A Rat-Race Coupler for Radar Applications to Improve Tx/Rx Isolation

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***Abstract*— This paper presents a rat-race coupler for radar applications. The proposed rat-race coupler is placed on the RF front-end of the radar and contributes to blocking signal leakage between the transmitter and receiver. The proposed rat-race coupler is composed of divider and marchand balun. The proposed rat-race coupler operates at W-band frequency, and the insertion loss is 3.9 dB and 5.1 dB respectively. And it provides sufficient transmit/receive isolation of about -30 dB.**

Keywords—rat-race coupler, leakage cancelling, Tx/Rx isolation, W-band, radar applications

I. INTRODUCTION

Recently, radar systems for various applications such as smart home, smart factory, and autonomous driving have been studied. For small radar systems, a monostatic type using only one single antenna is being used. As the monostatic radar system is transmitted and received through one single antenna, it is very vulnerable to signals leaking from the transmitter to the receiver. There have been many studies to improve transmit/receive isolation [1-4]. A circulator component is used as a method to improve the transmission/reception isolation. However, the circulator is bulky and not suitable for small radar systems.

This paper presents a rat-race coupler for radar applications. The proposed rat-race coupler is placed on the RF front-end of the radar and contributes to blocking signal leakage between the transmitter and receiver.

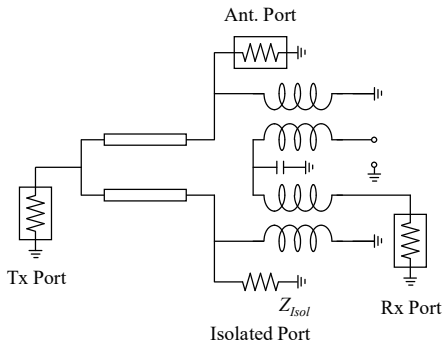

Fig. 2. A schematic of proposed rat-race coupler

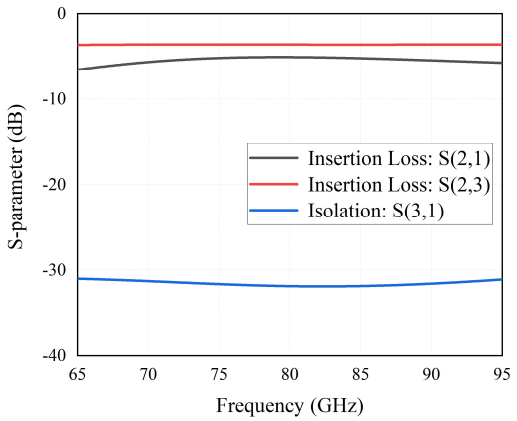

Fig. 1. Insertion loss and isolation characteristics of proposed rat-race coupler

II. A RAT-RACE COUPLER

A traditional rat-race coupler requires a quarter-wavelength length transmission line. However, the proposed rat-race coupler has a small size using a coupled line-based marchand balun. Fig. 1 shows the circuit diagram of the proposed rat-race coupler. Rat-race coupler has 4 input/output ports which are transmit port, receive port, antenna port and isolation port. Each input/output port is matched to a 50 ohm, and the isolation port is terminated with a 50 ohm resistor.

Fig. 2 show the insertion loss and isolation characteristics of a rat-race coupler. The proposed rat-race coupler operates in the W-band, 80 GHz frequency. All input and output ports of the rat-race coupler are well matched to 50 ohms and have a reflection coefficient of -15 dB in the operating frequency range. The insertion loss is 3.9 dB and 5.1 dB, respectively. The isolation characteristic is high isolation of -30 dB.

In the proposed rat-race coupler, when port 1 is referred to as an antenna port, the insertion loss S_{21} from port 1 to port 2 is

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3.9 dB, and the insertion loss S_{31} from port 1 to port 3 is 5.1 dB. Since the insertion loss occurring in the antenna receiving line also affects the receiver noise figure, it is more sensitive to the system performance than the insertion loss occurring in the antenna transmitting line. Since the insertion loss of S_{21} is smaller than that of S_{31}, it is suitable for radar system use to allocate port 2 as a receiving port and port 3 as a transmission port.

III. Conclusion

This paper introduces a rat-race coupler for radar applications. The proposed rat-race coupler includes a coupled line based marchand balun to achieve a small size. The insertion loss of rat-race coupler is 3.9dB and 5.1dB, respectively. The isolation characteristic is high isolation of -30dB. The proposed rat-race coupler is a passive transmission line-based leakage canceller, and the rat-race coupler is placed on the radar front end to block signal leakage between the transmitter and receiver.

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