A Varactor-Tuned Active Microwave Bandpass Filter

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Abstract— **Traditionally, microwave filters have been implemented as passive networks of wave guide, transmission-line, or discrete lumped elements. More recently, microwave active filters have also been realized. A microwave high-Q active bandpass filter is presented, using a varactor diode for tuning, and an active component giving a substantial increase in Q of the resonant sections of filter. High-Q filter elements offer low-filter insertion loss and also yield sharp passband corners, which cannot be achieved by lossy filter and amplifier combination.**

I. Principle

THE BASIC structure of the one-pole varactor-tuned active filter, is shown in Fig. 1. This is a microstrip half-wavelength resonator ($\lambda/2$), feedback via two quarter-wavelength couplers, by an active loop consisting of an amplifier (FET), an attenuator and a phase shifter. The introduction of these components into passive resonator structure giving substantial increase in Q. In doing so, it is necessary to match the appropriate phase and attenuation. The active loop is integrated on the same substrate as the resonator ($\lambda/2$).

By using varactor diode, the active resonator may be electronically tuned. However, introducing a varactor diode into a resonator degrades the unloaded Q. Fortunately, the inherent varactor losses can be compensated by the active loop. If the varactor is placed in the middle of the resonator ($\lambda/2$), the resonant frequency will change with respect to the varactor bias voltage.

The single-section filter just treated was employed as the basic element to design multisection active filters (Fig. 2). A three-pole agile active filter was realized on duroid substrate with a thickness of 0.8 mm and dielectric constant of 2.2 (Fig. 3). The varactors used are Thomson DH740 devices with a quality factor at 1 GHz and −4 volts :140.

II. Experimental Performance of Proposed Agile Active Filter

Experimental performance results are shown for three section bandpass active filter.

Tuning Range: The tuning range is a function of the capacitance ratio of the varactor between useful minimum and maximum varactor voltage limits and of the phase shifter of the external loop. For this filter the resonant frequency was tuned from 3.600 to 3.820 GHz, (the tuning range is about 220 MHz), with 0-dB losses, and return losses better than 20 dB.

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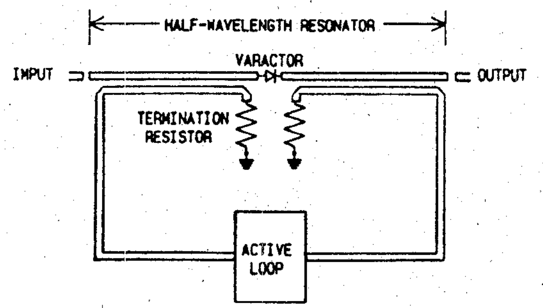

Fig. 1. Schematic view of microwave active tunable resonator.

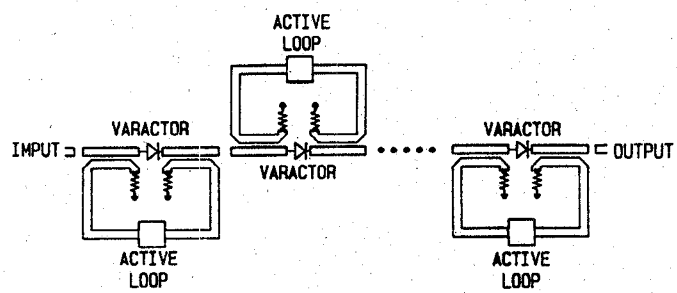

Fig. 2. Multipole active tunable filter.

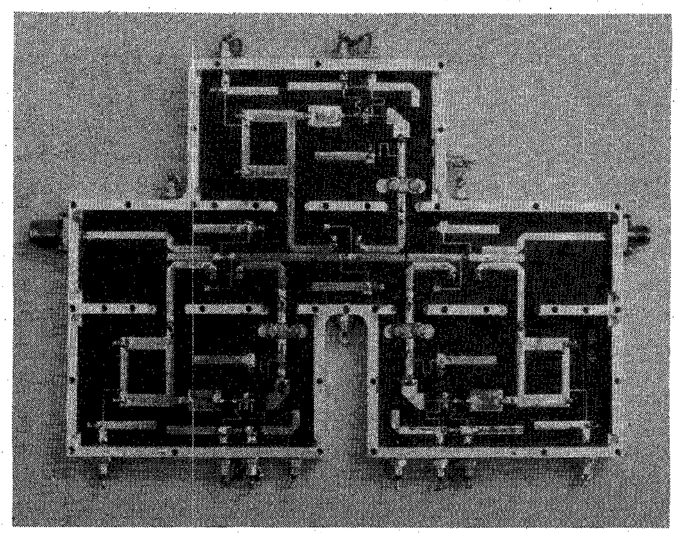

Fig. 3. Photograph of the three-pole active tunable filter.

In Fig. 4, we present the measured responses of the passband filter when varactors diodes were tuned. At each measurement, the filter was adjusted for 0-dB transmission loss.

Signal Input Effects: It was observed that power input affects the filter response. Generally, the transmitted power is reduced

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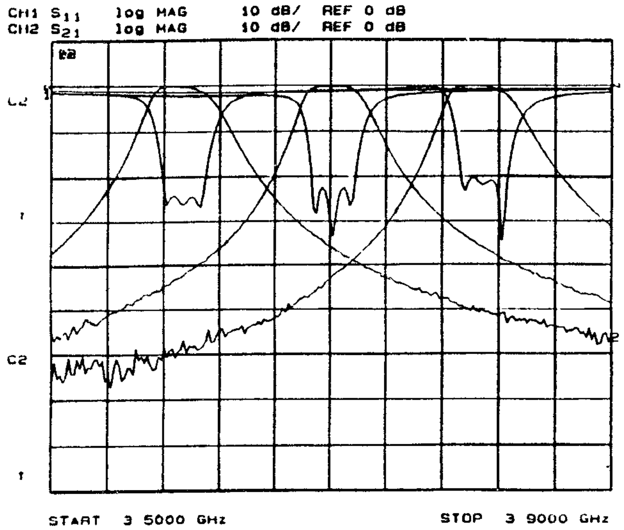

Fig. 4. Measured performance of the three-pole active tunable filter.

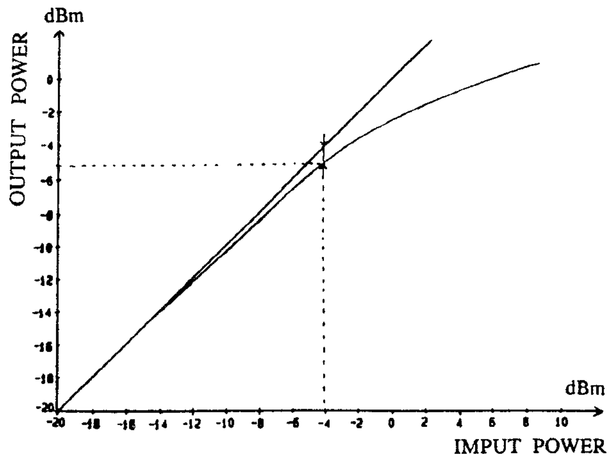

Fig. 5. 1-dB compression curve of the active filter.

as input power increased. One important parameter to evaluate the dynamic range of the active filter is the 1-dB compression point. Fig. 5 shows the measured 1-dB compression output power curve of the active filter, P1 dB = −5 dBm.

Nonlinear phenomena in the active filter lead to an increase in the insertion loss as the input power rises. This phenomena result of the dependence of compression gain of each active loop on the input signal level.

Noise Figure: In Fig. 6, we present the measured noise factor of the active filter, over the 3.660–3.720-GHz frequency range. At this measurement the filter was adjusted for 0-dB transmission loss and was centered at 3.690 GHz. The rejection of the filter is responsible for an additional increase in the noise figure outside of the bandpass. The noise factor depends upon the varactor losses (low Q) and the feedback amplifier. It can be decreased when every active loop was epitomized at the FET loading optimum noise impedance values, and when the varactor intrinsic Q increases.

Temperature Effects: The major effects of temperature upon filter performance are caused by the temperature sensitivity of the gain of each external loop. For the filter under study, the temperature and fluctuation of the insertion loss. In view

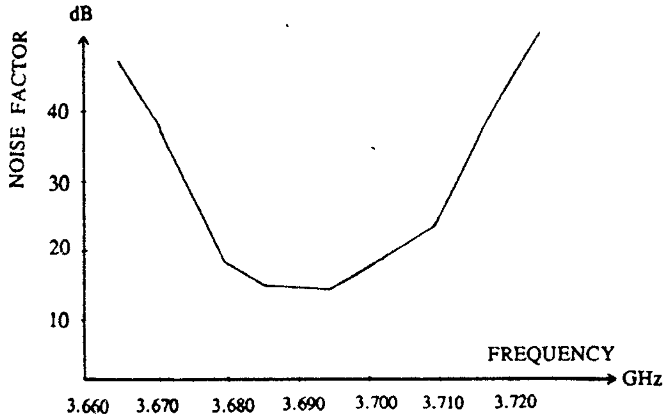

Fig. 6. Noise factor of the filter.

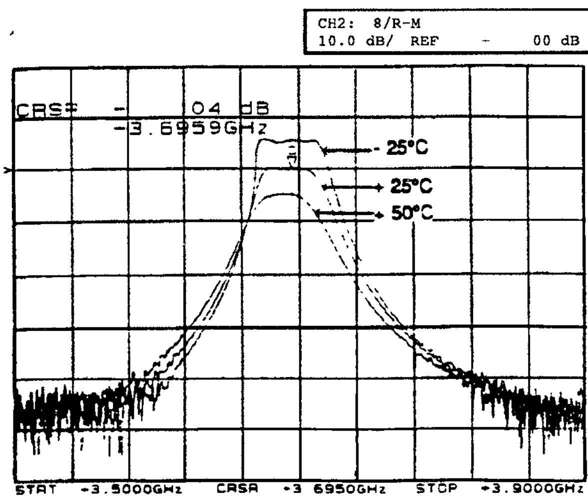

Fig. 7. Temperature fluctuation of the instertion loss.

of the temperature instability, it is worthwhile to utilize an external additional circuit to control and compensate for the temperature drift.

III. Conclusion

The new active filter design concept has been successfully applied to the design of a varactor tunable filter. The active filter shows a significant improvement of the filter Q-value, the passband corner rounding effect and insertion loss, but is suitable for use in the small signal environment.

However, it is still very difficult to make a filter in MMIC form because of the low-Q value of MMIC elements. To overcome this problem, an active filter concept is a hopeful approach.

References

[1] H. Matsumura and Y. Konishi, "An active microwave filter with dielectric resonator," *IEEE MTT-S Microwave Symp. Dig.*, 1979, pp. 323–325.

[2] H. Jiao, P. Guillon, B. Jarry, and B. Madrangeas, "Microwave frequency agile active filters for MIC and NMIC application," *IEEE MTT-S Symp. Dig.*, 1990, pp. 503–506.

[3] C.-Y. Chang and T. U. Ito, "Narrowband planar microwave active filter," *Electron. Lett.*, vol. 25, no. 18, pp. 1228–1229, Aug. 1989.

[4] ——, "A varactor-tuned active microwave band-pass filter," *IEEE MTT-S Symp. Dig.*, 1990, pp. 499–502.