



# Design of a Novel T-Type Power Divider Feed Network

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**Abstract.** A novel type of T-type Power Divider feed network is designed for the difficulty of meeting the needs of both the broadband and miniaturized applications of the existing circularly polarized antenna. At the center frequency, the input signal is transmitted through the active shift phase feed network, and the four-way signal is equitized at its output port, with a phase lag of  $90^\circ$  in turn. It is worth noting that the T-type node does not have an isolation resistor, so the matching and isolation of the output port is not considered. The test results list the echo loss of the internal functional feed network Input port, the insertion loss of the circuit, and the phase difference between the output ports. The network theory is applied in the antenna feed network, which can improve the performance of the antenna and is suitable for long-distance highly directional reading and writing applications.

**Keywords:** T-type power divider · Feed network · Antenna

## 1 Introduction

With the rapid development of modern wireless communication technology, wireless communication has played an increasingly important role in people's production and life. In recent years, 3G (3rd generation mobile communication technology), 4G (4th generation mobile communication technology), IEEE802.11 WLAN (Wireless Local Area Networks), WPAN (Wireless Personal Area Network), IEEE 802.16 WMAN (Wireless Metropolitan Area Networks) and a variety of communication technologies and standards have been rapidly developed and widely used. Wireless communication system is moving towards broadband, high speed and high quality [1–6].

In these communication systems, RF front-end and antenna, as an indispensable part of the communication system, play a key role in the quality of the whole communication system [7–10]. The RF front-end is mainly composed of microwave passive components such as filters, power splitters, directional couplers, phase shifters and microwave active components such as impedance converters, amplifiers, mixers [11–18]. Antenna is the key component of signal receiving and transmitting in wireless communication system. The performance of its feed network directly affects the quality of signal receiving and

transmitting. So, the feed network applied to circularly polarized antenna has a good theoretical significance and research value in the field of RF microwave communication.

Wilkinson power divider was first proposed by Ernest J. Wilkinson in document [19–25] in 1959. Based on the principle of quarter wavelength impedance conversion, this power divider realizes the matching of any port and the isolation between ports. The disadvantage is that the isolation resistance is located between each output port, which makes it difficult to add conveniently Load radiator, so it cannot be used in high-power occasions. To this end, Ulrich H. Gysel proposed an improved Wilkinson power divider [26–30], namely Gysel power divider, in 1975. The power divider successfully designs an eight-way combiner with 20% working bandwidth by grounding the isolation resistance. Because of the resistance grounding, it effectively conducts heat and is suitable for high-power occasions. However, no matter Wilkinson power divider or Gysel power divider, due to the use of isolation resistor, it has the disadvantage that it cannot be arbitrarily extended to any path in the plane. Therefore, a Bagley polygon power divider [31–35] is proposed. Because the isolation between output ports is not considered, only the matching of input ports and the transmission characteristics of the circuit are considered, the circuit structure can be extended to any odd number of paths. Therefore, a lot of research has been done. In addition, as the feed network of microstrip antenna, power divider plays an important role in the design of antenna. Next, the power divider theory is applied to the antenna feed network to improve the performance of the antenna [36–40]. In this paper, a new design method of T-type power divider feed network is proposed, and its simulation and test are carried out.

## 2 Structure of T-Type Power Divider Based Feed Network

The T-type Power Divider proposed in this section, shown in Fig. 1(a). The input port is the standard  $50\ \Omega$ , and the output port is  $100\ \Omega$ . Based on this Power Divider and microband delay line shifter, a four-point power feed network is formed. Figure 1 (b) is a T-type Power Divider based feed network with the same structure for the internal and external branch, but the four output ports of the two feed networks have different characteristic impedances. The characteristic impedance of the internal feed network output port is the standard  $50\ \Omega$ , and the characteristic of the external feed network output port is the input impedance of the rectangular radiation patch of  $130\ \Omega$ . The microstrip with an electrical length of  $180^\circ$  and  $90^\circ$ , respectively, and a microstrip with a characteristic impedance of  $Z_1$  is a delay line for both feed networks, with an electrical length of  $90^\circ$ . The microstrip line with feature impedances of  $Z_2$  and  $Z_3$  acts as an impedance converter.

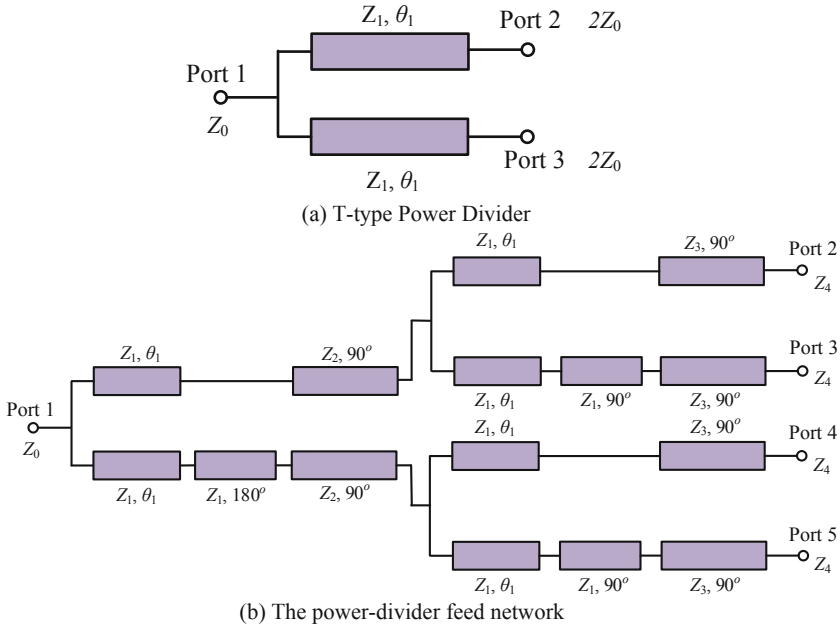


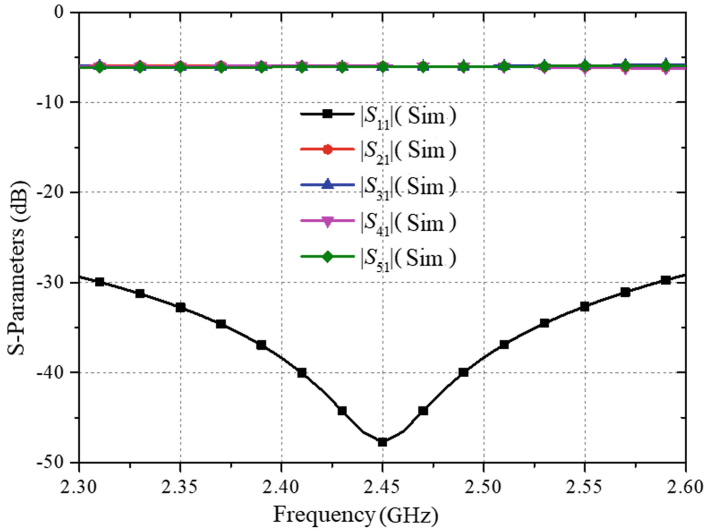
Fig. 1. T-type power divider and its power-divider feed network

### 3 The Working Principle of T-Type Power Divider Based Feed Network

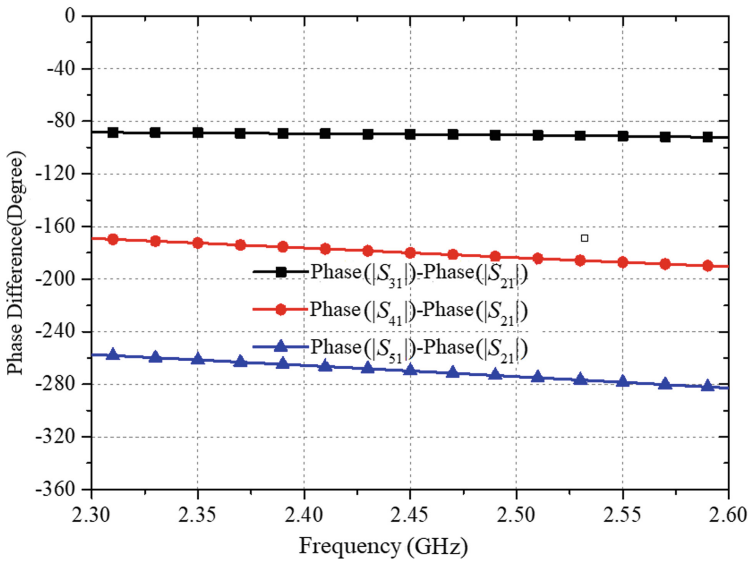
The following analysis of the antenna internal function feed network works (external function feed network works the same): the input signal feeds from the input port. The first through the first stage of the machine and  $180^\circ$  delay line shifter, so that the input signal is divided into two signals with equal amplitude and opposite phase. Then the impedance is transformed to the standard  $50 \Omega$  via a quarter wavelength impedance converter. The two inverted signals are passed through the second stage of the machine and the  $90^\circ$  delay line shifter, respectively. The above two signals are further assigned to two orthogonal signals with an equal phase difference of  $90^\circ$ . Finally, the impedance is transformed again to the output port, i.e.  $50 \Omega$ , through a quarter-wavelength impedance converter. It can be seen that at the center frequency, after the input signal passes through the power division phase-shifting feed network, four signals with equal amplitude and phase lag of  $90^\circ$  can be obtained at the output port. It is worth noting that the T-type power divider has no isolation resistance, so the matching and isolation of the output port are not considered.

### 4 Simulation and Testing

Based on the theory of odd and even mode analysis and two-stage feed network analysis, the expression of the circuit electrical parameters of the internal power division feed



(a) The echo loss of the input port and the insertion loss of the circuit



(b) Phase difference between output ports

**Fig. 2.** Scattering parameters and phase difference of the power divider feed network

network can be obtained:  $Z_0 = 50 \Omega$ ,  $Z_1 = 100 \Omega$ ,  $\theta_1 = 100^\circ$ ,  $Z_2 = 71 \Omega$ ,  $Z_3 = 71 \Omega$ ,  $Z_4 = 50 \Omega$ . The expression of the circuit electrical parameters of the external power division feeding network is:  $Z_0 = 50 \Omega$ ,  $Z_1 = 100 \Omega$ ,  $\theta_1 = 100^\circ$ ,  $Z_2 = 71 \Omega$ ,  $Z_3 = 114 \Omega$ ,  $Z_4 = 130 \Omega$ .

To make it clearer how the function divider feed network works, in Fig. 2 lists the echo loss of the internal function feed network input port, the insertion loss of the circuit, and the phase difference between the output ports.

From Fig. 2(a), it can be seen that at the center frequency, the input ports match and the insertion loss is equal, proving that the four outputs are signals with equal energy. From Fig. 2 (b), it can be seen that the phase difference between output port 3 and output port 2 is  $-90^\circ$ . The phase difference between output port 4 and output port 2 is  $-180^\circ$ , and the phase difference between output port 5 and output port 2 is  $-270^\circ$ . It is fully proved that the phase difference between the four output ports is  $90^\circ$  in turn, which feeds the circularly polarized antenna. The S-parameters and phase difference of the external power feed network are the same as those of the internal power feed network, which will not be analyzed here.

## 5 Conclusion

A novel type of T-type power divider feed network is designed. The structure and working principle of the antenna power division feed network are analyzed. Finally, the simulation and test show that the network theory can improve the performance of the antenna in the antenna feed network, and it is suitable for the reading and writing application of the long-distance and high directionality.

**Funding.** This work was supported in part by Xu Zhou Science and Technology Plan Project (Grant No. KC19003) Xu Zhou Science and Technology Plan Project (Grant No. KC17140) and Natural Science Research of Jiangsu province (Grant No. BK20161165).

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