration of the in-phase power divider/combiner proposed in [1]. All the transmission lines sections are assumed to be quarter wavelength long (θ1 = θ2 = θ3 = θ4 = π/2). According to the authors, the proposed device has been derived from the from the conventional Gysel power divider by applying three important modifications. The first modification is using only one isolation resistor. The second one is replacing the half wavelength transmission line connecting the two isolation resistors with two quarter wavelength lines that have different impedances (Z3, Z4). The third change is allowing the lower arm to have a different impedance (Z2) from the other lines. However, it looks like these modifications are included as a special case in previous work [2]. For example, a modified Gysel power divider structure is presented [2] in relation to [3–5] which is reproduced in Fig. 1b. The structure in Fig. 1b shows the most generalised structure of the Gysel power divider based on quarterwave transmission lines. It clearly incorporates all the modifications proposed in [1] and presents more general results including the arbitrary values of the port impedances, the power division ratios and the termination conditions as well as the line impedances.

The single isolation resistor case of Fig. 1a from [1] can be regarded as a special case of two isolation resistor case of Fig. 1b from [2] with the additional assumption of R1 = ∞ and R2 = R, which leads to the following results simplified from those in [2]

\[ Z_1 = \frac{1}{k} \sqrt{Z_{p1}Z_{p2}(1 + k^2)} \]  
\[ Z_4 = \sqrt{Z_{p1}Z_{p3}(1 + k^2)} \]  
\[ Z_2 = \frac{RZ_3^4}{Z_6}(1 + k^2)Z_{p2} \]  
\[ Z_5 = \frac{1}{k} \sqrt{R(1 + k^2)Z_{p3}} \]

In the above, \( k^2 \) is the power division ratio of the power divider shown in Fig. 1b.

The results of [1] can simply be reproduced from further specialisation of (1)–(4) for the equal power division case, \( k = 1 \), and the same port impedances \( Z_{p1} = Z_{p2} = Z_{p3} = Z_0 \)

\[ Z_1 = Z_4 = \sqrt{Z_0} \]  
\[ Z_2 = \frac{Z_3^2}{Z_6} \sqrt{2RZ_0} \]  
\[ Z_5 = \frac{Z_4}{Z_3} \sqrt{2RZ_0} \]

The above results (5)–(7) are reported in [1] with \( Z_6 \) replaced by \( Z_4 \) in accordance with Figs. 1a and 1b.

In the design procedure of [1], \( R = Z_0 \) is assumed, which reduces the solution as follows with the impedances referred to Fig. 1a

\[ Z_1 = Z_5 = \sqrt{Z_0} \]  
\[ Z_3Z_4 = \sqrt{2Z_0} \]

Under the condition of the \( ABCD \) matrix of the cascaded connection of three section connection of quarterwave lines \( Z_2, Z_3 \) and \( Z_4 \) in Fig. 1a can be expressed as follows (see (10) at the bottom of the next page)

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The above \(ABCD\) parameters are the same as those for a uniform transmission line with the characteristic impedance \(\sqrt{Z_0}\), quarter wavelength branches [6], if the isolation resistor \(R\) is regarded as a separate port. The \(3\pi/2\) long branch of the uniform impedance ring coupler is replaced with the equivalent 3 section cascaded connection of quarterwave lines \(Z_2\), \(Z_3\) and \(Z_4\) in the proposed divider.

Ports 1 and 2 are the sum (in-phase) ports and port 3 and the isolation resistor \(R\) corresponds to the difference (out-of-phase) ports of the ring coupler. The Gysel divider/combiner claimed in [1] can be regarded as the in-phase operating configurations of this modified ring coupler.

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4 References