TEMPERATURE INSENSITIVE DUAL-MODE PHASE SHIFTER

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ABSTRACT

This paper describes the temperature insensitive dual-mode phase shifter which has been developed in Mitsubishi Electric Corporation.

The phase deviation is less than 18° over temperature range -30°C ~ +90°C. This is about one-third of the conventional one.

INTRODUCTION

Dual-mode phase shifter is suitable for beam steering elements in high power phased array antenna because of its high power and reciprocal phase shift characteristics (1).

But in this phase shifter, the phase shift deviation is fairly large when temperature changes (2). So, a temperature compensation is needed when it is used in severe condition, temperature range -30°C ~ +90°C.

Flux feedback drive control is well known as one of the temperature compensation (3).

But in case of handling high power and being required low loss characteristics, the cross section of Faraday rotator in phase shifter becomes larger and non-uniformity of magnetic flux density in the cross section increases. Moreover the distribution of flux density has a temperature dependency. In the conventional flux feedback drive control, however , the flux density in the whole cross section is assumed to be uniform. So, temperature dependency of the flux distribution is not sufficiently compensated.

In the developed phase shifter, the area of flux distribution in the cross section is divided into two sections (as shown in Fig.3), and the flux density of the section, where almost all of microwave power are transmitted, is controlled.

In this phase shifter, the phase deviation less than 18° in temperature range -30°C ~ +90°C is obtained. This deviation is about one-third of the conventional one.

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Fig.1 shows the schematic drawing of temperature insensitive dual-mode phase shifter which consists of two nonreciprocal quarter-wave plates, Faraday rotator and yokes.

In Fig.2, the conventional one is shown.

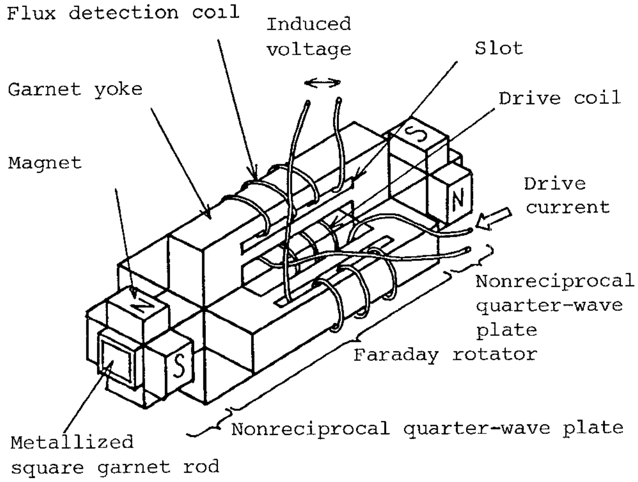


Fig.1 Temperature insensitive dual-mode phase shifter

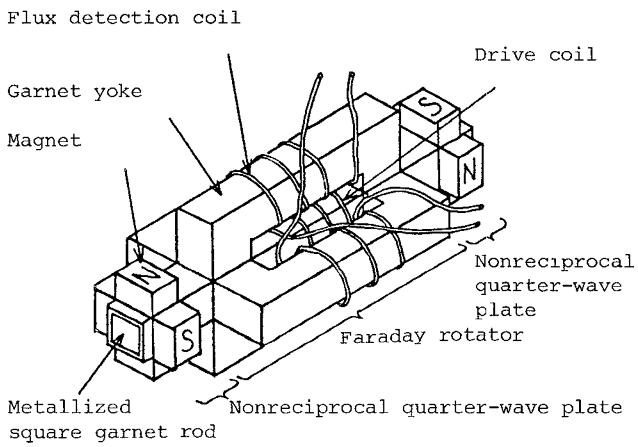


Fig.2 Conventional dual-mode phase shifter

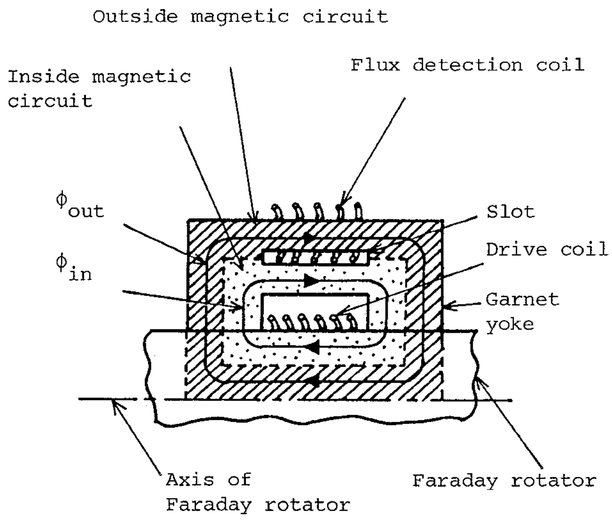
The feature of phase shifter in Fig.1 is that each yoke is separated into two layers. And the drive and flux detection coils are wound arround the Faraday rotator and the outside yokes through slots, respectively.

In the phase shifters,microwave with circularly polarization propagates along the axis of the Faraday rotator and its power concentrates at the center part. And the phase shift of microwave is determined by longitudinal magnetic flux density.

In the large cross section, the difference of magnetic reluctance between outer and inner magnetic circuits is large. On the other hand, coercive force H_c of garnet increases as temperature falls. Then, large bias magnetic field is required to obtain specified flux density and the difference between outer and inner bias magnetic fields becomes larger, because the ratio of outer and inner bias magnetic fields is constant. Therefore the non-uniformity of flux density increases.

In the conventional phase shifter, however, the flux density in the cross section is controlled by detecting the whole flux of the yokes, so the phase deviation due to the variation of non-uniformity of flux density is not sufficiently compensated.

But, in the new phase shifter , the flux density at the center part where microwave power concentrates is controlled by using the flux in the outside yokes. So, the detected flux is not much influenced by the variation of flux density distribution.



$(\phi_{all} = \phi_{in} + \phi_{out})$

Fig.3 Magnetic circuit separated into two layers, outside and inside

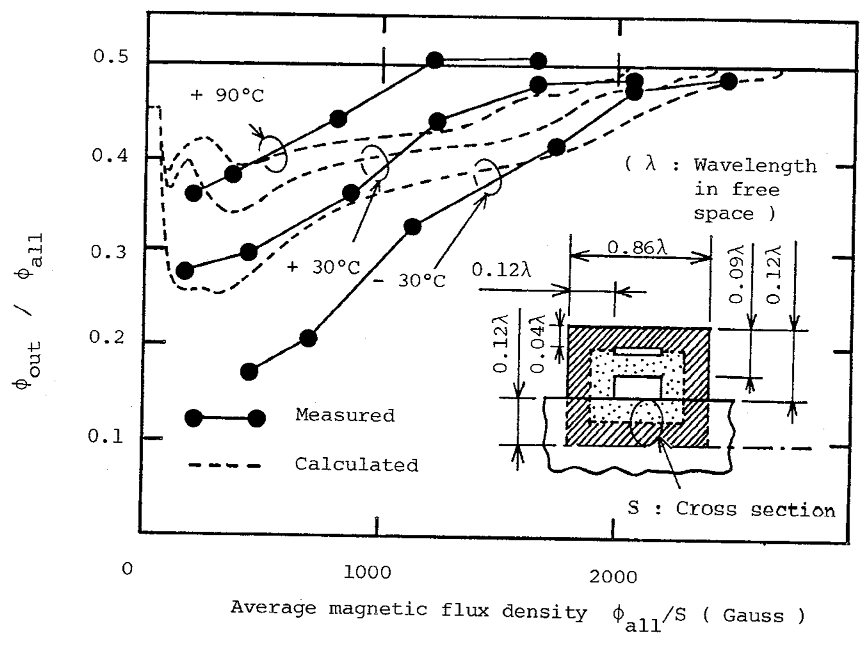


Fig.4 Flux distribution

EXPERIMENTAL RESULTS

The temperature dependence of flux distribution in the cross section of garnet yokes was investigated theoretically and experimentally. Fig.3 shows the Faraday rotator and yokes used for experiments.

The whole flux increment and the outside flux increment in the yokes are denoted by ϕ_{all} and ϕ_{out}, respectively.

Fig.4 shows temperature dependency of flux distribution in the cross section of garnet yokes. The solid lines show the measured values, ϕ_{out} / ϕ_{all}. The dotted lines show the calculated values. It is found from this figure that the ratio of the flux ϕ_{out} at the center of the Faraday rotator to the whole flux ϕ_{all} decreases as temperature falls. Therefore the non-uniformity of flux density is found out to become large.

The photograph of temperature insensitive 180° dual-mode phase shifter developed at X-band is shown in Fig.5. The dimensions of yokes are shown in Fig.3. The experimental results of the phase deviation in this phase shifter is shown in Fig.6. The phase deviation of this newly developed phase shifter is less than 18° in temperature range -30°C ~ +90°C. In Fig.7, the phase deviation of the conventional one is shown for comparison. The phase deviation in the new phase shifter is

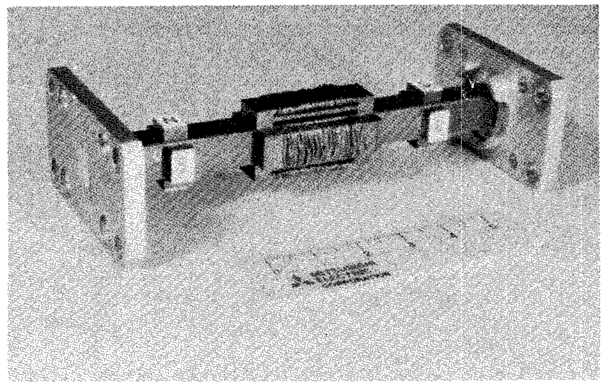


Fig.5 Photograph of temperature insensitive dual-mode phase shifter

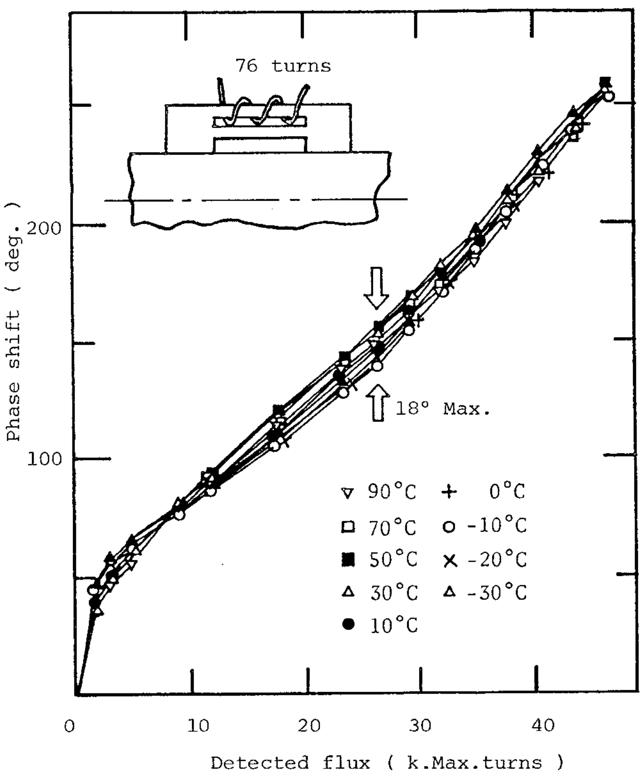


Fig.6 Phase shift characteristics of temperature insensitive dual-mode phase shifter

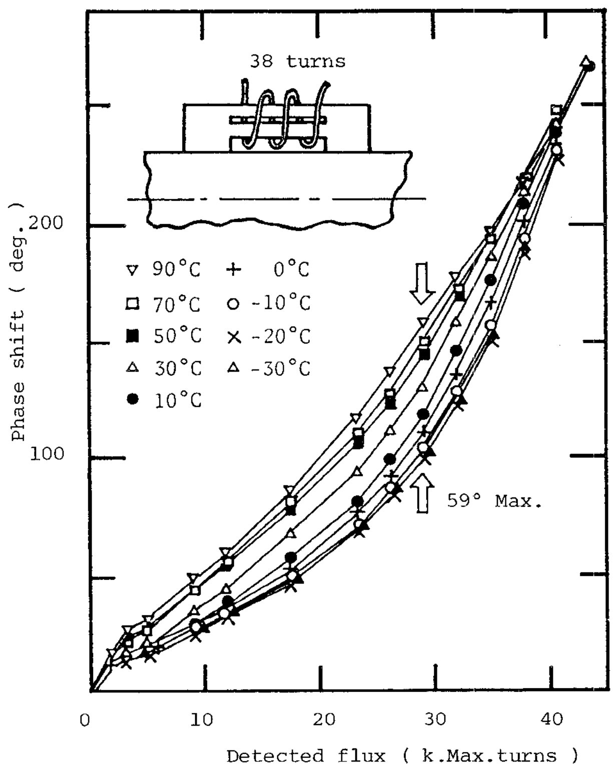


Fig.7 Phase shift characteristics of conventional dual-mode phase shifter

one-third of the conventional one.

CONCLUSION

The temperature insensitive dual-mode phase shifter was developed at X-band. The reduction of phase deviation is achieved by controlling the flux at the center part of Faraday rotator.

REFERENCES

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