# A New Input Power Divider Scheme for Dual-State Amplifiers

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**Abstract** - This paper presents a new dual-state power dividing scheme employing a 3 dB directional coupler controlled by a switch at a coupling port. The coupler connected with the switch provides better ON and OFF states for a dual-state amplifier than a switch in series with RF signal path. Furthermore, this approach eliminates the necessity of DC bias circuitry for the switch and the effect of DC signal on RF signal, as well as offers easier design than a power divider with series switches.

**Power Divider with Switchable 3 dB Coupler**

For modern high efficiency communication systems, dual-state amplifier schemes have been demonstrated [1-2]. By choosing proper device size depending on the output power level [1], the DC power consumption was minimized, thereby efficiency being improved. In [2], the number of operating active device was determined by input power level and dual operation was controlled by input series switches. However, placing a switch in series with RF signal path complicates the circuit because of the necessary DC bias circuit for the switch as well as some effect of the circuit on the RF performance. In this paper, a new dual-state power divider is proposed. The same circuit functionality can be realized by utilizing 3 dB directional couplers. The proposed switching scheme is shown in Fig. 1. It consists of a 3 dB coupler and a switch connected at the coupling port of the coupler. Note that the isolation port is always open in this configuration. When the switch is in the OFF state, the entire circuit behaves as a conventional transmission line with a characteristic impedance of $(Z_{0e}+Z_{0o})/2$, where $Z_{0e}$ and $Z_{0o}$ are even and odd mode characteristic impedances, respectively. On the other hand, the input impedance of the coupler becomes nearly short when the switch is conducting [3].

The proposed switching scheme was designed at 2.12 GHz. The designed circuit was fabricated on 31 mil thick Duroid substrate with $\varepsilon r = 2.33$. In Fig.2, the measured insertion loss characteristic is shown. By controlling the state of the connected switch, the coupler provides ON and OFF states corresponding to the operation of the switch. A dual-state power divider was designed based on the operation of the proposed switching scheme. The divider scheme shown in Fig. 3 provides dual-states, either one branch or 4 operating branches. Note that in each case the input and output are always matched by adding quarter-wave length transmission line with proper characteristic impedance. The photograph of the fabricated power divider on the same substrate as the switching scheme is shown in Fig. 3. The measured return loss and insertion loss characteristics with respect to frequency are shown in Fig. 4. As shown in the figure, matching is well accomplished over the designed frequency range for the two different states. Insertion loss of 1.6 dB was observed when one branch was conducting. This is due to the finite loss of about 4-5 Ω of the switch at ON state. From the Agilent ADS simulation, the insertion loss can be significantly improved as the ON state resistance of the switch approaches to about 1-2 Ω. When 4 branches are conducting, the input power is equally divided into each branch with insertion loss of 6 dB.

**Conclusion**

A dual-state input power divider has been proposed utilizing a 3 dB directional coupler connected with a switch. The necessity of DC bias circuit for the switch in a conventional dual-state power divider was eliminated. Input and output was always matched at each different state in this configuration.

**Reference**


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[2] C. Y. Hang, Y. Wang and T. Itoh, "A new amplifier power combining scheme with optimum efficiency under variable outputs," *IEEE MTT-S Int. Microwave Symp. Dig.*, pp. 913-916, 2002.

[3] G. L. Matthaei, L. Young, and E. M. T. Jones, *Microwave Filters, Impedance-Matching Networks, and Coupling Structures*, Dedham, MA: Artech House, 1980.


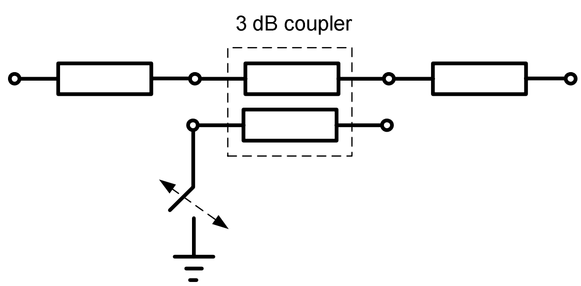


**Fig. 1** Architecture of proposed switching scheme with 3 dB coupler.

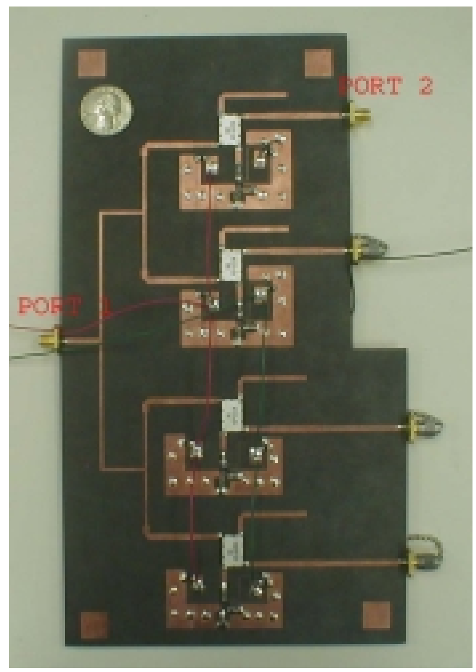


**Fig. 3** Photograph of fabricated dual-state input power divider.

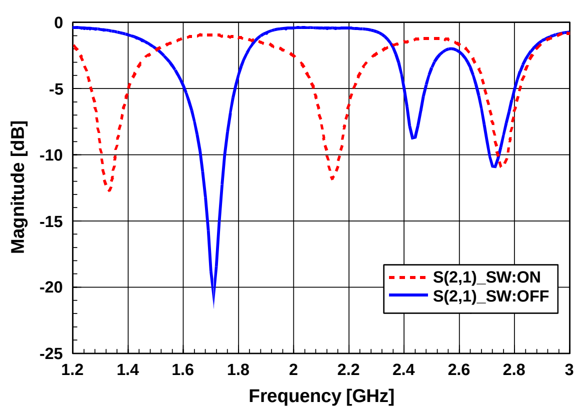


**Fig. 2** Measured ON and OFF state characteristics of the proposed switch with 3 dB coupler (Designed frequency = 2.12 GHz).

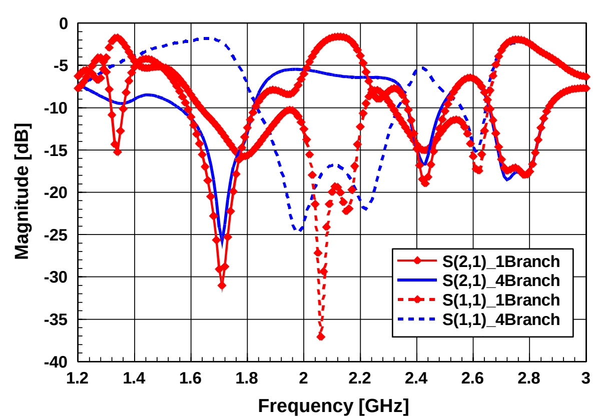


**Fig. 4** Measured insertion loss and return loss characteristics for the dual-state operation.