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High Isolation GYSEL Power Divider with fixed characteristic Impedance

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***Abstract*— In this paper, a high isolation GYSEL power divider (GPD) with fixed characteristic impedance is proposed. It was designed using electromagnetic simulators and then implemented for the low band of 5G applications, covering 2.3GHz. The proposed GPD consists of three transmission line sections with fixed characteristic impedances and two isolation resistors to dissipate power. The proposed design was printed on a Rogers's RO4003C substrate with a dielectric constant of 3.55 and a thickness of 0.813mm. To validate the performance of the GPD, simulation results are presented in terms of return losses (S_{11}, S_{22}), transmission coefficient (S_{21}), and isolation loss (S_{23}). The simulation results show that good matching, good transmission coefficient and high isolation between the two output ports at the operating frequency band.**

***Keywords*— GYSEL Power Divider (GPD), High isolation, Return Loss, 5G Ban.**

I. Introduction

The rapid development of RF/microwave communications systems has led to a number of advances in active and passive circuits, components, and devices. Power dividers (PDs), also called power splitters, are one of the critical passive components in many microwave circuits, such as balanced amplifiers [1], frequency multiplier [2] and antenna array feed networks [3]. PDs can be used to split the power from the input port to two or more output ports.

PD can be classified into two common types: Wilkinson power divider (WPD) [4], and GPD [5]. The GPD is known for its power-handling capability due to the external isolation loads, which can be high-power resistors connected between output ports for heat dissipation. However, the complexity of the isolation network has led to a narrow bandwidth and large circuit size.

Laterally, GPD's with different technologies are proposed to obtain enhanced performances in terms of dual-band or wideband operation, compact size, equal or unequal power division and high isolation loss. In [6], a compact and wideband GPD is presented. This design achieves a 60% size reduction of compared to the previous dividers. A micro-strip GPD with improved isolation was proposed in [7], where an L-type matching network is added at the input port to broaden the isolation bandwidth. Another study [8], presents a miniaturized GPD using six lowpass filters to reduce the size of the circuit. And recently, some new GPD designs have been developed, including both equal [9] and unequal [10] dividers with some enhanced features.

Previously, we proposed a coupled-line WPD design for UMTS mobile applications. The proposed divider achieved a size reduction compared to the corresponding conventional WPD [11]. Subsequently, in [12], we presented a parametric study of a conventional GPD design for mobile communication applications. In this study, the simulation of a high isolation GPD with fixed characteristic impedances is presented. First, the design circuit steps of the proposed divider are shown. Then, the prototype of the GPD design is simulated using ADS (Advanced Design System) and CST (Computer Simulation Technology) simulators. Finally, the outcomes are illustrated, discussed, and comprised.

II. DESIGN AND SIMULATION OF GPD

A. Configuration Circuit of our Proposed GPD

Fig. 1 depicts the configuration circuit of our proposed GPD, which is composed of three transmission line sections with fixed characteristic impedance (Z) and different electrical lengths (θ_1, θ_2, and θ_3). It also includes two isolation resistors (R) connected between the two outputs ports. Each port is terminated with internal impedance Z_0.

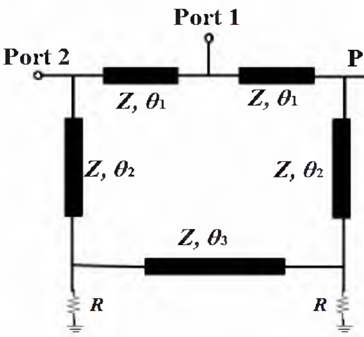


Fig. 1. Configuration circuit of our Proposed GPD

B. High Isolation

High isolation indicates that a power divider can successfully separate the output ports from each other to minimize interference between different system parts.

$$S_{23} = S_{32} = 0 \quad (1)$$

Where S_{23} and S_{32} represent the isolation loss between Port 2 and Port 3. In general, isolation level greater than 20 dB

C. Geometry of our Proposed GPD

The proposed GPD was printed on a Rogers RO4003C substrate with a dielectric constant of 3.55, a thickness h = 0.813 mm, and a loss tangent of 0.0027. The simulation was performed using both ADS and CST simulators. According to the simulation, the characteristic impedance of three transmission lines is found to be 70 Ω, with $\theta_1 = \theta_2 = \pi/2$ and $\theta_3 = \pi$. The value of the isolation resistor is R = 100Ω. The initial detentions of the proposed GPD are tabulated in Table 1.

TABLE I. INITIAL DIMENSION OF OUR PROPOSED GPD

Power Divider	***Parameters***	***Values (mm)***
GYSEL PD	W_{pl}	1.77
	L_{pl}	6
	W_z	0.94
	L_1	18.23
	L_2	21
	L_3	40
	W_r	0.4
	L_r	1

The proposed GPD model in ADS and CST simulators is shown in Fig. 2 and Fig. 3.

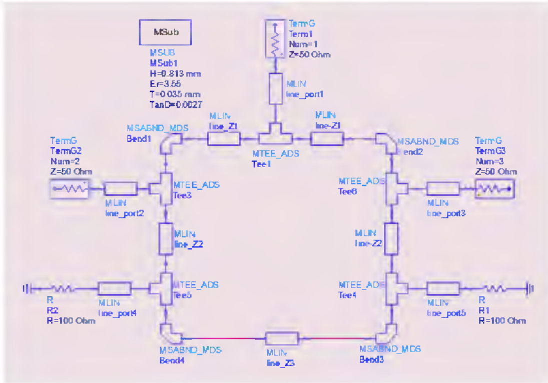
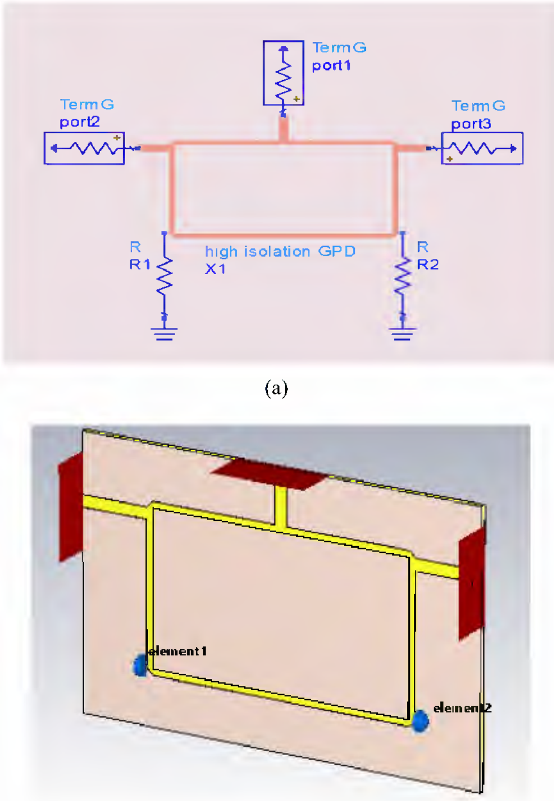


Fig. 2. ADS schematic model of our proposed GPD



(a)

(b)

Fig. 3. Proposed Model of GPD. (a) ADS and (b) CST simulator.

III. SIMULATION RESULTS AND DISCUSSION

The proposed GPD is designed and simulated using two-simulator, ADS V2023 and CST V2021 Simulators. The simulations results of our proposed GPD are plotted in Fig. 4 and Fig. 5. The return losses S_{11}, S_{22}, and the transmission parameter S_{21} are presented in Fig. 4 (a) and Fig. 5 (a). It can be seen that the return losses are less than 40dB and the transmission parameter S_{21} is quite around 3.08dB. Fig. 4 (b) and Fig. 5 (b) shows high isolation level between the two outputs ports (Port 2 and 3) in the two-simulator (ADS and CST), where in ADS ($|S_{23}| < -45$ dB) and in the CST ($|S_{23}| < -50$ dB) at 2.3 GHz. Overall, the simulation results demonstrate that the proposed GPD achieves a good ports matching, efficient signal transmission, and high isolation between outputs at the operating frequency of 2.3 GHz, which covers the low 5G application band.

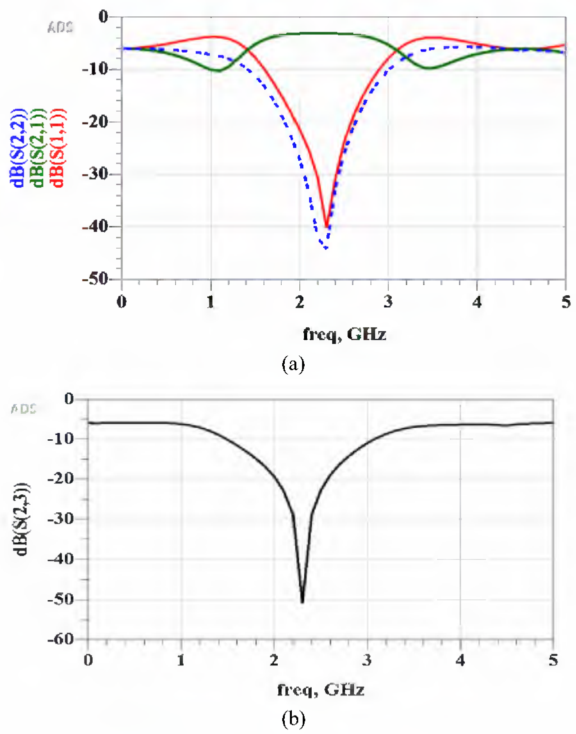


Fig. 4. Simulated Results of our proposed GPD in ADS. (a) Return Losses S_{11}, S_{22} and Transmission Parameter S_{21}. (b) Isolation Loss S_{23}.

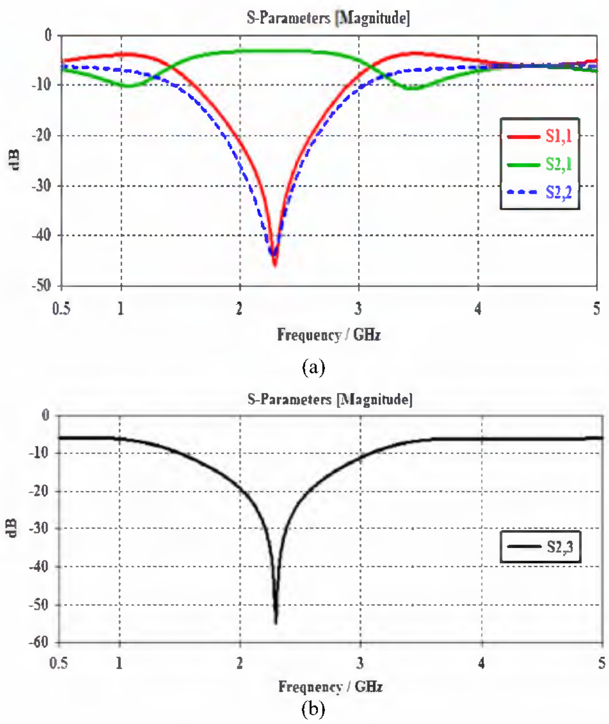


Fig. 5. Simulated Results of our proposed GPD in CST. (a) Return Losses S_{11}, S_{22} and Transmission Parameter S_{21}. (b) Isolation Loss S_{23}.

TABLE II. COMPARISON BETWEEN SIMULATION RESULTS IN ADS AND CST SIMULATORS

Simulator	Return Loss (dB)		Transmission Parameter (dB)	Isolation Loss (dB)
	$\|S_{11}\|$	$\|S_{22}\|$	$\|S_{21}\|$	$\|S_{23}\|$
ADS	40	40	3.09	50
CST	45	43	3.07	55

IV. CONCLUSION

This paper presents a high isolation GYSEL power divider with fixed characteristic impedance. The parameters of the proposed design were simulated using Agilent ADS/Momentum and CST Microwave Studio. The simulation results demonstrate high performance of the proposed design, with good input and output return loss (more than 20 dB), good transmission coefficient (less than 3dB) and high isolation (more than 30 dB) at 2.3GHz, along with wide bandwidth exceeding 1GHz, across 1.6GHz to 2.9GHz.

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