NOTCH FILTERS WITH VARIABLE CENTER FREQUENCY AND ATTENUATION

Sachihiro TOYODA

Osaka Institute of Technology, Osaka 535 Japan.

ABSTRACT

This paper describes notch filters whose center frequencies and the maximum attenuation are variable. Three different types of the filters using varactor diodes and GaAs FETs are proposed and tested at 2 - 4 GHz bands. The tunability over 2.2 - 4 GHz is obtained by changing the junction capacitances of varactor diodes, and the maximum attenuation over 15 - 60 dB is obtained by changing the inner resistances of FETs.

INTRODUCTION

Many studies of microwave bandstop or notch filters using rectangular waveguides, coaxial lines or striplines have been reported. However, in these filters, the center frequency giving the maximum attenuation and its quantity are fixed and cannot be varied. The notch filters in which both the center frequency and the maximum attenuation can be varied either mechanically or electrically have already been reported by the author (1),(2).

In this paper, the author proposes new notch filters in which the center frequency and the maximum attenuation are variable. Three types of the filters are constructed by using varactor diodes and FETs. The experiments were carried out at 2 - 4 GHz bands. The tunability over 2.2 - 4 GHz was attainable by changing the junction capacitances of the diodes, and the maximum attenuation was variable over 15 - 60 dB by changing the inner resistances of FETs.

STRUCTURES OF NOTCH FILTERS AND EXPERIMENTAL RESULTS

The equivalent circuit of a notch filter is shown in Fig. 1. The filter is composed of two resonance circuits

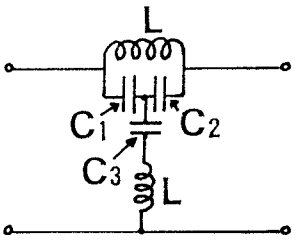

Fig. 1 Equivalent circuit of the notch filter

CH2725-0/89/0000-0595$01.00 © 1989 IEEE

connected to the transmission line. Varactor diodes are used as the capacitances C_1, C_2, and C_3 so that only the center frequency can be varied. A short section of a strip-line with a strip narrower than that in other part of the line is used as the inductance L. Figure. 2 is a photograph of the filter of Fig. 1. The attenuation characteristics of the filter is shown in Fig. 3. We see that the center frequency giving the maximum attenuation varies from 2.4 GHz to 4 GHz when the voltages of varactor diodes Z_{D1} and Z_{D2} are changed from 0 V to -6.5 V and that of Z_{D3} is changed from -2.5 V to -23 V. The maximum

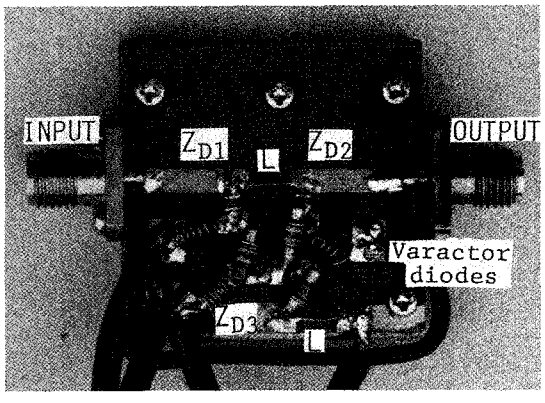

Fig. 2 Photograph of the notch filter constructed with the equivalent circuit shown in Fig. 1

attenuation is 55 dB, and the bandwidths for -3 dB and -30 dB are 100 MHz and 50 MHz, respectively.

Figure 4 shown the equivalent circuit of another filter. This filter is composed of a parallel resonance circuit and a resistance connected to the transmission line. A varactor diode is used as the capacitance C, and an FET is used as the resistance R.

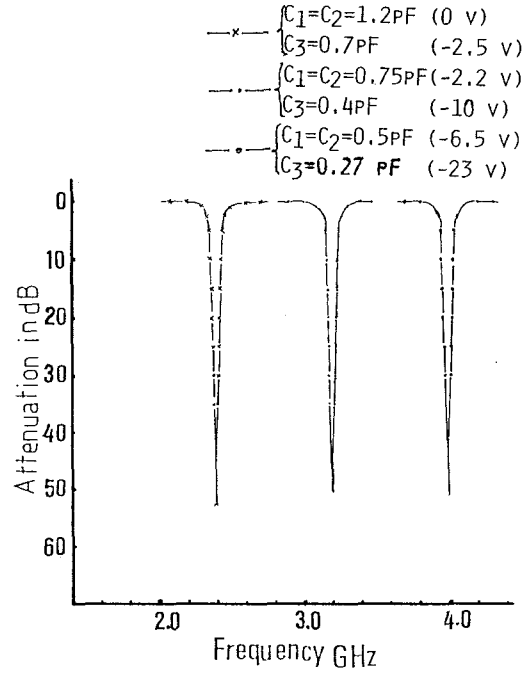

Fig. 3 Attenuation characteristics of the notch filter shown in Fig. 2

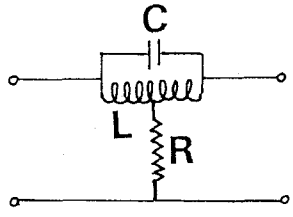

Fig. 4 Equivalent circuit of the filter with variable center frequency and attenuation

The inductance L is formed by a short section of the microstrip line with a narrower strip. Figure 5 is a photograph of the filter of Fig. 4. The attenuation characteristics of the filter is shown in Fig. 6. It is seen that the center frequency varies from 2.3 GHz to 3.8 GHz when the voltage of the diode is change from 0 V to -25 V. We see also that the maximum attenuation varies from 15 dB to 60 dB when the

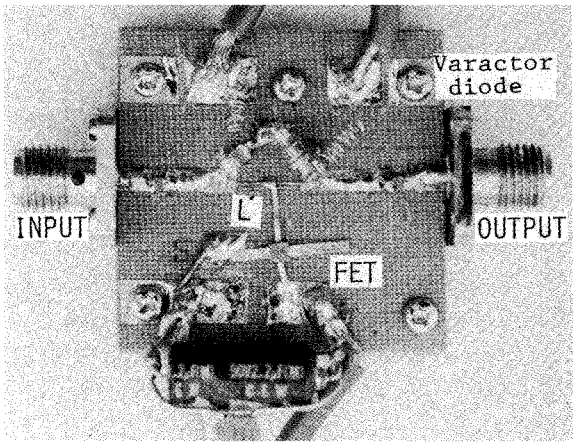

Fig. 5 Photograph of the notch filter constructed with the equivalent circuit shown in Fig. 4

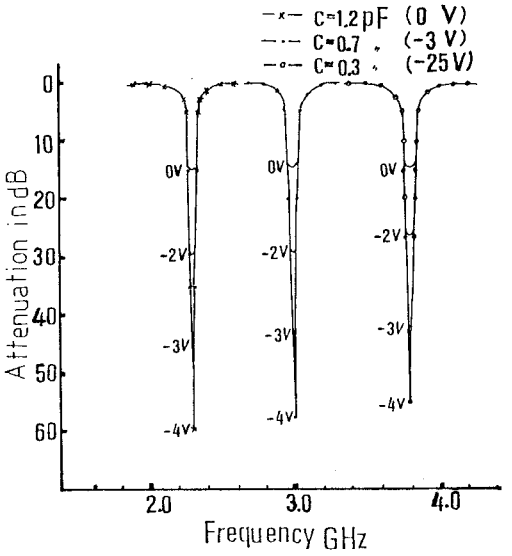

Fig. 6 Attenuation characteristics of the notch filter shown in Fig. 5

voltage across the gate and source of the FET is changed from 0 V to -4 V. The bandwidths for -3 dB and - 30 dB are 100 MHz and 45 MHz, respectively.

A circuit shown in Fig. 7 also works as a nocth filter. In this filter, a capacitance of series resonance circuit is divided into two capacitances C_1 and C_2, and between them the resistance R is connected. To vary

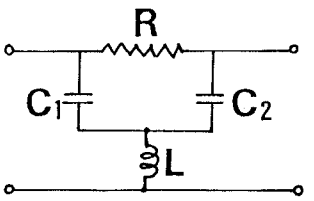

Fig. 7 Equivalent circuit of the notch filter with variable center frequency and attenuation

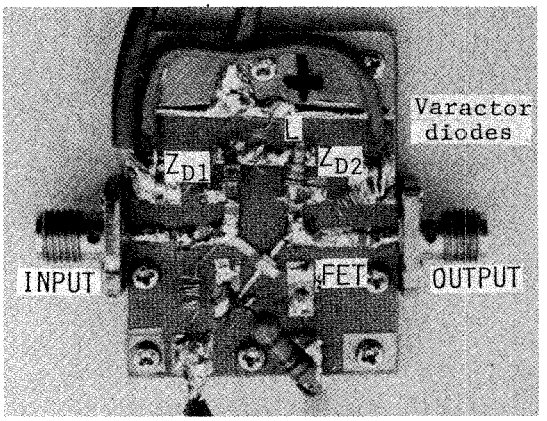

Fig. 8 Photograph of the notch filter constructed with the equivalent circuit shown in Fig. 7.

the center frequency and the maximum attenuation, C_1 and C_2 were replaced with varactor diodes and R was replaced an FET. The inductance L was made of a 0.8ϕ gold lead. Figure 8 is a photograph of the filter of Fig. 7. The attenuation characteristics of this filter is shown in Fig. 9. We see that the center frequency varies from 2.2 GHz to 4 GHz when the bias voltages of the diodes are changed from 0 V to -25 V, and that maximum attenuation varies from 20 dB to 55 dB when the voltage across the gate and source of the FET is changed from 0 V to -1 V. The bandwidths for -3 dB and -30 dB are 95 MHz and 40 MHz, respectively.

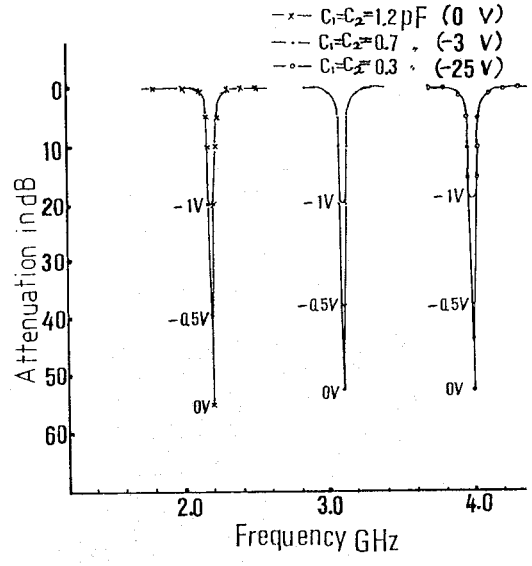

Fig. 9 Attenuation characteristics of the notch filter shown in Fig. 8.

CONCLUSION

Three types of notch filters with variable center frequency and the maximum attenuation have been devised. All of them are composed of varactor diodes, an FET, and an inductance. By changing the capacitances of the diodes and the inner resistance of the FET, we can vary both the center frequency and the maximum attenuation.

The future subject is to construct a notch filter in which the center frequency and the maximum attenuation are variable and the bandwidth for the attenuation is narrow in the X-band.

REFERENCES

1) S. TOYODA "Variable Band-pass Filters Using Varactor-Diodes" IEEE Trans., Microwave Theory and Technique MTT-29. No. 4 PP 356-363 April 1981.

2) S. TOYODA "Quater-Wavelength Coupled Variable Bandstop and Bandpass Filters Using Varactor Diodes" IEEE Trans., Microwave Theory and Technique MTT-30 No. 9 PP 1387-1389. September 1982.