INTEGRATED MIXER FOR 18 AND 26 GHZ

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Summary

Two integrated mixers on a ceramic substrate of 10 mil thickness for frequencies of 18 and 26 GHz and an IF of 1 - 2 GHz have been developed. The development of Schottky-Barrier beam lead diodes for signal frequencies of 30 GHz and higher and the high state of thinfilm technology makes it possible to build low noise integrated mixers in this frequency range. The advantages are small size and a simple way of production, the disadvantages are high ohmic losses with increasing frequency.

With the growing demand for telephone-channels in the last years and on account of the coming picture phone, it was necessary to develop new communication systems. Circular waveguides excited in the H_{01}-mode have a very large useful bandwidth and may be used for this purpose. Since it is not easily possible to amplify such high frequencies, the signal must be downconverted by a mixer. Normally, these mixers are made in the usual waveguide technique. The integration of microwave circuits using thinfilm technology was done with success up to x-band and there is the question if it is possible to integrate mixers at even higher frequencies.

The excited wave in microstrip is nearly of the TEM type. To suppress undesirable transverse components, it is necessary to keep the width B of the microstrip conductor very small compared with the effective wavelength. If lumped elements are used in a mixer circuit the dimensions of the capacitors and of the inductors also have to be much smaller than the wavelength. To realize this condition, the thickness of the microstrip must decrease with increasing frequency. According to experience the width B of the microstrip conductor must be smaller than $\lambda eff/10$, that means the relation $B/\lambda eff/10 < 1$ has to hold. Accordingly it is possible to use a 10 mil thick ceramic up to nearly 30 GHz. (figure 1)

The losses in microstrip are growing with decreasing ceramic thickness, and the associated decrease in center strip width causes increased current density and propagation losses. The dielectric losses are very small, so only ohmic losses are considered, which give a nearly constant value per wavelength. In figure 2 the measured loss of a microstrip line inclusive connectors is plotted versus the microstrip wavelength.

Two integrated balanced mixers have been developed at a signalfrequency of 18 GHz and 26 GHz. For this, a high standard of thinfilm-technology and the use of beamlead diodes with a high cut-off frequency have been necessary. The mixers consist of a hybrid, diode-matching section, lowpass filter and an IF short circuit. It was difficult to build the hybrid, since the $\lambda/4$ sections become extremely short. For the 26 GHz mixer hybrid $3\lambda/4$ sections were used, the bandwidth will get therefore somewhat smaller. The RF is fed with an OSM cable to the diodes at 18 GHz, with a riged waveguide at 26 GHz. The VSWR of such a waveguide - microstrip section is plotted in figure 3. The low-pass filter prevents the RF from propagating into the IF sections, the dc loop is closed through the diodes. Some shorted, high-ohmic $\lambda RF/4$ stubs, present an open circuit for the radio frequency signal and a short circuit for the IF. Without these stubs, there are ripples in the conversion-loss curve, which are caused by multiple reflections in the RF lines. The conversion-loss of the mixers is plotted in fig. 4, further datas are as shown:

Signal frequency f_s	17 GHz	26 GHz
Conversion loss	7 dB	9 dB
Noise figure with a preamplifier of 1,5 dB noise figure	≥ 8 dB	≥ 10 dB
Input VSWR	$< 1,8$	< 2
Output VSWR	< 2	$< 2,3$

The noise-figure of a mixer with an IF-amplifier in cascade may be expressed by the equation

$$F = L_c \; (N_r + F_{IF} - 1)$$

where L_c is the conversion loss, F_{IF} the noise figure of the IF amplifier and N_r is the diode noise ratio, (the ratio of the noise output of the diode to the thermal noise output of a resistor having the same resistance as the diodes). Experience shows, that with Schottky-Barrier-Diodes $N_r \sim 1$ and so

$$F \sim L_c \, F_{IF}$$

The noise figure of the system is approximately sum of the mixer-conversion loss and the IF noise figure in dB. That means, the shot noise of a Schottky-Barrier-Diode is negligible, the only major contribution is from the conversion loss.

Conclusion

It was shown, that it was possible to integrate high frequency microwave circuits with success. The small circuit dimensions, the simple method of production are the advantages. Also the possibility of application of beamlead-diodes, which have minimum parasitics give best mixer datas.

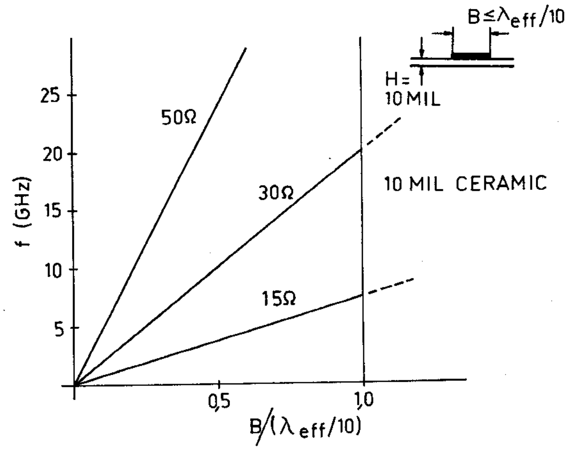

Fig.1:

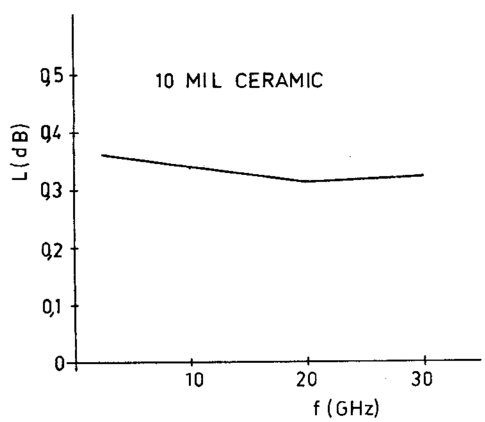

Fig.2: Microstrip Loss pro Wavelength

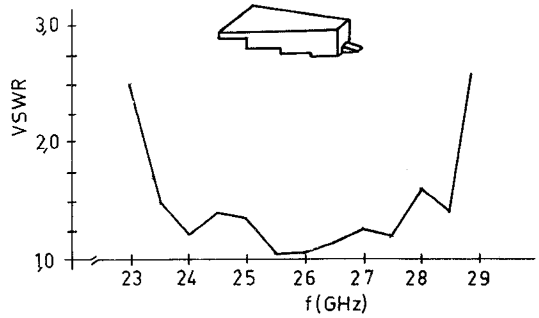

Fig. 3: VSWR of a Microstrip-Waveguide

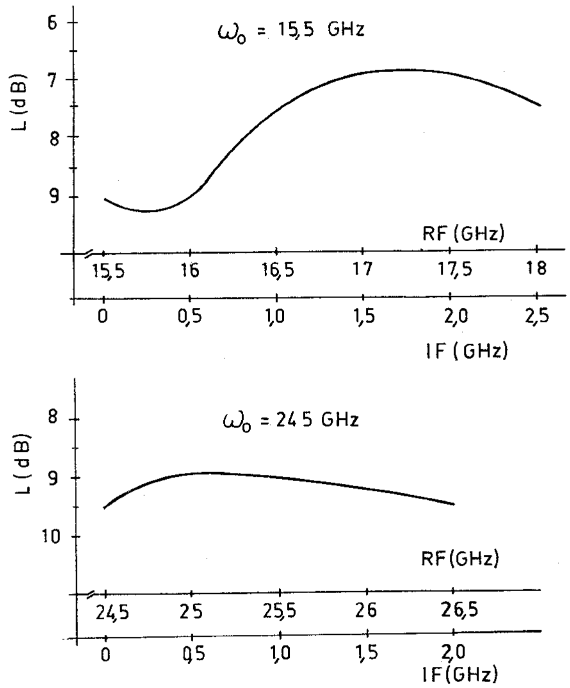

Fig. 4: Conversion Loss

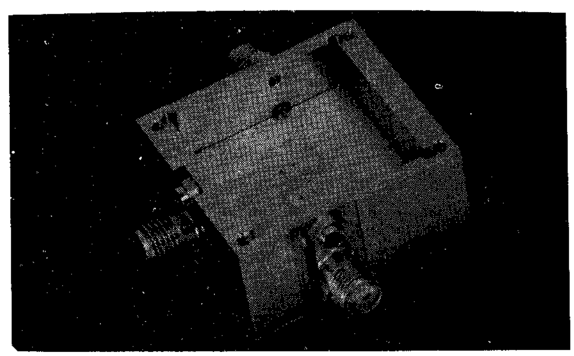

Fig. 5: P-Band Mixer