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Compact UHF Power Divider with Decoupling Between Inputs

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Abstract. The paper deals with a new compact UHF power divider with decoupling between inputs, the amount of which may be chosen from 1 to 4, and a number of outputs can vary from 2 to 4. The input signal is fed to the one of the inputs and divided into equal parts between the outputs. Transmission factor from one of the inputs to any output independent of the number of the outputs does not exceed 6.8 dB. The power divider is implemented on four Lange bridges, which in the plane form the square. The construction of the model and experimental results are presented in the C-band. The power divider is successfully used in UHF units of the cross reservation for the onboard equipment of a command and measurement system.

Keywords: UHF power divider, directional coupler, Lange bridge, coupled lines

Introduction

To ensure a long active service life of the onboard equipment of spacecraft, it is required to unite up to four UHF devices by means of compact devices of cross reservation to provide decoupling between the inputs in the reserved group. Such devices are passive power dividers.

The power dividers of $n \times m$ made according to the binary scheme [1] are known. The dividers of this type are synthesized employing basic elements including a directed coupler, phase shifters, attenuators, etc. [2]. Disadvantages of such solutions are in the excess quantity of basic elements, restriction of the width of an operating band, complexity of coordination, and non-optimal mass-dimensional characteristics.

To apply spacecraft in the onboard equipment of a command and measuring system (OE CMS), it is required to use power dividers up to the power divider 3 × 3. Development of such power divider, which would allow one to employ it in the separate case or integrally as a part of the UHF device is expedient, as well as such device would possess the minimum losses, a good decoupling on inputs and outputs applicable to in the set frequency bands, and have the minimum dimensions and weight.

In a power divider 3 × 3, the defects peculiar to the dividers created according to the binary scheme that provides increase in number of the decoupled inputs up to four and decoupled outputs up to four are eliminated. It is especially important at coupling of the antenna-feeder device with receivers, when about 3 antennas with redundant low noise amplifiers and triplex receiving-transmitting devices are used. Multipolar distributors of UHF power, for example, 3 × 3, are used in OE CMS for cross reservation of triplex sets of receiving-transmitting devices and power amplifiers.

1. Power divider

Fig. 1 depicts the electric circuit of a power divider for the OE CMS [3] where 1, 2, 3, and 4 are the designations of the microstrip directed coupler with communication 3 dB. Microstrip pieces of the coupled lines 1 and 3 are coupled to the inputs 1, 2, 3, or 4, and microstrip pieces of the coupled lines 2 and 4 are coupled to the outputs 1, 2, 3, and 4, respectively.

Figs. 2–4 illustrate block diagrams of power dividers 4 × 4, 4 × 2, 3 × 2 representing modifications of the scheme 4 × 4.

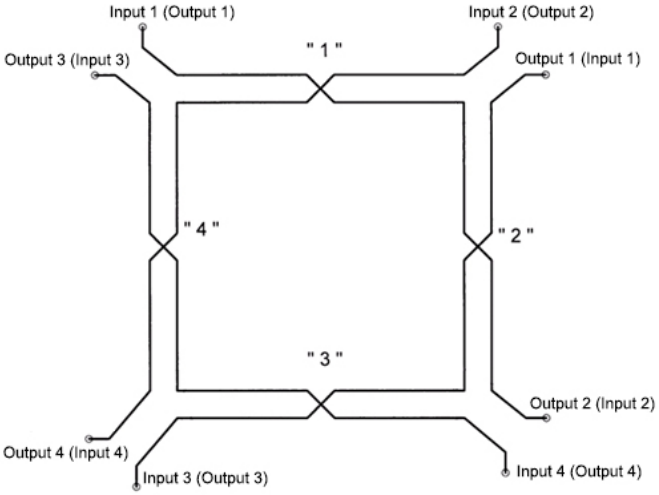

Fig. 1. The power divider 3 × 3

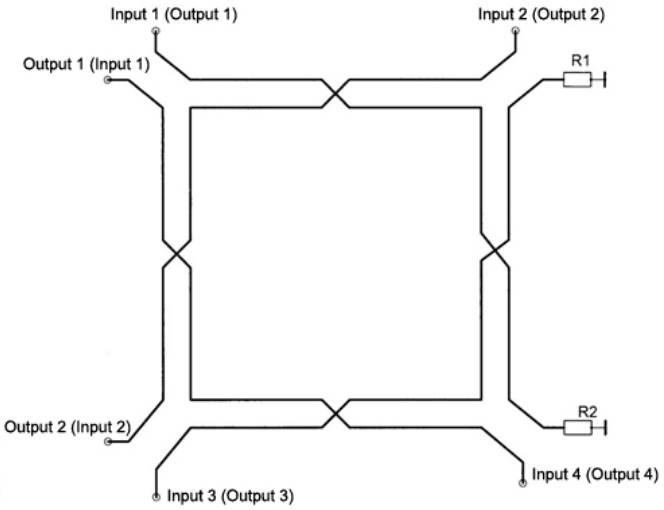

Fig. 2. The power divider 4 × 4

Generally, the divider 4 × 4 is for splitting of signal power given on one of four inputs on four outputs. Thus, at the outputs "Output 1", "Output 2", "Output 3", and "Output 4", there are signals weakened by 6 dB in relation to the power of the input signal P_a (without losses at the coupled lines 1, 2, 3, 4). The same way when giving a signal P_a on "Input 2", or on "Input 3", or on "Input 4", at the outputs "Output 1", "Output 2", "Output 3", "Output 4", there will be the signals weakened by 6 dB in relation to the signal power P_a. The submitted scheme of a divider 4 × 4 provides decoupling between the inputs "Input 1", "Input 2", "Input 3", and "Input 4", and also between the outputs "Output 1", "Output 2", "Output 3", "Output 4", not less than 20 dB. Thus, the possibility to use this divider operating according to the scheme 4 × 4 to ensure reservation of the onboard UHF equipment of spacecraft, in particular, a power amplifier of in OE CMS is confirmed.

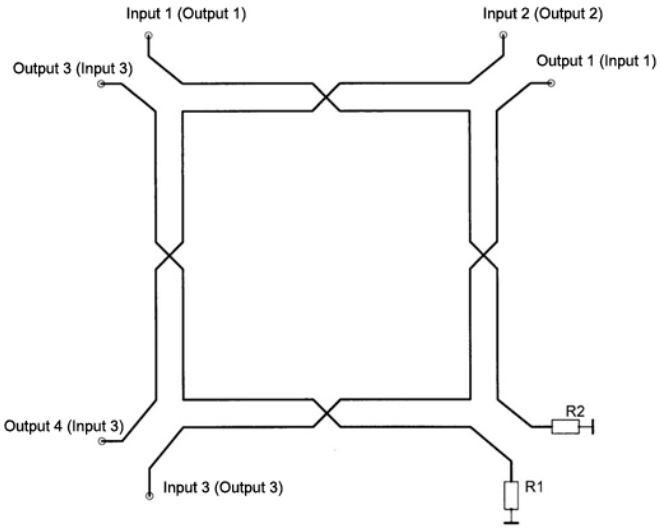

Fig. 3. The power divider 4 × 2

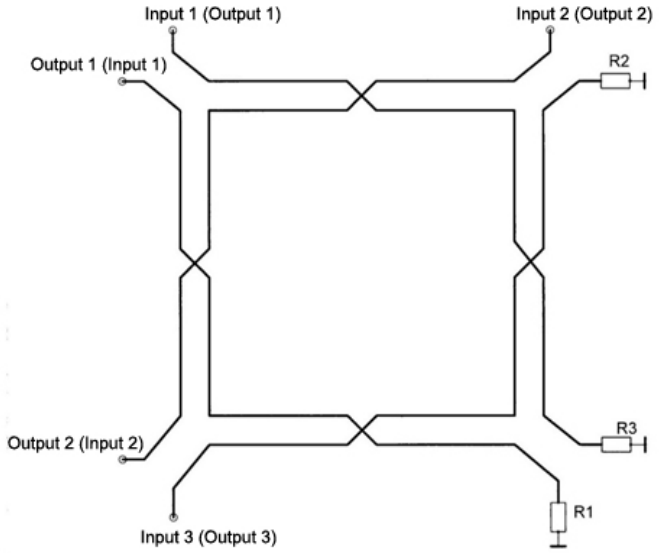

Fig. 4. The power divider 3 × 2

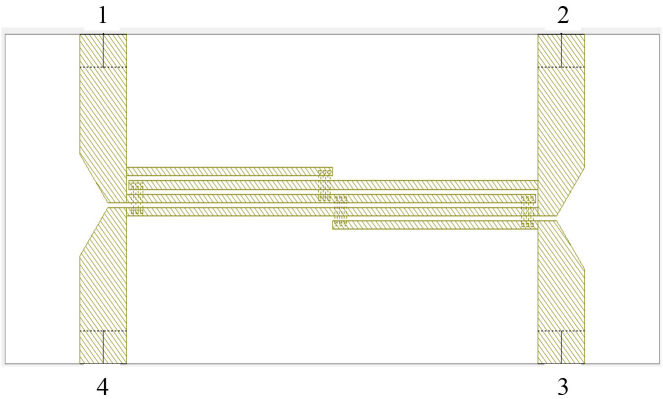

Fig. 5. The configuration of Lange bridge.

When coupling to one of the inputs of a power divider of the coordinated loading, the scheme 3 × 4 is implemented, and when coupling of the coordinated loadings to other ends of Lange bridges, it is possible to create other dividers: 4 × 3, 3 × 3, 3 × 2, 2 × 3. It is possible to create dividers 2 × 2 and 1 × 2, however for their realization there are more compact schemes.

The originality of a design of the offered power divider is in use of Lange bridges which existence of crossing of pieces of coupled lines in their middle, as shown in Fig. 5 is characteristic.

This property of Lange bridges has allowed one to realize a compact power divider with four Lange bridges located one in relation to next to it at right angle.

2. Simulation and experimental research of a power divider

When simulating a power divider 3 × 3, possible dispersions of parameters of ceramics and also dispersion of parameters of structural elements of the whole divider, including the form and length of the bridles connecting the corresponding conductors were considered. Simulating was carried out for the substrate of the Polikor material with the characteristics of $\varepsilon_r = 9.6 \pm 0.2$, $\mathrm{tg}\delta = 10^{-4}$, thickness $h = 1$ mm. At production of a printed circuit board, technological "constriction" of metal conductors was no more than 10 microns per side.

The appearance of a power divider is shown in the Fig. 6.

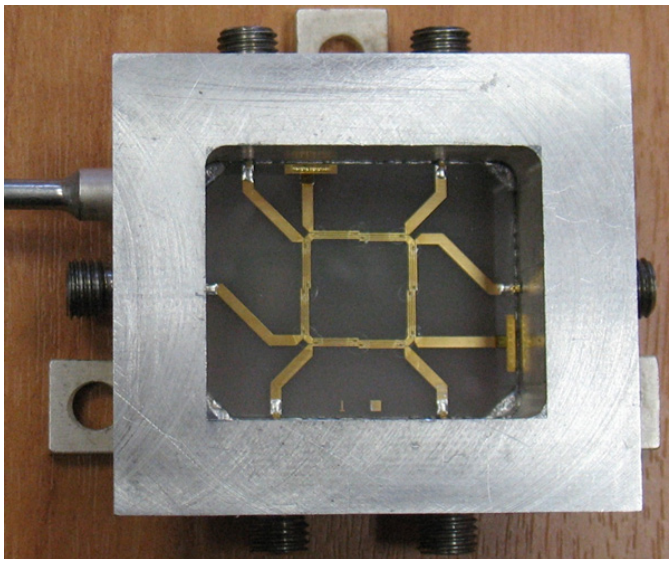

Fig. 6. The appearance of the power divider 3 × 3.

Production of a divider 3 × 3 placed in a separate tight case was made according to standard manufacturing techniques of plates of the UHF devices. Resistance of the spray ballast R1, R2 resistors was regulated by means of the laser.

Research data of the parameters of the built power dividers 3 × 3 are presented in Fig. 7–10. We can see that characteristics of power dividers 3 × 3 have an insignificant resonance frequency shift that is explained by the difference of ε_r from its nominal rate and a technological backlog on "constriction".

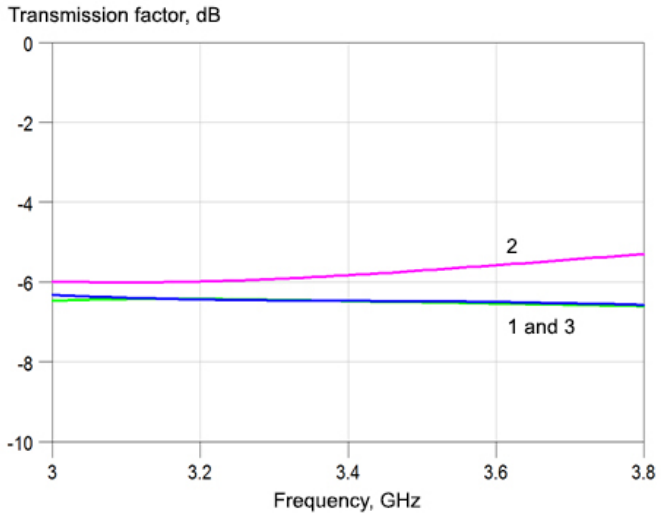

Fig. 7. Dependency of transmission factor in the power divider 3 x 3 on frequency: *1* is from the input 1 to the output 2; *2* is from the input 1 to the output 3; *3* is from the input 2 to the output 3.

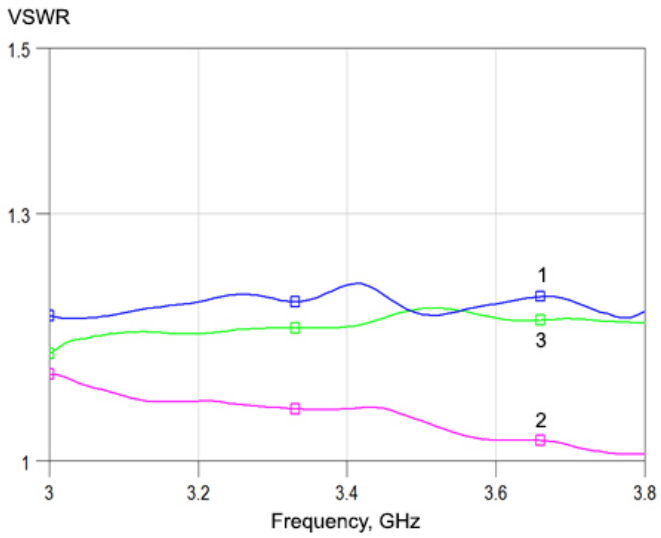

Fig. 8. VSWR Dependency of the inputs 1, 2, and 3 of the power amplifier 3 x 3 on the frequency.

As a result of the research, the values of key parameters of a divider are received:

- transmission factor from the input to the output is no more than –6.8 dB;
- decoupling between inputs and outputs is not less than 23 dB;
- VSWR of inputs or outputs is no more than 1.15 dB.

The measured electric characteristics of power dividers 3 × 3 validate the choice of parameters of a mathematical model and coincide well with the results of calculation.

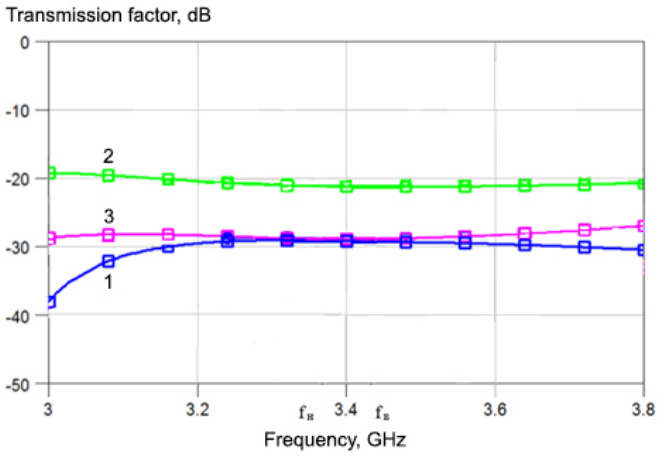

Fig. 9. Dependency of transmission factor (Kp) between the inputs of the power divider 3 x 3 on frequency: *1* is between the inputs 1 and 2, *2* is between the inputs 1 and 3, *3* is between the inputs 2 and 3.

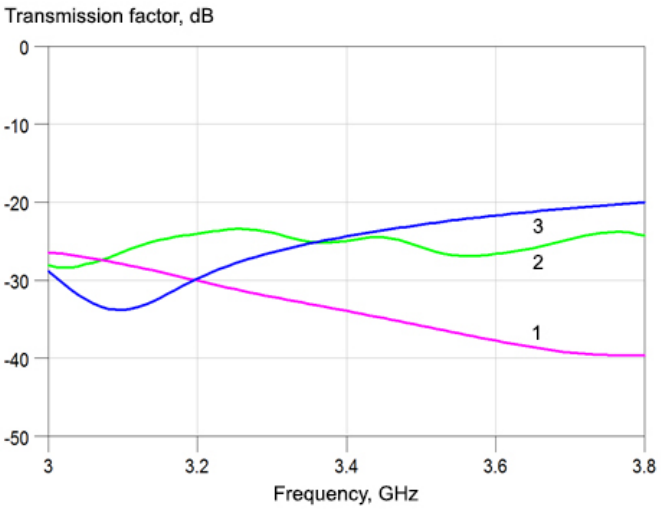

Fig. 10. Dependency of transmission factor (Kp) between the inputs of the power divider 3 x 3 on frequency: *1* is from the output 1 to the output 2, *2* is from the output 1 to the output 3, *3* is from the output 2 to the output 3.

Conclusion

The results of development of the compact power divider of the C-band capable to work with the number of inputs and outputs from 2 to 4 are shown. The feature of the design and the reached experimental parameters

allow one to use it both as a self-contained unit and as a component of the power amplifier of OE CMS as a device for cross reservation.

References

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