AUTOMATIC RIEKE DIAGRAM DRAWING SYSTEM

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Abstract

The development of a system which provides the power-constant loci on a Smith chart automatically is presented. The system consists of a couple of ferrite phase shifters, ended with PIN diodes, and a network analyzer.

Introduction

In the measurements of microwave oscillators, Rieke diagram drawing has been one of the most time-consuming works. The system proposed here is intended to get the power-constant loci on a Smith chart automatically. Impedance variable termination, the main part of the system, is also mentioned in detail.

Impedance variable Termination

When 360° ideal phase shifter is terminated at one port with an ideal PIN diode, the input impedance of the other port can be so controlled as to cover all over the area inside Smith chart. On impedance chart, the radial component is controlled by the bias current of PIN diode, and for the angular component, the phase shifter plays its part.

The setup of the termination under test is designed at S-band in strip line form. As for the phase shifter, reciprocal ferrite phase shifter is adopted here for its power lineality and structual simplicity. The phase constant of quasi-TEM mode propagating along the ferrite filled stripline which is longitudinally magnetized can be approximated by the equ.(1) under the condition of small spacing.[1]

$$\beta \simeq \beta_0 \sqrt{\varepsilon_r (\mu^2 - \kappa^2)/\mu} \qquad (1)$$

Where μ and κ are the components of Polder tensor. Analog phase shifter can be realized by changing the anisotropy κ/μ, that is, by changing the applied magnetic bias field.

Fig.1 shows the changes in input impedance of the termination setup. When the bias current of PIN diode increases, the RF resistance of PIN diode decreases and the increment of radial component results. Though the resistance of PIN diode can be reduced to few ohms, insertion loss of phase shifter (about 2dB/360°) prevents the loci to expand much greater in radius.

Rieke Diagram Drawing

Circuit diagram of the system is shown in Fig.2 schematically. Channel A and B have the same phase shifters and PIN diodes. The oscillator under test is mounted at the end of channel B. The net output power of the oscillator is measured by the subtractive power meter through the directional coupler. Then the measured power:pi-Pr is compared with the setting power:P_0 which was set previously. If the output power Pi-Pr is greater than the setting power P_0, negative voltage appears at the output of the comparator, then the amplifier increases the bias current of PIN diodes until the reflection coefficient becomes an large value which makes the net output power to be equal to the setting power P_0. Keeping the balanced condition, angular component of the impedance is changed by the phase shifter independently. So the input impedance of the channel B changes circularly, keeping the output power constant. That of the channel A also changes just the same way. When the network analyzer is connected at the end of the channel A, power constant loci can be obtained on the Smith chart automatically.

Subtractive Power Meter

To operate the Rieke diagram drawing, the immediate measurement of subtractive power is required. As shown in Fig.2, the power meter is consist of an automatically balanced bridge that has two barretters on the neighbored edges. One of the barretters is for the measurement of incident power, and the other one is for the reflected power. When no power is applied to both of the barretters, the bridge is balanced. And when the incident power and reflected power are applied to the barretters, of course the former is greater than the latter, the unbalanced output of the bridge is negatively fed back in the shape of high frequency power. If the gain of the amplifier is large enough, the compensated high frequency power is nearly equal to the subtractive power:Pi-Pr.

Operation in Practice

The main part of the system made for trial is shown in Fig.4. In the picture, phase shifters are center-sited, and the channel A streches to the right side, and to the left "B" does. The trial measurement is done for a klystron 6BL6 coupled with system through co-axial line, under the following condition : Va=350V, Vr=70V, Ia=25mA, f_0=3.48GHz. In order to eliminate the influences of the coupled signal between two channels, that will disturb the impedance measurements, the measured frequency is slightly shifted from that of the oscillation. The equi-power loci measured with this system is shown in Fig.5. Whenever the off-set voltage exceeds a limit, which may be caused by the imperfection of the system, blanking action has been taken in the chart drawings. So the blanked area does not always correspond to the stop of oscillation.

Conclusion

The equi-power loci can be obtained in several minutes with this system automatically. For the improvement of the system, it is required to keep the characteristic impedance of phase shifter constant and minimize the insertion losses. Influence of PIN diode bias wire, and band width of the directional coupler are also the restractive factor for the operation.

Further, to complete the Rieke diagram, equi-frequency loci should be added, which may be measurable in the same way using some sharp filtation technique, for example, a tunable YIG filter.

Acknowledgement

The authors are grateful to Dr. Miyakawa, Fuji-tsu Co. for the offering of PIN diodes.

Reference

1 M. E. Brodwin, "Propagation in Ferrite-filled Micro-strip", IRE MTT, P.150, April 1958.

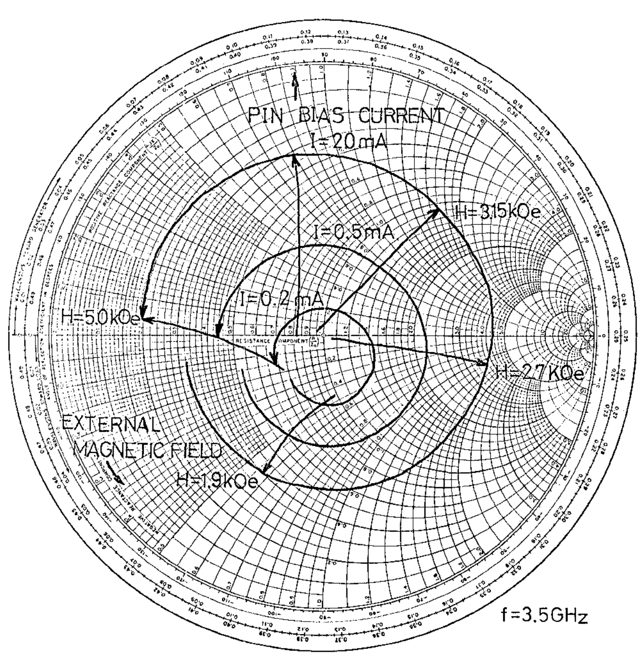

FIG.1 INPUT IMPEDANCE OF THE VARIABLE TERMINATION

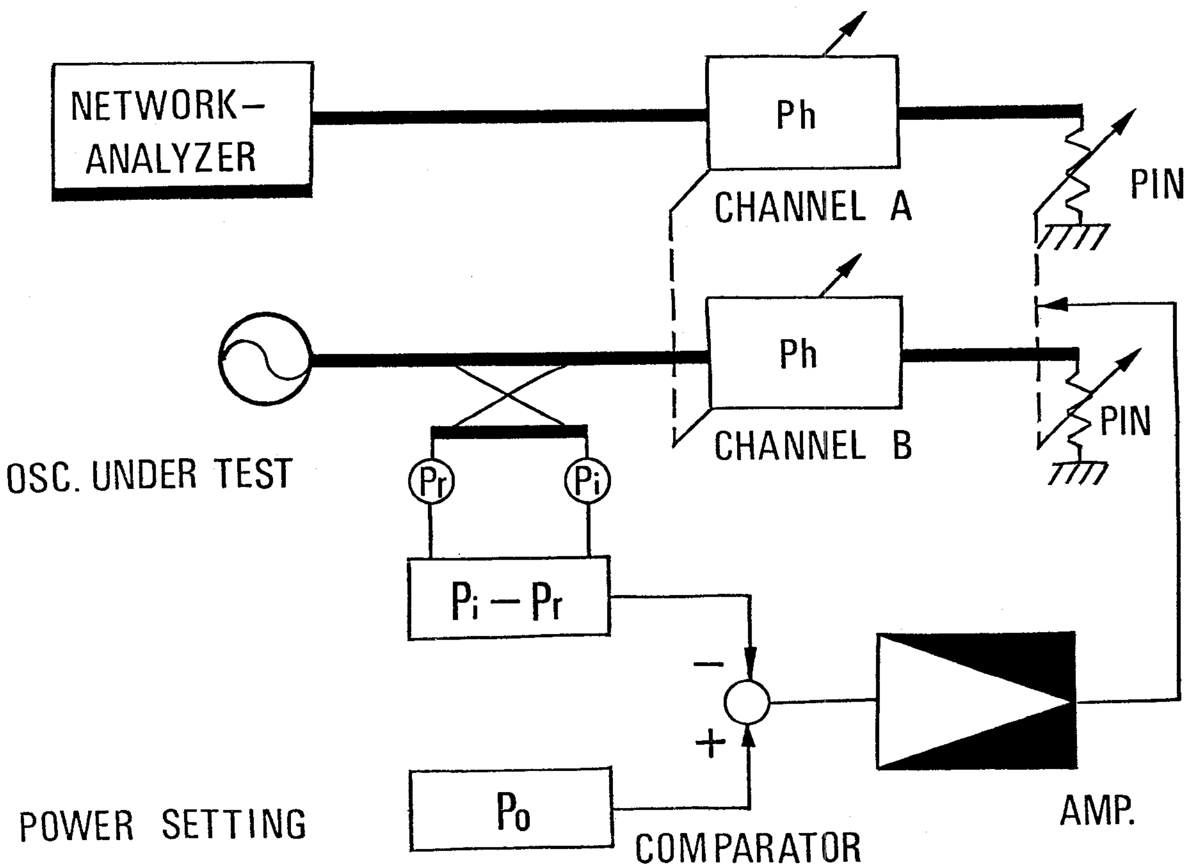

FIG.2 CIRCUIT DIAGRAM OF THE SYSTEM

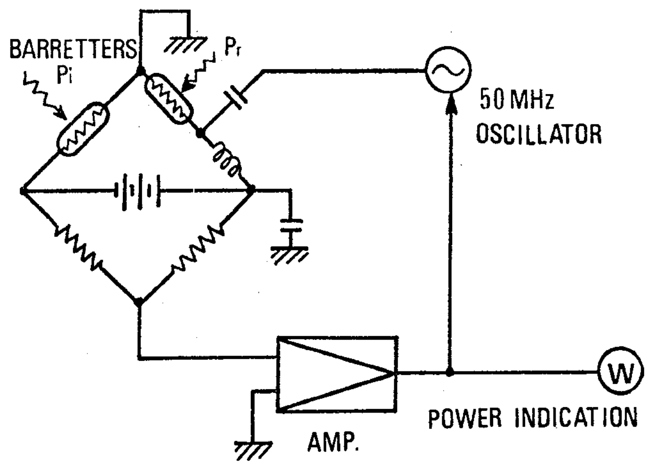

FIG.3 SUBTRACTIVE POWER METER

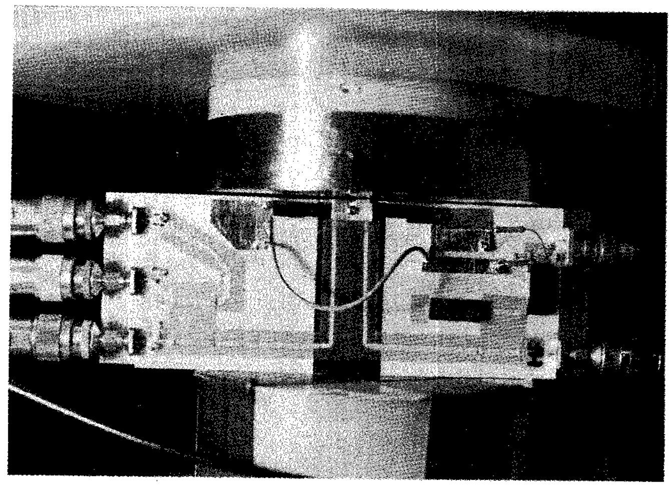

FIG.4 MAIN BLOCK OF THE SYSTEM

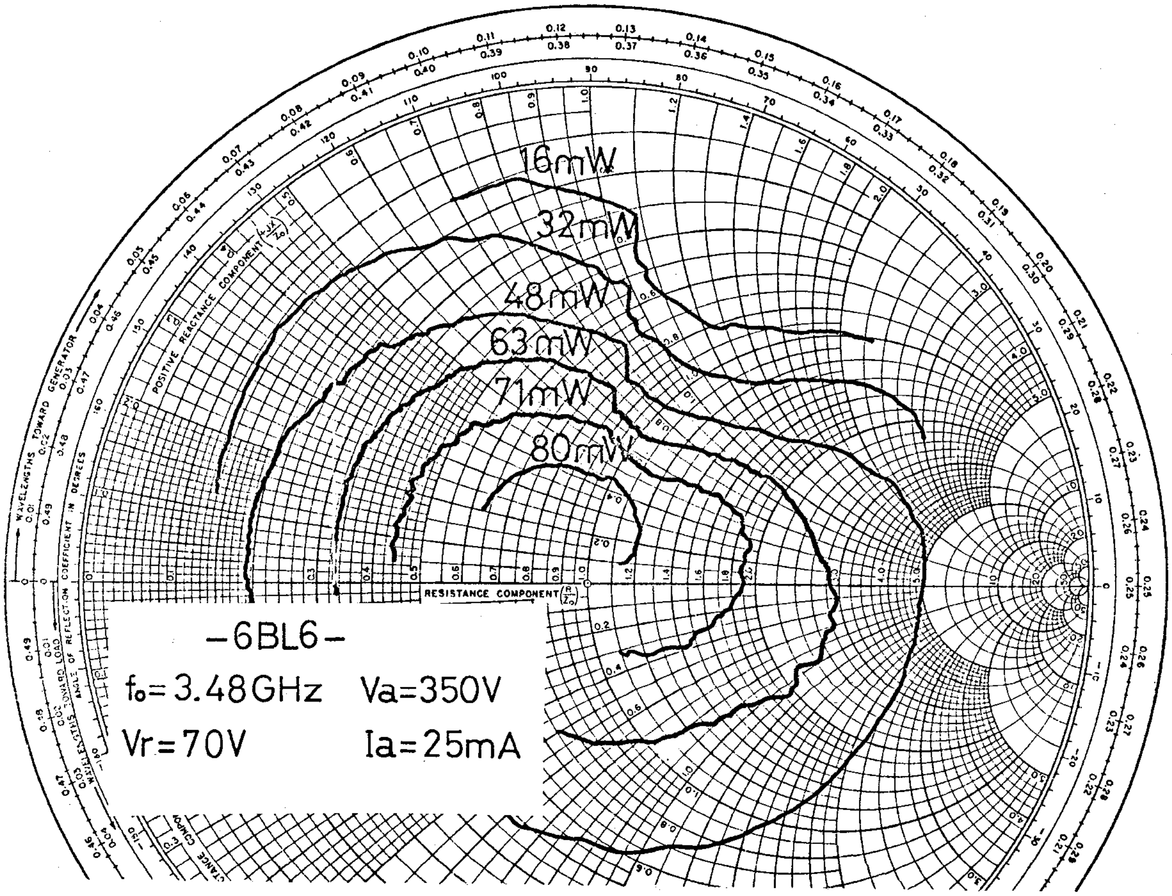

FIG. 5 EQUI-POWER LOCI OF A KLYSTRON